ARCHAEOLOGY IN THE WESTERN ISLES: THE MOLLUSCAN EVIDENCE

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SUMMARY

Using assemblages of marine and non-marine mollusc shells from recent excavations in the Western Isles of Scotland, with reference to previously published studies, this thesis contributes to an enhanced understanding of the cultural palaeoecology of insular societies.

Chaoter 1 sets out the topics that will be covered in this thesis. Chapter 2 introduces the methods and principles that drive molluscan analysis; Chapter 3 outlines the natural history of the Western Isles; and Chapter 4 the archaeology. Previous work on molluscs from the islands are summarised in Chapter 5, and emergent themes identified.

Chapter 6 presents the results of analyses of new non-marine molluscan assemblages from 9 sites, ranging in date from the Mesolithic to the Norse period. Comparative data collected from a transect of samples for modern snails are also presented, along with a statistical meta-analysis of the data. Chapter 7 presents the results of marine shell analyses from 4 sites, ranging in date from the Early Bronze Age to the Norse period.

The results are discussed in terms of their regional and wider significance in Chapter 8, and the thesis concluded in Chapter 9.

Studying non-marine and marine molluscs from a wide range of sites across the islands has made important contributions to the archaeology of the Western Isles. The movement of new species of snail into and across the islands emphasises the connectedness of prehistoric communities across wider social networks on the Atlantic coast of Europe. The study of non-marine molluscs and the use of statistical analysis contributes to a broader understanding of taphonomy and site formation processes. Combined analysis of marine and non-marine mollusc shells highlights the agricultural practices and land use of prehistoric and Norse farmers. Studies of larger marine shells indicate changing tastes at the time of increasing contact with the Norse diaspora.

DECLARATION OF ORIGINALITY

I hereby declare that, except where indicated by specific reference, the work submitted herein is the result of my own investigation, and that the views expressed are my own.

I further declare that no portion of the work presented has been submitted in substance for any other degree or award at this or any other university or place of learning, nor is being submitted concurrently in candidature for any degree or other award.

Signed ____

Date____

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Professor Niall Sharples acted as second supervisor, and provided access to the Bornais and Sligeanach material. His unparalleled understanding of Hebridean archaeology and energetic interest in marine shell assemblages and wider issues of coastal resource acquisition were an inspirational force guiding this study.

Nigel Thew's 1980s study of four assemblages of snails from the islands set the tone for much of this research by taking archaeological land snail analysis in important and exciting new directions. I am incredibly fortunate that he has been consistently willing to discuss ideas about snails in the Hebrides, and to travel from Neuchâtel to Cardiff several times to check identifications. His importance to this work, and my gratitude, cannot be overstated.

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My thanks to Professor Ken Thomas, my MSc course director at UCL, who first introduced me to the potential importance of molluscs for understanding human pasts; and to Dr David Smith, my undergraduate tutor at Birmingham, whose environmental archaeology lectures first set me on this path.

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1. INTRODUCTION

This thesis is concerned with the role that assemblages of mollusc shells from archaeological contexts can have in understanding past human lives in the Western Isles. It concentrates on the changing environment, whether the changes are naturally or culturally mediated; as well as the contribution molluscs may have made to food and material culture in the Hebridean past. The methodological aims of this thesis are twofold. Firstly, to consolidate pre-existing knowledge about environmental change, landscape use and the role of molluscs in human lives in the Western Isles, and secondly to identify and analyse mollusc shells recovered from fieldwork in the Western Isles to contribute to a fuller archaeology of the islands.

The Western Isles are also known as the Outer Hebrides or the Long Isle, and in Gaelic as *Na h-Eileanan Siar* or *Na h-Eileanan an Iar*. They are a group of islands that lie off the north-west coast of Scotland, on the eastern shore of the Atlantic Ocean (Figure 1.1). Their western coast is dominated by a low-lying plain of windblown sand, known as the *machair*. This provides fertile soils in an otherwise acidic landscape. The sands that make up the machair started to accumulate on the shore late in the second millennium BC, and became the focus of human settlement on the islands at various times in their history. This thesis explores how the shells of molluscs preserved in this machair and its associated dune systems may be used to explore past human activities and cultural changes, as well as describing an emerging picture of the natural history of molluscs in the islands. Although the Western Isles, and especially the machair plains, have been subject to several recent archaeological investigations, there has been limited work on molluscan assemblages. This is despite the very good degree of preservation to be expected in several deposits owing to the presence of highly calcareous sand.

Within this thesis both marine and non-marine molluscs have been studied. The distinction between the two is not always clear ('marine' molluscs of the intertidal zone spend much of their lives outside of water, and some 'non-marine' molluscs thrive in brackish water), and has largely persisted due to the different research questions the two categories are used to address (the former most likely to be viewed as a dietary resource, the latter as proxies for past environmental conditions). This research looks at the evidence both can contribute to an understanding of changing environmental conditions at the coast, and changing cultural (and especially agricultural) practices on land. Integrated analyses of both marine and non-marine molluscs are seldom undertaken, although Evans (1979) did refer to both in his review of molluscs from archaeological sites on windblown sand.

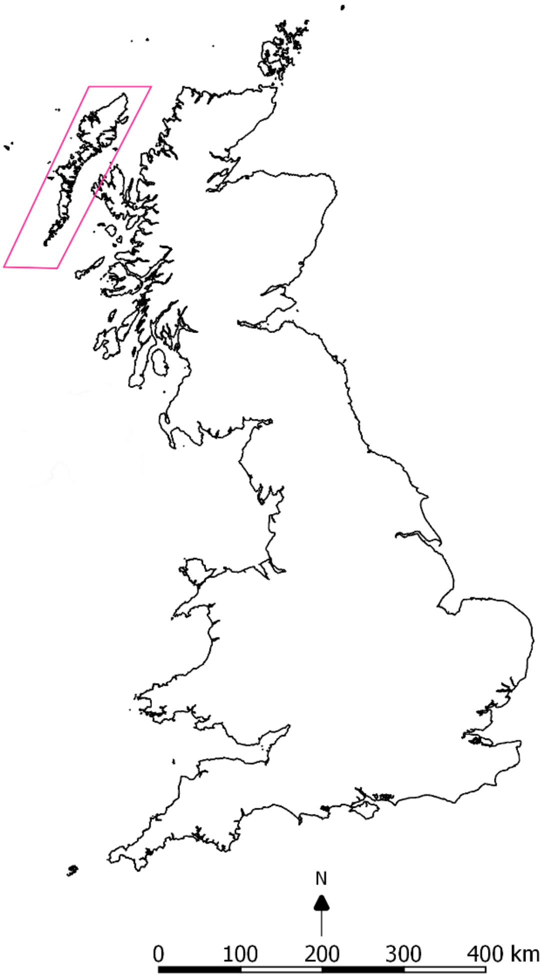


Figure 1.1: The location of the Western Isles (in pink box) in relation to Great Britain.

Much of the work that has been done on assemblages of non-marine mollusc shells from coastal blown sand environments in the Western Isles and elsewhere in Britain has taken the form of palaeoenvironmental analyses of vertical sequences, which have not included horizontal investigations of substantial archaeological layers (Thew 2003, 163). This thesis uses a combination of both approaches, and in doing so can correct some problems with the temporal fidelity of snail assemblages.

Nigel Thew was the first archaeologist to use lateral sampling of archaeological deposits for molluscan analysis in the Western Isles during the 1980s as part of the Central Excavation Unit's Farm Mounds in the Outer Hebrides project (published some time later as Thew 2003). A significant component of this project was a range of palaeoecological of bulk samples from occupation and activity areas. Through his work, significant insights were gained into site formation processes, surface stability, the arrival of new species, flooding and the use of seaweed and midden material, the latter aspect in collaboration with Celia Pain, who identified the small marine gastropods (Pain & Thew 2003). Regrettably, the bulk of the marine mollusc shell from these excavations was never analysed.

The SEARCH (Sheffield Environmental and Archaeological Research Campaign in the Hebrides) investigations began in the Western Isles in 1987, primarily on the islands of Barra and South Uist, and investigated a range of sites from earliest settlement to the nineteenth century (Parker Pearson *et al.* 2011, 60). From the outset, environmental archaeologists were a key part of the project, which involved extensive sampling of excavated contexts and an emphasis on sampling for lateral variation within house floors (Sharples 2005, 9). Of the SEARCH sites, only Howmore (H. Smith 1994) and Cille Pheadair (Walters forthcoming) have been subject to land snail analysis, while an analysis of vertical sequences at Sligeanach undertaken by John Evans has been completed posthumously as part of this study (Evans *et al.* 2012). Figure 1.2 shows the locations of some key sites, and gives the names of major inhabitated islands discussed in this thesis.

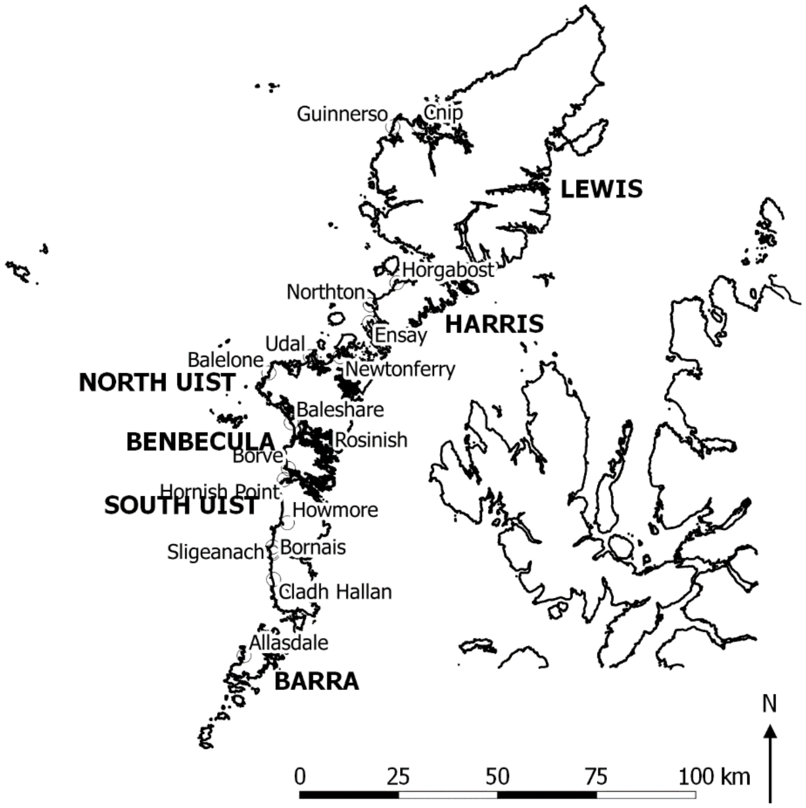


Figure 1.2: Key sites for this study in the Western Isles. The names of major islands are in bold.

1.1 CONTENTS OF THIS THESIS

This thesis takes the position that archaeomalacology, the study of mollusc shells from archaeological contexts, is a form of social archaeology. In this thesis, mollusc shells from archaeological sites have biographies not just of the animal itself, but also of the humans who shaped the ecological niche it came to occupy, or exploited that niche for the resources it offered. Behind this thesis is a desire to tackle a sizable collection of shell recovered by over twenty years of excavation, to incorporate it into a broader landscape (and seascape) synthesis, and to contribute to a social archaeology, or cultural palaeoecology, of the islands.

Chapter 2 looks at the history of molluscan analyses within archaeology and Quaternary science, and then outlines the theoretical principles and practical methods that drive archaeomalacology. Chapter 3 explores the environmental distinctiveness of the Western Isles and examines how this engenders some very specific site formation processes and offers a distinct suite of ecological niches. Chapter 4 presents a brief introduction to the archaeological context of the Western Isles molluscan assemblages of the islands. Chapter 5 discusses the research on Western Isles molluscan assemblages carried out prior to this study. Chapter 6 and 7 presents the results of molluscan analysis, with terrestrial molluscs in Chapter 6 and the analysis of marine molluscs in Chapter 7. The significance of these results is discussed in Chapter 8, and conclusions drawn in Chapter 9.

The Chapters are followed by a series of appendices with ancillary information. Appendix One presents a definitive listing of the current state of knowledge of non-marine molluscs present in the Western Isles at different times in the Holocene. Detailed tables of results from the larger assemblages are presented in Appendix Two, whilst smaller assemblages are presented in text. Appendix Three presents the results of molluscan analysis at Quoygrew, in Orkney, and Appendix Four the record of animal bone found at Ceardach Ruadh, Baile Sear. These last two Appendices contain data that fall outside of the scope of this study, but which are nonetheless useful in discussing broader trends.

The sites included range from Barra (Allasdale) across South Uist (Sligeanach, Cladh Hallan, Cill Donnain, Bornais), North Uist (Ceardach Ruadh), and onto Harris (Northton, Horgabost) and Lewis (Guinnerso). Except for Guinnerso, these are on the machair plain or at the coast within dune systems. The sites range in date from the Mesolithic and Neolithic (Northton), through the Beaker and Bronze Age (Sligeanach, Cladh Hallan, Allasdale), the Iron Age (Horgabost, Ceardach Ruadh, Cill Donnain) to the Norse period (Bornais, Guinnerso). The sites have been chosen because they are (or were at the time of writing) each in the process of being brought to publication and had archives of shell available to study. The exception is Ceardach Ruadh, which was sampled specifically for this study. As an aid to interpretation of the archaeological assemblages I have also sampled modern terrestrial molluscs along a transect from the coastal edge of the machair to a freshwater loch at Cladh Hallan.

Before setting the scene for the present research in Chapters 2, 3 and 4, there are a few details about conventions that it will be useful to note.

1.2 NAMING OF SITES

In the Western Isles, places are officially named in the local Gaelic, although variants exist both on Ordnance Survey and on the Scottish historic environment record, Canmore (Parker Pearson & Smith 2012, 9). In this thesis, I wanted to make my work as relatable to the original excavation and its archive as possible, therefore I have given sites an “excavation name”, the name under which the work was originally carried out and brought to publication. Thus, some excavations have English names (Northton, Hornish Point) while others have Gaelic names (Bornais, Cill Donnain). Numbers for Canmore entries are given where available on the first occasion a site is mentioned.

.

2 MOLLUSCS IN ARCHAEOLOGY

This chapter introduces archaeomalacology. The theory and practice of using molluscs to answer archaeological questions is presented. The chapter starts with a review of the historical development of the discipline. Typically, there has been a distinction within archaeomalacology between the analysis of marine mollusc shells (whose presence is often the result of resource acquisition, generally food), and non-marine mollusc shells (which often belong to species that were living at a site, and so reflect past ecology). Therefore, I will explore their historical development separately, beginning with non-marine molluscs.

2.1 HISTORICAL DEVELOPMENT

2.1.1. Non-marine molluscs

The possibility that snails might be useful as indicators of past environmental conditions was first suggested in the nineteenth century. Among the early advocates was General Pitt Rivers, who commented on the presence of large quantities of *Cyclostoma* (now *Pomatias*) *elegans* (O.F. Müller, 1774) and other species in the ditch during the excavation of the hillfort at Cissbury in Sussex (Evans 1972, 6); however, the true pioneer of systematic work on archaeological snail assemblages was A. S. (Alfred Santer) Kennard. He published a number of regional studies of sub-fossil Mollusca at the end of the nineteenth century and early to mid-twentieth century, occasionally in collaboration with B.B. (Bernard Barham) Woodward, a librarian at the British Museum (Natural History) (Evans 1972, 7; Preece 1990, 241). Kennard was an enthusiastic amateur who went on to be president of the Geologists' Association in 1944-45 (Preece 1990, 239), and although some of his work was purely geological, Kennard was interested in prehistoric sites, and worked on shell assemblages from Grimes Graves in Norfolk, establishing a post-glacial date for the mines, which at the time was in dispute (Evans 1969, 109; Preece 1990, 248). He also worked on assemblages from several of the sites investigated by Maud Cunnington in Wessex, such as Woodhenge, The Sanctuary, and Yarnbury Castle (Evans 1972, 7). Kennard's methodology relied on the spot sampling of shell-rich archaeological sediments, with results presented as lists of species with simple counts for each taxon, or a frequency estimate using a graded scale of terms such as 'abundant', 'common', 'frequent', and 'rare' (Evans 1972, 7).

The sub-fossil assemblages were then compared to modern populations for environmental interpretation (Evans 1972, 7).

Much of Kennard's work was conducted in the years between the two World Wars, and towards the end of this period, ecological studies of living snails based on local observations stretching back to the late nineteenth century were combined with wide-ranging reading by A.E. (Alfred Edwin) Boycott, principally in two seminal papers based on a presidential address to the British Ecological Society in 1933 (Boycott 1934, Boycott 1936). In these papers, Boycott summarised the knowledge at the time of the preferred habitats of different molluscs, noting that

"Working conchologists know that different species are found in different kinds of places and that the connection is such that experience enables them to predict from the appearance of a place what they are likely to find in it. Comparatively few attempts have been made however to systematise this knowledge..." (Boycott 1934, 1).

Boycott arranged the British fauna into groups based on habitat preferences (Fig. 2.1), hence some species could, for example, be considered primarily 'woodland' species, or primarily species of 'wet places'. This meant that there was now a more systematic possibility for matching molluscan assemblages from archaeological and Quaternary sediments to analogous modern habitats.

Kennard died in 1948, and his death was followed by a short lull in the prominence of snail analyses in archaeological reports (Evans 1972, 10), exacerbated by the growing realisation that pollen was more suitable than snails for constructing chronologies (Kerney 1977, 32). However, the groundwork laid by Boycott was seized upon by workers like B.W. (Bruce Wilfred) Sparks (1923-1988), based at Cambridge University, and Michael Kerney, based at Imperial College London. Sparks and Kerney coupled ecological knowledge with stratigraphic sampling for sub-fossil molluscs (Davies 2008, 1; Wilkinson 2011, 5). In 1963, Sparks summarised the possibilities of land snail analysis, not just for environmental reconstruction, but also for studying past climate and for dating Quaternary deposits, in a review paper for the collection *'Science in Archaeology'* (Sparks 1963, 313-323), which also included three other papers on mollusc remains (Bar-Yosef Mayer 2005, 2).

The archaeological study of snails came of age with the publication in 1972 of the first book on the subject, *Land Snails in Archaeology* by John G. Evans. Evans had been a student of the first ever Professor of Environmental Archaeology, Frederick Zeuner, at the Institute of Archaeology in London, and after Zeuner's early death in 1963 became a PhD student of Kerney (Limbrey 2005; Allen 2009, 5). Evans's PhD, '*The Stratification of Mollusca in Chalk Soils and their Relation to Archaeology*', was completed in 1967. At this time, environmental archaeology was being developed as a discipline at the Institute, which was home to a Department of the Human Environment, led at the time by the palynologist Geoffrey Dimbleby with the soil scientist Ian Cornwall (Allen 2009, 5; Grimes 1969, 276). Shortly after his PhD, Evans (1969, 111) noted that the unpopularity of land snail analysis in archaeology at the time had been due to interpretations, which had often been uncritical and biased by attempts to date deposits and draw climatic inferences. Evans moved to Cardiff in 1970 as Lecturer in Environmental Archaeology, the first such position outside of London (Allen 2009, 3).

Evans's early work did much to transform archaeologists' understanding of the prehistoric environment of Britain, for example demonstrating that early Neolithic long barrows were constructed in landscapes that had already been farmed for some time (Wilkinson 2011, 5). Since then, methods have been steadily refined, in particular through the work of Evans, Kenneth Thomas (also of the Institute of Archaeology), and Evans's and Thomas's students at Cardiff and London, notably Paul Davies and Mike Allen. In the 1980s, Allen, Thomas and Martin Bell began to explore the wider landscape around archaeological sites such as dry valleys using snail assemblages, while in the 1990s Evans, along with Davies and Diane Williams, explored numerical approaches to archaeological land snail faunas (Wilkinson 2011, 6). This refinement culminated in the publication of another book, *Snails: Archaeology and Landscape Change*, by Davies (2008).

Boycott's (1934) groupings of terrestrial fauna:

- Wet places – hygrophiles
- Dry places – xerophiles
- Houses/ gardens – synanthropes
- Anthropophobes
- Stone walls

Figure 2.1: Ecological groupings of non-marine Mollusca, after Boycott (1934)

2.1.2 Marine molluscs

Shell middens were first recognised as evidence of past human cultures by Carl Linnaeus in the 18th century, but formal archaeological investigations of marine shell deposits did not start until the nineteenth century, when the *Kjökkenmöddings* (kitchen middens) of Denmark were investigated along with shell mounds in the American states of Maine and Florida (Bar-Yosef Mayer 2005, 2). From 1848, the Danish government sponsored a research project investigating the shell mound sites of Jutland, that brought together archaeologists with geologists and biologists, and employed ethnographic comparison to contemporary Inuit populations in Greenland (Claassen 1998, 3; Rowley-Conwy 2004, 294). This led to the recognition for the first time of a period of Danish prehistory during which subsistence was not dependent on agriculture (Pollard 1994, 10). The Danish example was followed by excavations of shell midden sites around the world, including sites in mainland Scotland in the 1860s, and by the beginning of the 20th century, middens had been investigated on almost all Scottish coasts (Pollard 1994, 11-12; Pickard & Bonsall 2014, 251).

Interest in shells from archaeological excavations largely waned, however, until the late 1960s when Lewis Binford hypothesized that Late Palaeolithic populations in coastal and riverine areas of the eastern Mediterranean incorporated shellfish into their diet due to a shortage of preferred terrestrial foodstuff (Claassen 1998, 6). The *New Archaeology*, or processual archaeology, of the 1960s and 1970s attempted to increase the scientific validity of archaeology, and a new breed of specialists emerged who initially trained as archaeologists but adopted biological techniques to practice as zooarchaeologists (Pollard 1994, 28). These scientific approaches led in the 1970s to the emergence of palaeoeconomics or economic archaeology, led primarily by Eric Higgs and Claudio Vita-Finzi at the University of Cambridge. They developed theoretical approaches to resource procurement in prehistoric societies such as Site Catchment Analysis (Vita-Finzi & Higgs 1970; Pollard 1994, 28). Marine shells were among the classes of biological remains that were studied as part of palaeoeconomics, with work on large midden deposits from Australia and Scotland being carried out in the 1970s by Geoff Bailey (e.g. Bailey 1975), and on smaller sites in the Inner Hebrides and Orkney by John G. Evans in the 1970s and 1980s (e.g. Evans & Spencer 1977; Evans 1983). From the 1980s, systematic excavation and recording of shell middens was carried out on the Inner Hebrides and west coast of Scotland, at sites such as Oronsay, An Corran, Carding Mill Bay and Ulva Cave, as well as in the Forth Estuary and other sites on the east coast (Sloan 1985; Pickard & Bonsall 2014, 251).

The research areas which drove marine shell analysis in the 1970s to 1980s have been summarized by Claassen (1998, 7) as

a. dietary reconstruction
b. seasonality of shellfishing
c. palaeoenvironmental reconstruction
d. variations in types of shell-bearing sites
e. forager or collector settlement patterns
f. formation processes

The desire to address these areas lead to the development of new techniques, such as isotopic analysis and counting of growth-lines on shells (Claassen 1998, 7).

Processual archaeology came to be criticized for not giving adequate consideration to the behavioural, social and other unobservable aspects of past cultures (Hodder 1992, 73), and post-processual archaeologies emerged. Although the two approaches may be seen as being in opposition to one another, Ken Thomas (1996, 3) argued that post-processualism and processualism are equally valid and should not be mutually exclusive, preferring the 'more modest title para-processual archaeology'. John Evans returned to thinking about shell middens in the late 1990s and early 2000s, dissatisfied with the interpretation that they accumulated through incidental discard of waste. Instead, he saw the shell mounds of Oronsay in the Inner Hebrides as deliberately constructed monuments, referencing textural boundaries in the landscape (Evans 2003, 61). Indeed, he considered the word 'midden' inappropriate, with its connotation of finality and disposal, preferring instead the term 'shell-mound' (Evans 1999, 48).

Criticisms were also levelled at the oversimplification of ecological systems assumed by archaeologists working on marine shell assemblages. For example, the shape of the shells of some species of marine mollusc are highly variable, such as limpets (*Patella* spp.), and some studies have sought to link this variation to one particular environmental variable (in the case of limpets this tends to be the position the animal occupies on the shore) (Campbell 2008). This overlooks the problem of equifinality, the fact that responses to different environmental variables may have the same outcome (Campbell 2008) – in fact several stressors in the environment may affect shell shape.

Marine mollusc analysis has continued to develop, and recent methodological advances were explored by Thomas (2015a; 2015b) in a pair of review articles published in 2015. For the analysis and interpretation of marine molluscan shell these include sclerochronology and sclerochemistry, which use the accretionary structure of shells as a source of high-resolution dating and palaeoenvironmental (typically palaeotemperature) data or information about season of collection; the contribution of molluscs to diet; and their use as a raw material.

Having presented an overview of the historical development of archaeomalacology, I will now introduce the Phylum Mollusca, and the contributions they have made to archaeological knowledge.

2.2 INTRODUCTION TO MOLLUSCS

This section introduces both non-marine and marine molluscs. This is followed by a review of the principles that underlie the analysis of both non-marine and marine molluscan shell assemblages in archaeology, and the methodologies developed. Starting with a description of molluscs this section then goes on to consider the factors affecting the preservation of molluscan material in archaeological sites (preservation and taphonomy), interpretative foundations and then goes on to describe the sampling and analytical methodologies developed to address these issues. This section therefore lays the methodological foundations for the analysis of the Western Isles assemblages in this thesis.

The Phylum Mollusca is the second most populous phylum in the Kingdom Animalia (Morton 1979, 11). They occupy a wide range of habitats, from the deep ocean to dry landscapes, and include molluscs that live as parasites in other animals, and those that live underground (Morton 1979, 11). The molluscs in this study occupy environments ranging from the nearshore seabed, through intertidal habitats and coastal dunes, to terrestrial and freshwater environments, including those that are prone to drying out.

2.2.1 Characteristics of non-marine molluscs

Molluscs occupy a range of habitats on dry land and in freshwater, as well as intermediate environments that may be submerged part of the time. Molluscs which live on land belong to the Class Gastropoda, and generally have hard external shells, although slugs are gastropods which have vestigial, internal shells (Morton 1979, 49). Freshwater molluscs can include gastropods and members of another class, Bivalvia, which have hinged shells that completely enclose the animal. The hard shells of land snails consist of four layers. The outer layer, or periostracum, is composed of a protein called conchiolin. This can be expected to degrade quickly after burial (and in some cases, may be abraded during life, for example in dune systems where aeolian transport of sand presents an abrasive force (Kerney & Cameron 1979, 13)). The inner shell layers are made of calcium carbonate in the form of aragonite or calcite, sometimes both are present. The outermost calcareous layer is generally prismatic, having vertical crystals of calcite or aragonite surrounded by protein, whereas the innermost layers are laid down as sheets over a thin organic matrix (Barnes 1987, 350). Because they are calcareous, shells are frequently well-preserved in soils and sediments with high pH (this is largely in contrast to pollen).

2.2.2 Characteristics of marine molluscs

Molluscs occur in all marine and intertidal environments. There are five main classes - the Gastropoda, similar to land snails; the Bivalvia, which have a hinged shell; the scaphopods or tusk-shells which have long tusk-shaped shell; the Polyplacophora (which include chitons), which have shells made of overlapping plates; and the Cephalopoda, such as squid (Janus 1965, 12; Hayward *et al.* 1995). Cephalopods may be represented in the fossil record by cuttle bone from cuttlefish (*Sepia* spp.) or 'quills' of squid (Evans 1978, 52; Smart 1996; Claassen 1998, 16). The shell chemistry of marine gastropods is like that of non-marine snails, although the shells are often more robust. Bivalves, the other significant component of archaeological marine shell assemblages, have an outer periostracum and two to four calcareous layers made of aragonite or both aragonite and calcite. These may be deposited in prisms, in a foliated structure built of laths, or a nacreous structure built of tablets (Barnes 1987, 404). In the present study, only gastropods and bivalves were encountered.

2.2.3 Preservation of shells

The structure and composition of a living ecosystem becomes distorted after the death of the organisms within it, so that an assemblage of biological remains from a sediment sample does not represent a community of plants and animals that once lived together at the same time. At the simplest level, gravity brings all living things to the ground surface (or bed in the case of communities in the sea or other water bodies) on their death, so that what was once a three-dimensional *community* or *biocoenosis* become a two-dimensional *death assemblage* or *thanatocoenosis* (Evans 1978, 13-4; Boyd 1980, 17).

Taphonomic processes that lead to the preservation of shells may be thought of as occurring in two phases (Hunt 2009, 22). *Necrolysis* describes the processes leading to death and the breakdown of the individual. *Biostratinomy* covers the processes that lead to the burial and preservation of biological remains. Hunt (2009, 22) also introduces *palaeontology* as a third process – the sampling methodology, preparation and analysis of the researcher, which may introduce biases to assemblages.

Anticipating Hunt's (2009) addition of palaeontology to the list of taphonomic processes, Smart (1996, 249) notes an absence of cephalopod remains in British archaeological fish assemblages, and asks whether it is the case that no such remains have survived, or whether they are simply not recognised as such by archaeologists.

Necrolysis and biostratinomy may be separated by a considerable amount of time, in other cases such as rock falls, they may be simultaneous. In the case of terrestrial molluscs, necrolysis may occur when the organism dies at the end of its life cycle. They may die during aestivation or hibernation– in which case clusters of shells may be found together in cracks in walls or in the loose soil of tree throws and similar features (Hunt 2009, 22). Natural events such as flooding and wildfires may kill land snails, or they may be preyed upon by amphibians, birds, rodents, insects and humans. In most cases, predators such as birds, rodents and amphibians will choose larger, more visible, species of snail (Figure 2.1), although smaller snails may be preyed upon by a variety of invertebrates, including other molluscs.

Figure 2.2: Accumulation of snail shells that have been predated by birds, Leighton, Somerset.

Shells left on the surface are likely to disintegrate after a few years, especially if they are burnt, so biostratinomy is important for ensuring the survival of shells into the archaeological record (Hunt 2009, 23). The probability of burial is low if there is not active sedimentary deposition (Hunt 2009, 23) – although earthworm action will bring smaller shells into the soil profile, in fact sometimes worms do this deliberately (Carter 1990, 496-7). Deposition of colluvium at the foot of slopes, of overbank or marine alluvium, or of aeolian sediments (such as the machair sand) will bury shells however. Hunt (2009, 23) notes that some human activity- the digging and infilling of pits, ditches, tombs etc., building walls and piling up middens will either bury molluscs rapidly or offer suitable crevices for them to aestivate or hibernate. Within the soil profile, shells may be destroyed via solution or via fragmentation, the latter being more significant in calcareous soils (Carter 1990, 498). Using a site which had experienced little environmental change (Martin Down, Hampshire), Carter (1990) examined the annual input of shells of different species into the soil and from that and the number of shells of that species within the whole A horizon profile, calculated their mean residence in the soil before destruction. Larger species, which have robust shells and lower input numbers, had residence times much larger than smaller species (335 years for *Helicella itala* (Linnaeus, 1758), against 25.6 years for *Pupilla muscorum* (Linnaeus, 1758) and 5.7 years for *Cochlicopa lubricella* (O.F. Müller, 1774), the latter a larger shell than *Pupilla* but with a relatively fragile apex). The implication is that more robust shells in a sample are likely to represent a larger timespan than smaller and more fragile shells, due to the fragmentation of shells over time due to the effects of soil compaction, especially in biologically active soils (Carter 1990, 498-9).

Particular site formation processes are of interest in the case of shells that are deliberately transported by humans (e.g., for food). The shells recovered during an archaeological excavation do not necessarily represent all of the shells that were brought onto that site while it was in use. The processes that create the assemblage the archaeologist recovers fall into two broad categories: *accretion processes*, which result in the deposition of shell within the site; and *depletion processes* which either remove shell from the archaeological deposits on the site, or prevent shells from being deposited at the site (LaMotta & Schiffer 1999, 20).

One type of accretion process is *primary deposition*, which is the process by which objects become part of the archaeological record through being deliberately discarded as primary refuse, or accidentally as 'loss' refuse

(LaMotta & Schiffer 1999, 21). In practice, however, many occupied areas would have been subject to regular cleaning, with refuse being deposited elsewhere (LaMotta & Schiffer 1999, 21). This deliberate dumping of refuse is known as *secondary deposition*, and is the process behind the creation of archaeological features such as middens. A typical site for secondary deposition might be a midden, toft, landfill, abandoned structure, or cemetery (LaMotta & Schiffer 1999, 21). A third process is *provisional discard*, where an artefact is stored rather than discarded, presumably with the thought that it might serve a purpose at some later point (LaMotta & Schiffer 1999, 21). As LaMotta and Schiffer note (1999, 22), when looking at house structures, very little of the deposition there will have occurred during the occupation phase(s).

To take as an example the case of the European oyster (*Ostrea edulis* Linnaeus, 1758), clear evidence of depletion processes can be seen throughout history in archaeological assemblages from Britain, with the right valves tending to outnumber the cupped left valves. This trend has been attributed to a combination of both deliberate removal and discard of the right valve prior to the oyster being served on its left valve, and to taphonomic processes taking a greater toll on the left valve due to its less robust composition (Law & Winder 2009).

2.2.3 Principles (Non-marine molluscs)

As Boycott (1934; 1936) demonstrated, non-marine molluscs often favour particular habitats. By matching the sub-fossil shells to the preferred habitats of the living snails, it is hoped that some insight into the prevailing environmental conditions at the time the deposit was laid down can be gained.

In practice, this approach, which can be termed *uniformitarianist* (Bell & Walker 1992, 15; Davies 2008, 2), has serious limitations as it relies on several unsupportable assumptions. In particular, there is the assumption that the mollusc *assemblage* recovered from the ground represents a *population* of molluscs that at some point lived together. In reality, this is an extremely unlikely scenario. In life, snail populations exist in three dimensions, with some snails living on the stems of plants, and others on the ground; however, after death the assemblage is compressed into two dimensions (Davies 2008, 2, see Chapter 2.2.2). After death, various depletion processes might remove shell from the sub-fossil assemblage. These can include chemical changes to the shell because of the surrounding physical and chemical environment, and mechanical processes occurring in the soil or sediment containing the shells. Shells which were not part of the original community may also be added to the assemblage, for example by being carried into the soil in the burrows of earthworms. At the very best, the shells recovered from a sample represent shells which became sub-fossils throughout *all* the time it took the part of the deposit sampled to accumulate, and so are likely to represent a mix of the communities that existed during the period the deposit was laid down, rather than any particular community (Davies 2008, 2-3).

To address these problems, the types of deposit or feature that are sampled are limited to those that are likely to have been subject to limited mechanical disturbance, and are not likely to be derived from several source environments in the first place. This means that ploughsoils, for example, do not make good deposits for meaningful palaeoecological analyses of land snails. On the Hebridean machair, however, cultivation often relied on shallow harrowing to avoid disturbing the root mat and creating instability (H. Smith 1994, 40) so this may be less of a problem than in areas where there is deep ploughing. Context types that have been used in ecological modelling include buried soil surfaces (for example under barrows or positive lynchets), calcareous precipitates (for example tufa), fine floodplain overbank alluvium, fine lake deposits, and some lower fills of ditches and pits (Evans 1991a, 78).

Some snail species, known as *stenotopic* species (in ecology, *steno-* meaning ‘narrow’ contrasts with *eury-* meaning ‘broad’ (Odum 1959, 92)) have very narrow ecological tolerances across their whole range, in particular in environments that are subject to extremes (such as wet ground that dries out seasonally). It is likely that these species have always had limited tolerances, and so may be used as *indicator species* in palaeoecology (Evans 1991a, 75), although many of the stenotopic species are also very rare, such as *Vertigo moulinsiana,* and so have limited utility (Evans *et al.* 1992, 69). In general, however, the ecology of individual species depends on an often-complex mix of variables, which each may vary in relative importance at different times or in different localities (Thomas 1985, 140).

This problem has been overcome in palaeoecology by the observation that modern, living snails occur in associations with particular relative abundances and that distinctive assemblages of snail recur in some palaeoecological contexts (Thomas 1985, 140; Evans 1991a, 76; Evans *et al.* 1992, 65). As these tend to be limited to a single taxonomic group in palaeoecology, the term *taxocene* is preferred over community to describe these associations (Evans 1991a, 76). Taxocenes are taxonomic segments of communities, and the members of a taxocene are likely to be closely analogous, having a similar size and similar life histories, and competing over both evolutionary and ecological time (Deevey 1969, 42). Within a taxocene, interaction both between the member species (directly in terms of competition for food, and indirectly in terms of being the choice of a particular predator), and with the environment, are of fundamental importance. This means that a taxocene gives us more information about the environment than stenotopic species do (Evans 1991a, 76). To function meaningfully, the membership of a taxocene should not be too exclusive, as that would offer little advantage over assessing individual species, but also not be so inclusive as to include species that are highly non-equivalent in terms of parameters such as life history or size (Hulbert 1971, 585).

The taxocene concept does not counter the problems of habitat variation across the entire range of species however (Evans 1991a, 76), and so can only be expected to work on the local or regional scale, because climatic variation can lead to differences even when environments are otherwise similar (Evans 1991a, 76). Taxocenes should also include species that encounter one another, thus taxocenes have restricted territorial and environmental dimensions (Hulbert 1971, 585). Most work to date on taxocenes in archaeological land snail analysis has been carried out in central-southern England (Evans 1991a, Evans *et al.* 1992), and as yet no molluscan taxocenes have been described that cover the Western Isles.

2.2.4 Sampling and laboratory procedures for non-marine molluscs

As mentioned above, because of their calcareous nature shells are most readily recovered from sediments with higher pH. They may be collected by hand during excavation, although most species are too small to be seen easily by the naked eye, and so hand collection will lead to a bias towards larger shells. Conversely, larger snail shells are more easily damaged during sample processing, and so hand collection may correct biases towards smaller species in sediment sampling (Evans 1972, 43).

Where vertical sequences are being considered, sediment sampling should be continuous where possible, so that the full depth of the target deposit(s) is sequentially sampled (Davies 2008, 3). The best way to do this is to take the sample from exposed sections using a monolith tin or series of tins or bags, although with some deposits such as tufa and lake sediments this may not be possible, and so coring can be used instead (Davies 2008, 3). As well as vertical samples, lateral sampling can also be used, especially when the sampled deposit is a buried surface. Lateral sampling can give an insight into spatial variation of molluscan communities, especially as studies of modern fauna have shown that many snails respond to small-scale changes in vegetation or surface (Davies 2008, 4-5).

In the laboratory, samples should be air-dried and then a standard weight extracted. Generally, between 1-2 kilograms are sufficient, although particularly shell-rich sediments may need less (Davies 2008, 5). Evans (1972, 83) suggests from his own experimentation that a sample of between 150 and 200 shells is sufficient to reconstruct the broad composition of an archaeological fauna. Boiling water should be added to the dried sample, and the mixture stirred until the sample disaggregates. Many of the shells will float to the surface of the mixture, and can be poured off into a nest of sieves with mesh sizes 2 mm, 1 mm, and 0.5 mm (Evans 1972, 44; Davies 2008, 5). The nest of sieves can then be taken to dry in an oven, and a solution of 30% hydrogen peroxide added to the remaining residue. After the reaction has stopped, the residue can also be poured through a nest of sieves (Davies 2008, 5).

In practice, however, many snail assemblages studied in archaeology, including some used in this study, come from larger 'bulk samples' (*sensu* Dobney *et al.* 1991) which have been processed using a Siraf-style flotation tank, from which lighter contents of the sample (many seeds and snail shells) float off onto a sieve (collectively becoming the flot, or washover), while heavier elements larger than the chosen mesh size are collected on a mesh (becoming the residue, or retent). Some caution is required when reconstructing past environmental conditions based on snails recovered from flots only, as flotation introduces a bias into the mollusc assemblages. Slug plates (Limacidae), larger, rapidly uncoiling taxa (such *Cepaea hortensis* (O.F. Müller, 1774)) and species with very fragile shells (such as the Succineidae and Vitrinidae) may be under-represented or missing in flots, while small, robust (for example the *Vallonia* spp.) and slowly uncoiling species (such as *Pupilla muscorum*) may be over-represented.

Shells should be sorted under a low power binocular microscope using a fine paint brush or watch spring forceps. Identification is determined by looking at a number of morphological variables, and is best achieved by comparison with a reference collection. For British fauna, a key identification text is Kerney and Cameron (1979), while Naggs *et al.* (2014) provide a simple photographic guide. Juvenile forms are illustrated by Evans (1972). Understanding of taxonomic relationships is steadily being improved by genetic investigations, with the result that the names given in references are likely to be out of date. At the time of writing, the most current taxonomic checklist is Anderson (2008). This nomenclature has several differences from the names used in Evans (1972), Kerney and Cameron (1979), and even Davies (2008).

Counting the number of snails in a sample is not necessarily straightforward. As recovered shells are often fragmentary, a non-repeating element (NRE) should be selected to determine a minimum number of individuals (MNI) for each taxon recorded. Generally, this has been the shell apex, however experiments by Giovas (2009) showed that *a priori* selection of a NRE can lead to gross underestimation of MNI. It might, therefore, be better to count all shell fragments and then select the most frequent NRE to determine MNI.

In the present study, a variety of different sampling methods were used. Samples from Bornais, Cladh Hallan and Cill Donnain (all on South Uist) had been sieved around the time of the excavations in the 1980s, 1990s and early 2000s, using a flotation tank. The flot had been caught on a 250µm mesh sieve, and residue on a 300µm mesh sieve. Only the flots were analysed from these three sites. Similarly, material from Guinnerso (Lewis), Horgabost (Harris), Allasdale (Barra), and the first year of Northton (NT10) (Harris) was provided from flots of samples that had been processed at Durham University (Guinnerso and Northton), the University of Birmingham (Horgabost), and Wessex Archaeology (Allasdale), again caught on a 250µm mesh sieve. The vertical sequence from Northton (NT11), the modern mollusc transect at Cladh Hallan and the samples from Ceardach Ruadh (Baile Sear), were obtained as unprocessed samples, and so were sieved using the methods outlined above as part of this study.

2.2.4.1 Metrical analyses

Studies of modern fauna have shown that many snails respond to small-scale changes in vegetation or surface, and Thomas (1978) notes that such small-scale factors can lead to morphological differences between populations of the same species. This kind of variation, known as phenotypic plasticity, has been observed in *Cepaea* spp., whose colouring may be a response to environmental factors (Currey & Cain 1968) and *Cepaea nemoralis* (Linnaeus, 1758), whose size and shape (including relative size of the aperture) may be environmentally determined (Thomas 1978). *Cochlicella acuta* (O.F. Müller, 1774), a prominent species on the modern machair, also shows colour variation related to vegetation (Lewis 1965). Goodfriend (1986) reviews a number of species worldwide that show phenotypic plasticity which may have archaeological relevance – commonly shells of many species (generally larger species, in particular Helicidae) may be larger with higher rainfall, larger on high-calcium soils and smaller with higher population density, although the same change in an environmental variable may elicit a different phenotypic response from different species, for example a rise in temperature may cause some snail species to become larger, others smaller, and other species may be unaffected (Reyment 1971, 71). Despite pleas from Thomas (1978; 1985, reiterated by Evans *et al.* 1992), this remains an under-investigated area of archaeological interpretation.

Modern data on phenotypic variations are relatively common. The colour morphs of *Cepaea hortensis*, *Helicella itala* and *Arianta arbustorum* (Linnaeus, 1758), at coastal sites in northern Scotland were investigated by Cain *et al*. (1969). Shell size in *Candidula intersecta* (Poiret, 1801), *Cochlicella acuta* and *Helicella itala* on sand dunes on Coll in the Inner Hebrides was investigated by Tattersfield (1981), where he found a negative relationship in all three species between shell size and population density.

In the present study, the opportunity was taken to measure a small assemblage of *Cepaea hortensis* shells which were found amongst assemblages of marine shell in the >10mm fraction of samples from Norse period Mound 2, Bornais. Measurements were taken following Thomas (1978, Figure 5), and the number of bands visible on the shell were counted. No attempt was made to investigate colouration of shells, as colour pigments reside in the periostracum of shells, which is protein-based and tends to be abraded or decayed on sub-fossil shells.

2.2.5 Sampling and laboratory procedures for marine molluscs

Marine shells can give information about exploitation of shellfish for food, or may have been used as raw materials or as decorative objects. The shells themselves, especially exotic species, may also have been kept and curated as curios (e.g. Gerrard 2007). They can help reconstruct trade networks. Being able to recognise the habitat requirements of different species may help reconstruct past sea levels, although it is important to remember that shellfish have always been economically important to humans, and vast accumulations of empty shells may have been built up by ancient people. Large accumulations of shells in middens may be the only major type of evidence about some past cultures and their economies (Thomas 1981, 49). Thomas (1981, 61) notes that molluscs are among the most commonly preserved and easily identified of the marine resources exploited by humans in the past, but that their numerical superiority at some archaeological sites vastly overestimates their dietary significance as they tend to have a low meat to weight ratio.

Extensive deposits of shells can be sampled in vertical sequences, with blocks of about 1 kg of material being cut from the deposits either at intervals through the sequence or from specific contexts (Evans n.d., 11). In the case of smaller collections of shells, all shells can be counted as they are excavated, or bulk sediment samples sieved with a 2mm or 4mm mesh (Evans n.d., 11). This method was used in the case of Ceardach Ruadh, Baile Sear.

As with non-marine snails, for each gastropod taxon within a sample the most commonly represented non-repetitive element (usually the shell apex, umbilicus, or body whorl with mouth) can be counted to determine the minimum number of individuals (MNI) present (Giovas 2009). In the case of bivalves, left and right valves should be determined and the largest number used as the MNI. Shells should be identified to species by comparison to a reference collection where possible, and brief notes made on preservation of the shell, the presence of any epibiont organisms and signs of deliberate modification. For British waters, identification guides include Hayward *et al.* (1995) and, for bivalves, Oliver *et al.* (2009). As with land snails, genetic revision of taxonomy means that nomenclature is subject to frequent updating. In this study, nomenclature follows CLEMAM (Checklist of European Marine Molluscs, online at http://www.somali.asso.fr/clemam/).

In the present study, marine shells from Bornais and from Sligeanach were provided from residues of bulk sediment samples caught on a 10mm mesh sieve. Shells from Allasdale were provided from residues caught on a 1mm mesh sieve. The marine shell from Ceardach Ruadh, Baile Sear, was from samples sieved as part of the present study on a 500µm mesh sieve. As a general principle, a 1mm mesh size is suitable for marine shell analysis (see Campbell 2015), however 10mm is felt here to be adequate as smaller individual molluscs are highly unlikely to have been collected for food. Small marine molluscs were also analysed in the same samples as the non-marine molluscan assemblage. Their incidence is discussed along with non-marine shells, creating a false distinction, but one which makes sense in terms of the information they reveal. A small amount of marine shell from Bornais and Ceardach Ruadh was hand-collected during excavation. A sub-sample of the limpets and common periwinkles from Bornais was measured to look for size variation across the samples. A sub-sample of the limpets from Bornais were also assessed for recurrent patterns of breakage to assess both levels of preservation, and whether any evidence exists for shell harvesting strategies (2.2.6.1, below).

2.2.5.1 Limpets

Limpets that are found higher on the shore tend to have more pointed shells, and so the ratio between the height and length of shells found in excavations may be invoked as a proxy for the position on the shore that was being exploited (e.g. Sharples 2005; Milner & Barrett 2012). Campbell (2008, 117) makes the point that other factors may also affect limpet shell shape, however, especially decreasing dampness at constant tidal level. Limpets high on the shore may be squatter than expected if they are living in sheltered locations such as rockpools where the risk of desiccation is lower (Campbell 2007), and so local environmental conditions rather than tidal level may impact distributions of shell shape.

Usually, limpets are removed from rocks with a sharp, lateral blow, although once warned they stick tenaciously. When this happens, they may be levered off by inserting a blade under the animal. It is also possible to release their suction by breaking the shell apex (Cunliffe & Hawkins 1988, 36). The method by which a limpet has been removed may leave characteristic breaks on the shell, although post-depositional taphonomic (and peri- and post-excavation archaeological) processes may also create similar breaks. In some cases, the presence of ingrained dirt in a break may suggest that it occurred either before or during the time the shell was in the ground, although this should not be seen as completely reliable. Studying the distribution of breaks may reveal patterns that could help elucidate whether they are related to harvesting or taphonomy. Figure 2.2 presents the simple numerical zonation scheme used in this study for a sample of the limpets from Bornais.

Figure 2.3: Zonation scheme for breakage on limpet shells. Reproduced from Law 2014, p.10.

2.2.5.2 Predators and epibiont organisms

Marine ecosystems frequently contain organisms which prey on or parasitise marine molluscs, or which use the shell as a substrate on which they are attached for most of their life cycle (these are called *epibionts*, and the marine molluscs hosting them are *basibionts*). Predatory gastropods bore holes in shells through which they feed upon the animal inside. The holes are bored from the outside in, and may be distinguished from man-made holes by virtue of being parallel-sided rather than bi-conical in section (Thomas 1981, 50).

Analysing epibiont organisms may help elucidate the source location of the mollusc they have settled upon, as epibionts may have narrower ecological tolerances or biogeographic ranges than their host (see Law (2013) for a discussion of bryozoans in this context). The presence of epibiont organisms on the inside of a shell is also worthy of note as it shows that the shell was collected empty from the beach, which means that it cannot be food waste (Thomas 1981, 50).

2.2.6 Summary

Molluscs occupy a range of habitats and occur in several forms. In this study, two classes, bivalves and gastropods are present. These have calcareous shells which will be well-preserved in conditions where pH is high, as it is on the machair. A standard set of methods have been developed for the sampling and analysis of mollusc shells from archaeological sites. These include analysis of the species composition of assemblages, as well as looking at variation between individual shells within the same species. Both approaches will inform this study.

This section has described the methods of primary analysis that will be used in this study; I will now move on to introduce the statistical methods that will be used for further exploration of the molluscan data.

2.3 *STATISTICAL ANALYSES*

Statistical analyses are used in this study to explore patterns in the species composition of non-marine molluscan assemblages both within and between sites. The key techniques used are diversity indices and multivariate analyses, especially detrended correspondence analysis. These techniques, and their uses, are introduced and explored below.

There are several caveats to the use of statistical techniques. Ecological reconstructions drawn from sub-fossil assemblages are always subject to reservations, because it is death assemblages rather than actual coherent communities that are being examined (Carrott & Kenward 2001, 901). Strong correlations between species may not imply that they were part of the same ecological community in the past – they may have exploited co-occurent habitats or may have been brought together by human activity (Carrott & Kenward 2001, 901). If a close relationship between a sample and the target population is unlikely on taphonomic grounds, statistical analyses are likely to be inappropriate (Milles 1991, 1-7). Despite these problems, Carrott and Kenward (2001, 902) reported remarkable consistency between sites in the clear groupings they identified when looking at insect death assemblages.

The spread and retreat of various taxa throughout the past, and adaption to new ecological niches by individual species makes simple matching of species present to the ecological ranges of modern analogues problematic (Thomas 1985, 137, 141). Far better is an approach which makes use of associations of species which occur together. Useful approaches include ecological groups, diversity and overall abundance (Rouse & Evans 1994, 327).

2.3.1 Diversity Indices

Diversity within a statistical population, which is a biological community containing multiple species, ('*alpha'* diversity (Ringrose 1993, 280; Reitz & Wing 1999, 102) - diversity may be described on scales from alpha to epsilon, or regional, diversity) takes into account both the number of taxa present (the "*variety component*") and the relative frequency of each taxon (the "*evenness component*") (Cruz-Uribe 1988, 179). This gives us more information about the population than simply looking at the number of taxa alone. Diversity of species within a sample can be expressed in several terms. *Richness* (species richness or species abundance) is the number of taxa in a community or region. As the sampling of any community is increased, the probability of adding rare species also increases (Hulbert 1971, 577; Reitz & Wing 1999, 102), therefore diversity measures are particularly sensitive to sample size (Reitz & Wing 1999, 107). *Equitability* (V') (species equitability or species evenness) is the degree to which species are equally abundant (Hulbert 1971, 577; Reitz & Wing 1999, 105). A third possible constituent of diversity (alongside richness and evenness) is *heterogeneity* (Orton 2000, 172). The basic principle of diversity is that if all species within a population are present in the same frequency, then that population is more diverse than one where they are not; and if two populations share this property, then the one with the most species is most diverse (Ringrose 1993, 280). Studies of modern molluscan communities have found that greater diversity is associated with 'complex' habitats which can accommodate more species, such as woodlands or fens, and that that diversity indices can vary according to minor topographic, calcium or pH variation across small distances (Davies 2008, 10). It has been demonstrated for insects that species diversity relates more to plant structural diversity than plant species diversity (Magurran 1988, 83). As Thomas (1985, 143-144) demonstrates, diversity indices may be difficult to interpret – for example low diversity in an autochthonous assemblage may be the result of relatively unstable habitats which do not favour molluscs or very stable habitats which are favoured by a small number of competitively superior species.

Archaeological assemblages are usually samples from an original target population. The number of species in the sample can be denoted as *s*, and the number of species in the original target population as *S*. The true value of *S* is unknown, and the value of *s* is likely to increase along with *n*, the number of individuals in a sample, as sample size increases (Ringrose 1993, 279-280). Diversity indices may not be appropriate for comparisons between sites, or even samples at the same site, where there might be taphonomically-induced bias (Ringrose 1993, 283).

A few different techniques may be applied. Some of these more commonly seen in palaeoecological analyses are outlined below:

Shannon index (H' = information content of the sample).

The Shannon index is also known (incorrectly according to Magurran 1988, 34) as the Shannon-Weaver function. It is calculated by the formula

$$H' = -\Sigma p_i \ln p_i$$

where p_i is the proportion of individuals found in the *i*th species (that is to say in any given species). In a sample, the true value of p_i is unknown, but it is estimated as n_i/N (Magurran 1988, 35); N being the total number of individuals, n_i being the number of individuals in the *i*th species.

In this index, samples with an even distribution between taxa have a higher diversity than samples with the same number of taxa but with disproportionately high abundance of a few taxa (Reitz & Wing 1999, 105). More taxonomic categories lead to greater diversity values when samples show the same degree of equitability in abundance. Equitability may be calculated by the formula

$$V'=H'/\ln S$$

where H'= Shannon index and S = the number of species in the community (Reitz and Wing 1999, 105). Equitability close to 1.0 shows equal abundance of taxa.

Ringrose (1993, 281) comments, however, that in fact the Shannon index depends very heavily on the most abundant species, and that low abundance species-rich assemblages may have similar values to others if there are similar proportions of more abundant species. Gordon and Ellis (1985, 155) note that the measure was derived from Information Theory and rests on the assumption that organisms act as "channels" for the free flow of "information". In fact, they argue, if information can be equated with food, most organisms will act to prevent its movement. Evans and Williams (1991, 117) note, however, that because the Shannon index considers the total number of species and the evenness of individuals amongst the species, it is appropriate for archaeological data as it is applicable to samples rather than whole populations.

Simpson's Index (D)

Simpson's Index of Concentration is a measure of dominance, that is to say that it is heavily dependent on the abundances of the commonest species rather than providing a measure of species richness (Magurran 1988, 39). It measures the 'evenness' of the community from 0 to 1. It is calculated by

$$D=\Sigma(n_i(n_i-1)/N(N-1))$$

As D increases, diversity decreases, and so the index is usually expressed as 1 – D or 1/D (Magurran 1988, 39). Simpson's index is not very sensitive to species richness.

Brillouin index

The Brillouin index (HB) is appropriate when the randomness of a sample cannot be guaranteed (Magurran 1988, 37), and is calculated by

$$HB=\frac{ln(N!)-\sum lnn_i!}{N}$$

Differences between the Shannon and Brillouin indices arise because the Brillouin index describes only the known collection, whereas the Shannon index estimates the diversity of the unsampled as well as the sampled portion of the community (Magurran 1988. 37). Davies and Grimes (1999, 1061) applied a test of statistical significance, Student's t-test, to the difference between the mean Shannon and Brillouin indices for molluscan samples from a carrier and a drain in a relic water meadow system, finding a statistically significant difference, with p (the probability that the difference between the two means was due to chance) = 0.0001 for both indices.

Walker (2014) also explored the possibility of using the difference between the Shannon index and Brillouin index to assess the completeness of samples. The Brillouin index will approach the Shannon index for an infinite sample. Walker found a 'break point' difference between the two indices of 0.1, demonstrating that samples with more than 180 shells are more likely to be adequate. Nonetheless, he stresses that smaller samples are still useful guides to habitat types.

Fisher's alpha

Kenward (1978, 21) suggests that the most suitable diversity index for death assemblages is Fisher's alpha, derived implicitly from the formula

$$S=\alpha \log_e(1 + N/\alpha)$$

where S is the number of species, N the number of individuals and α the index of diversity. Fisher's alpha is relatively independent of sample sizes, and is well suited to assemblages which are subject to many random variables (Kenward 1978, 23). An index of diversity gives only the relationship between number of species and individuals. The way individuals are divided up between species ('equitability') is important. More information is included in a rank order curve (Kenward 1978, 26), which is based on absolute numbers, but numbers per unit of weight or percentage of the total assemblage can be used as well (Kenward 1978, 18). Using percentages allows a comparison between assemblages of different sizes. The flatter a rank order curve, the richer the population is in species and the more diverse the probable origin (Kenward 1978, 18-19). Even without knowing the ecology of individual species, general observations about the environment they were living in can be made (Evans & Williams 1991, 115).

2.3.2 Multivariate Analyses

Ordination techniques are descriptive techniques based on the presence/ absence of taxa within a sample, as well as upon the abundances of species (Davies 1992, 156). They can be used to discover structure or patterns within a dataset, to highlight relationships between species or samples, to summarise large datasets, to reduce noise and classify outliers, or classify samples based on their contents (Smith 2014, 182). They are designed to help describe relationships between species compositions and environmental factors (Davies 1992, 156). They are thus descriptive techniques, which help inform hypotheses about variations in the data rather than explaining the cause of the variation (Davies 1998, 48). Indirect ordination techniques such as Principal Component Analysis, Correspondence Analysis and Detrended Correspondence Analysis are suited to data from sub-fossil assemblages as they do not require measurement of the environmental factors which may control sample variation (Davies 2008, 48), whereas direct ordination techniques such as Discriminant Analysis and Canonical Correspondence Analysis measure the influence of a known variable (Smith 2014, 182).

Detrended Correspondence Analysis has been most commonly applied to land snail data. This organises data on the basis of species abundances, and so is readily applicable to archaeological situations. It presents a simplification of the different environmental factors or gradients which act on a species, by plotting each gradient along one axis (Davies 1992, 157). The *eigenvalue* of each axis quantifies how much of the variation is accounted for by that axis (Davies 1992, 157), with axis 1 lying as far from all the points as a straight line can, and axis 2 being perpendicular to axis 1, but positioned to account for as much of the remaining variation as possible (Peacock & Gerber 2008, 134). The process can continue over many axes, however in most cases the first two will account for most of the variation (Peacock & Gerber 2008, 134). Taxa will be either positive or negative along each axis, and species that respond similarly to an environmental gradient will be grouped close together, as the factor loading process for each of the axes assigns each species a score which represents a quantification of the preferred ecological optimum of the species along the environmental gradient that axis represents (Dale & Dale 2002, 268). Organising the spread of species on the graph into groups of similar behaviour is a subjective exercise (Davies 1992, 158).

The detrending procedure has the advantage over Correspondence Analysis that it corrects for artificial patterns that may occur if samples are taken along an ecological gradient by making the axes independent as well as uncorrelated (Hill & Gauch 1980, 48; Peacock & Gerber 2008, 134), it also corrects the problem in Correspondence Analysis that the distance at the ends of the ordination axis tend to be compressed relative to the middle, meaning that the relative distance between species along the axes in Correspondence Analysis does not have a consistent meaning (Hill & Gauch 1980, 50; Dale & Dale 2002, 270).

Before attempting a multivariate analysis, it may be necessary to 'clean' the dataset. Multivariate techniques are often sensitive to low snail counts and rare taxa that are only present in a few samples. Many archaeobotanists routinely eliminate samples with a seed count of less than 30 to 50, as well as taxa that only occur in less than 5% to 10% of samples (Smith 2014, 189-190). David Smith (2012, 83) similarly eliminated samples with fewer than 50 individuals and taxa that occur in less than 10% of samples in his analysis of insects from archaeological sites in London. In the present study samples containing fewer than 50 snails, obviously intrusive or residual snails (usually determined by radically different shell preservation) or taxa that are not likely to be autochthonous (marine snails in terrestrial contexts, for example), have been eliminated.

Working with Correspondence Analysis, Rousseau (1987, 296) introduced coding of his results before analysis to limit numerical variation between taxa. This required transformation of the data values to abundance classes on a logarithmic scale (base 2), giving 13 classes:

0: absence of species

1:1 to 2^1 = 1-2 individuals

2: (2^1+ 1) to 2^2 = 3-4 individuals

3: (2^2+ 1) to 2^3 = 5-8 individuals

Up to

12: (2^{11}+ 1) to 2^{12} = 2049-4096 individuals.

In each case the number of individuals is replaced by the number of the corresponding class (Rousseau 1987, 296).

One of the key strengths of ordination techniques is that they group the taxa within a sample without making any *a priori* assumptions about the ecological tolerances of each species at that particular place and time. Smith (2012, 77) makes the point that although this may sound like a circular argument, what has happened is that the archaeological record is able to be used to interpret archaeological assemblages, with modern ecology serving as a reference point.

In addition to exploring the ecology of species within samples, ordination techniques may be used to explore ecological variation between samples from the same site. At Kingsmead Bridge, Wiltshire, UK, Davies (1998) used Detrended Correspondence Analysis to do this with a vertical sequence of samples, which grouped the samples along what was interpreted as a moisture gradient, with a trend from wet conditions up to slightly drier conditions and then back to dampness.

Schembri and Hunt (2009) used a different ordination technique, Non-Metric Multidimensional Scaling (NMDS) based on a Bray-Curtis similarity matrix, on a series of samples from the Brochtorff Circle at Xagħra, Malta. Non-Metric Multidimensional Scaling differs from other ordination techniques as it does not show how species are responding to particular ecological gradients. It may be preferable to Detrended Correspondence Analysis in cases where factors other than ecological gradients (such as biogeography or species extinction) are likely to be significant, for example on islands where species diversity is likely to be low. Unlike other ordination techniques, NMDS does not calculate many different axes, rather it fits the variation to a small number of user-selected axes. It is not an eigenvalue method, so axes 1 and 2 do not account for differing amounts of variation. A matrix of pairwise similarity between samples is constructed using one of several statistical difference measures (Euclidean and Bray-Curtis are two common examples), and then plotted. Samples that are close together are thus more similar. Stress values indicate the relationship between the position of samples on the similarity matrix and their position on the ordination. Higher stress values (above 0.20) should be treated with caution.

2.3.3 Summary

A range of different statistical techniques have been developed to aid the interpretation of palaeoecological data. Diversity indices assess the components of an assemblage in relation to the number of taxa present and degree to which those taxa are evenly represented. Different indices use different algorithms to do this, and comparison between them can be revealing in relation to the range of inputs into an assemblage.

Multivariate techniques explore the relationship between species or samples by organizing them along multiple axes that account for this variation. Detrended correspondence has been most widely used in studies of non-marine molluscs.

2.4 CONCLUSIONS

The analysis of mollusc shells from archaeological contexts has a long history, and has developed from an initial practice of listing species present in a sample, to giving detailed counts, and ensuing interpretation based on species ecology and human behaviour. Archaeomalacological practice profited from the mid twentieth century theoretical trajectory of archaeology towards becoming a more empirical discipline. Increasingly numerical analyses are applied to palaeoecological problems, these may illuminate aspects of species ecology as well as taphonomic factors.

Now that I have established the analytical framework within which archaeomalacology operates, and set out the methods that will be applied in this study, I will turn my attention to the Western Isles themselves, introducing the natural environment in Chapter 3, archaeology of the islands in Chapter 4, and the work that has previously been done on archaeological mollusc shells from the islands in Chapter 5.

3 GEOLOGICAL AND ENVIRONMENTAL CONTEXT

This chapter presents the environmental factors that have influenced the distribution of molluscan fauna and constrained human ecology in the islands. The chapter starts with a general description of the islands and then examines the geology, soils, climate and vegetation history. The next section examines one particular landform, machair, in detail. Most of the sites analysed in this study lie on the machair plain and the distinctive preservational and site formation process found there are discussed. The chapter then moves on to consider the fauna of the islands, commencing with a discussion of the native fauna, followed by the description of the arrival of domestic species and the development of agriculture and animal husbandry. Finally, the range and availability of marine resources are explored.

The Western Isles are a string of islands situated some 50-80 km off the north-west coast of mainland Scotland, separated from the mainland and the Inner Hebrides by the Minch and Little Minch in the north and the Sea of the Hebrides in the south (Figure 1.1) (H. Smith 1994, 14; Boyd & Boyd 1996, 8; Hall 1996, 5). The archipelago consists of 119 named islands, only 14 of which are presently permanently inhabited (Boyd & Boyd 1996, 8). It stretches 213 km from The Butt of Lewis in the north to Barra Headin the south , and is effectively divided into two groups by the Sound of Harris (H. Smith 1994, 14). The northern group, which includes Lewis and Harris, is larger than the southern, which includes Barra, South Uist, Benbecula and North Uist. The small island group of St Kilda lies some 60 km off the west coast of the Western Isles (Fleming 2009, 137), and the Monach Isles are 10 km south west of North Uist (Randall 1974, 15).

The islands rise locally to heights over 500 m, but are low-lying on the western coast, where they are fringed by a largely stabilised sand dune system which overlies a sub-horizontal rock surface a few metres above sea level (Figure 3.1) (Dawson *et al.* 2004, 282; Dawson *et al.* 2011, 31). Harris is mountainous, Lewis gently hilly, and the southern islands generally low-lying, except for Eaval on North Uist and a chain of mountains down the east coast of South Uist. There are numerous freshwater lochs in the southern islands. The serrated coastline and network of lochs means that water is never far from any point on land (Robinson 2004, 5).

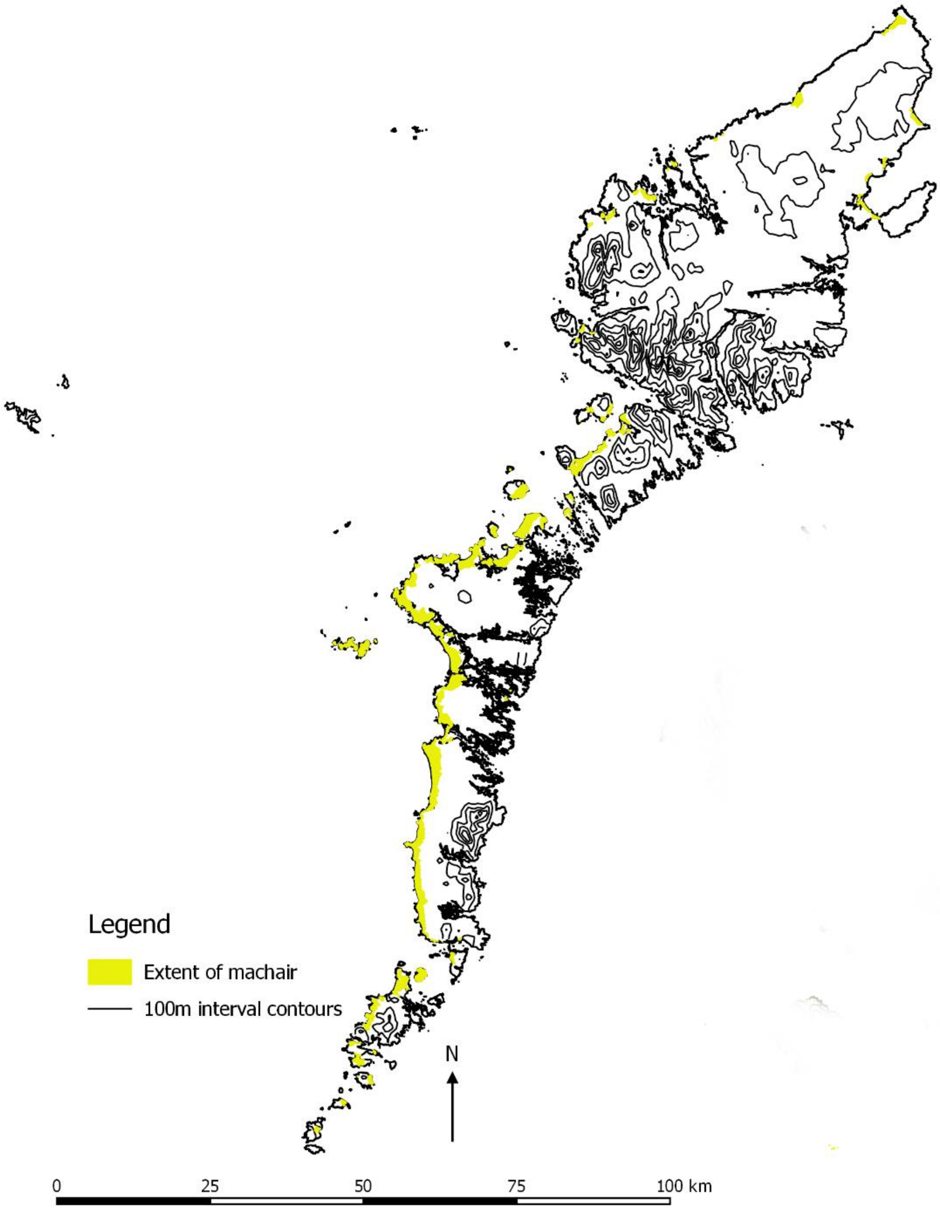
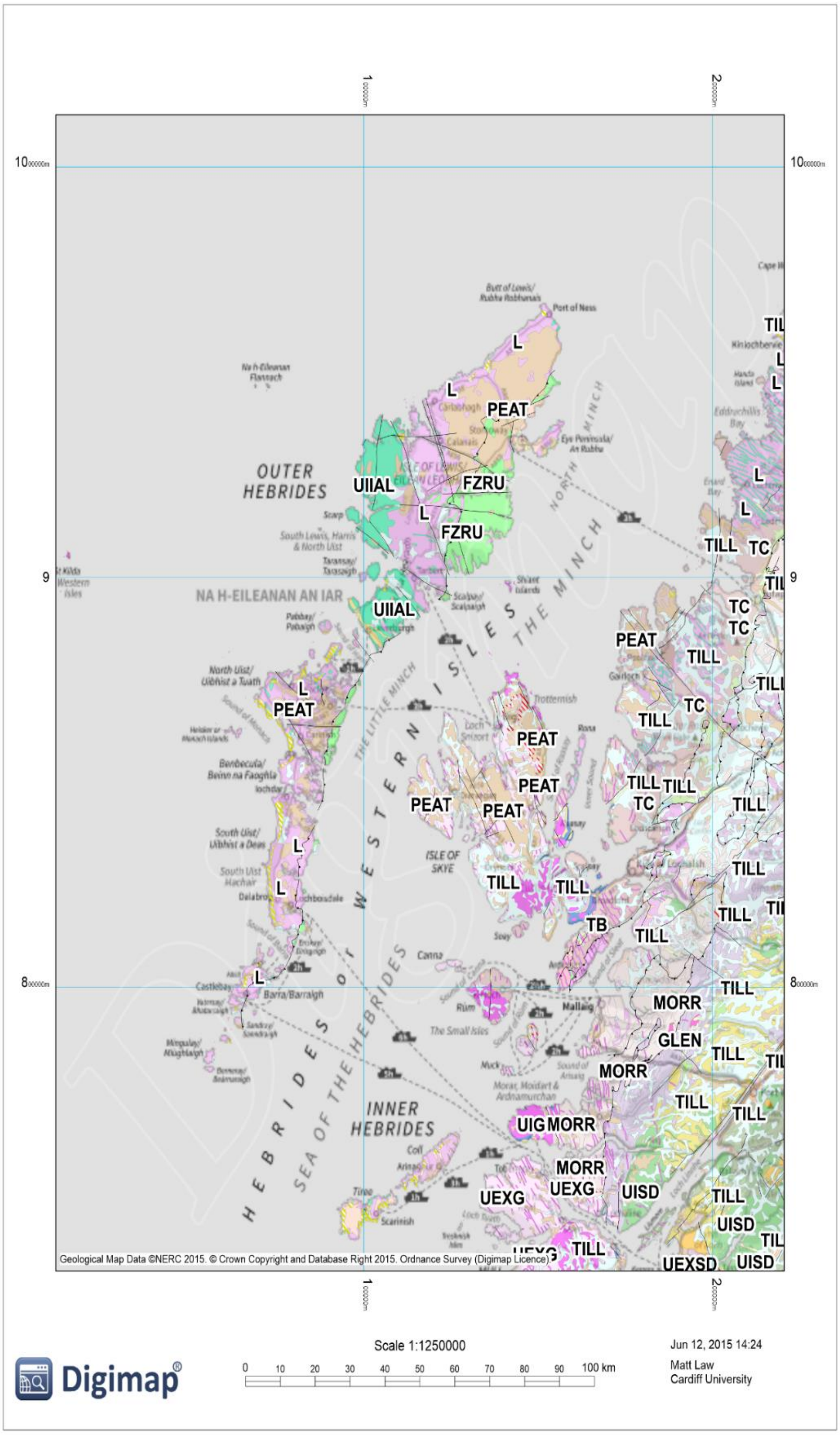


Figure 3.1: The topography of the Western Isles, showing 100 metre interval contours and the extent of the machair. Altitude data derived from DivaGIS (www.diva-gis.org).

3.1 *GEOLOGY*



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Jun 12, 2015 14:24
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Cardiff University

Geology Roam

British Geological Survey 1:625 000 (1:625 000 Geology)

Bedrock	
Appin Group (APP)	■
Ardvreck Group (ARDV)	■
Argyll Group (ARGY)	■
Durness Group (DNG)	■
Fault Zone Rocks, Unassigned (FZRU)	■
Glenfinnan Group (GLEN)	■
Grampian Group (GRAM)	■
Unnamed Igneous Intrusion, Late Silurian To Early Devonian (UISD)	■
Lewisian Complex (L)	■
Lias Group (LI)	■
Loch Eil Group (LEIL)	■
Loch Maree Group (LMR)	■
Lower Old Red Sandstone (LORS)	■
Mesoproterozoic Rocks (Undifferentiated) (AXRU)	■
Middle Jurassic Rocks (Undifferentiated) (JURM)	■
Moine Supergroup (M)	■
Morar Group (MORR)	■
Unnamed Igneous Intrusion, Neoproterozoic (UIAZ)	■
New Red Sandstone Supergroup (NRS)	■
Old Red Sandstone Supergroup (ORS)	■
Unnamed Igneous Intrusion, Ordovician To Silurian (UIIOS)	■
Unnamed Igneous Intrusion, Palaeogene (UIG)	■
Unnamed Igneous Intrusion, Palaeoproterozoic (UIIAL)	■
Scottish Coal Measures Group (CMSC)	■
Sleat Group (TB)	■
Stoer Group (TA)	■
Torridon Group (TC)	■
Unnamed Extrusive Rocks, Palaeogene (UEXG)	■
Unnamed Extrusive Rocks, Palaeoproterozoic (UEXAL)	■
Unnamed Extrusive Rocks, Silurian To Devonian (UEXSD)	■
Upper Cretaceous And Palaeogene Rocks (Undifferentiated) (PALUC)	■
Upper Jurassic Rocks (Undifferentiated) (JURU)	■
Dykes	
Unnamed Igneous Intrusion, Carboniferous To Permian (UIICP)	■
Unnamed Igneous Intrusion, Late Silurian To Early Devonian (UISD)	■
Lewisian Complex (L)	■
Unnamed Igneous Intrusion, Neoproterozoic (UIAZ)	■
Unnamed Igneous Intrusion, Palaeogene (UIG)	■
Unnamed Igneous Intrusion, Palaeoproterozoic (UIIAL)	■
Superficial Deposits	
Alluvium (ALV)	■
Blown Sand (BSA)	▨
Glacial Sand And Gravel (GSG)	■
Peat (PEAT)	■
Raised Marine Deposits (RMD)	■
Landslip (SLIP)	▨
Till (TILL)	■
Faults	
Fault At Rockhead	—
Thrust Fault	─▲─

Digimap

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Figure 3.2: Geological map of the Western Isles

Geologically, the islands are formed from an eroded platform of Lewisian gneiss which dates to the Precambrian, around 2900 Ma (Figure 3.2) (H. Smith 1994, 15; Hall 1996, 5). These rocks were repeatedly modified under conditions of high pressure and high temperature deep in the Earth's crust over a period of 1000 million years (Smith & Fettes 1979, 77). On weathering, the gneiss produces a gently undulating landscape.

On land, the only younger rocks are Permo-Triassic sandstones and conglomerates of the Stornoway basin, and a few Permo-Carboniferous and early Tertiary age igneous dykes (Hall 1996, 5; Colls & Hunter 2010, 18). Pleistocene exposures are relatively rare; however, exposures at Cleit on Barra provide evidence of slightly higher sea level than in the modern period (Gilbertson *et al*. 1996, 62). Glacial erosion during the Quaternary era has given rise to the present landscape; with evidence of scouring being evident throughout the islands (Hall 1996, 5), and till deposits visible around upland areas (Figure 3.3).

The full extent of Devensian glaciation over northern Scotland and the Hebrides is uncertain (Clark *et al.* 2004, 66), and two distinct theories have emerged. The first suggests that there was complete ice cover over Scotland and the Hebrides, while the second sees the north-east of Scotland, around Buchan, as being ice free, with the Western Isles nourishing their own ice cap (Clark *et al.* 2004, 68). It is clear from geomorphological studies that the last ice movement was west to east across the islands, except at the southern tip of Barra, where lee-side roughening of bedrock hills suggests ice sheet movement from east to west (Hall 1996, 6). Mapping of weathering limit altitudes on Harris and SE Lewis suggests that the Outer Hebrides ice cap reached a maximum altitude of 700 m (Ballantyne & Hallam 2001, 155), while on South Uist a maximum altitude of 470 m has been recorded (Ballantyne & Hallam 2001, 163).

Figure 3.3: Glacial till deposits exposed alongside the road at Langais, North Uist. September 2014.

Local sea level at the Last Glacial Maximum was some 40-50 m lower relative to its present level (Gilbertson *et al.* 1999, 440), meaning that the islands were one land mass. Relative sea level began a sharp rise after 13000 BP (Lambeck 1995, Figure 1) although even as recently as c.5164 BP, relative sea level was some 5m below present level (Ritchie 1985, 167). Neolithic monuments such as Sig More on South Uist and Geirisclett on North Uist, which are now intertidal, were originally on dry land (Henley 2005, 303; Cummings *et al.* 2012, 122). Submerged organic peaty deposits have been discovered dating to the fourth millennium BC at Borve, Benbecula some 3.7m below the mid-tidal level. These deposits would originally have been some 1.5 m above sea level (Ritchie 1985, 165). Although the general trend in Scotland is for large scale isostatic rebound after the ice load was lifted from the land, the Western Isles have undergone isostatic subsidence, in common with south-west England and the Shetlands, as materials in the Earth's crust adjusted to changes in loading on the Scottish mainland (Gilbertson *et al.* 1996).

Hudson (1991) identified five soil landscapes in the Outer Hebrides:

- Machair and associated dune systems
- Till-covered plain
- Hummocky moraines
- Rock-controlled lowland and hills
- Mountains

Much of the till plain is now covered by blanket bog (Lomax 1997, 7). Figure 3.3 shows a till exposure at Langais on North Uist photographed as part of this study.

The southern islands can be divided broadly into three zones of soil types – the *machair* of the western coasts, the acidic blacklands, and the moorland zone (H. Smith 1994, 15; Smith & Mulville 2004, 49). Alpine/ sub-alpine lithosols are found on high ground, while moorland and mountain slopes tend to be covered by blanket peat, peaty podsols, gleys, and rankers (Grattan *et al.* 1996b, 27). An additional category – the skinned lands – has been applied to areas that are now stripped by people of all but a thin layer of peat (Barber 2003, 23). The very clear longitudinal division of the islands from gently sloping coastal plains on the west to the eastern uplands would have provided important features on both the physical and the cognitive landscapes of the inhabitants (Henley 2005, 301). Figure 3.4 presents a south-facing representative section of the western part of one of the southern islands.

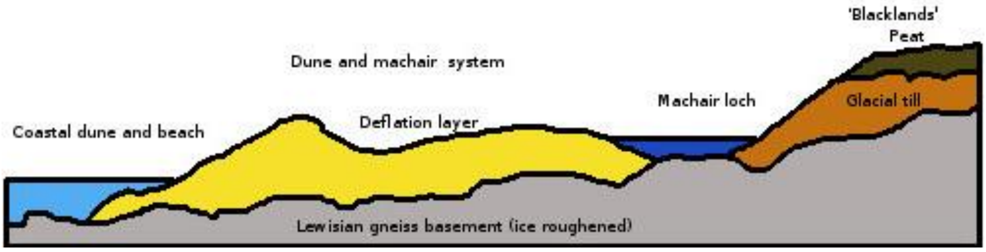

Figure 3.4. Simplified south-facing cross-section of the dune and machair system of the Uists (redrawn after Ritchie 2006).

3.2 CLIMATE

The Hebridean climate is cool, cloudy, windy and wet, although the North Atlantic drift gives the islands relatively mild winters (Manley 1979, 48; H. Smith 1994, 16). In the period 1961-90, the lowest mean minimum monthly temperature at Stornoway on Lewis was 1.4°C, obtained in February. The warmest mean maximum monthly temperature in the same period was 15.7°C, obtained in August (Roy 1997, Table 10.1). The record minimum temperature for the Western Isles is-11.1°C, recorded at Stornoway on the 20th January 1960, and the record maximum is 27.2°C, recorded on the 30th July 1948 at Benbecula (this does not appear to have been exceeded since 1997, although temperatures above 25°C were reached on 16th and 17th July 2003, and 8th August 2004) (Roy 1997, Table 10.2; WeatherOnline n.d.). Spring is slow to warm up, with the soil temperature rising very slowly above 6˚C, which is regarded as the threshold for plant growth, although there are seldom severe frosts (Manley 1979, 48).

As well as cool, the air is prevailingly humid, meaning that evaporation is slow (Manley 1979, 48). The islands lie across a latitudinal range of 56 – 58° N, the heart of middle latitude atmospheric circulation patterns and of the North Atlantic storm track (Dawson *et al.* 2004, 282; Dawson *et al.* 2011, 31). On lower ground, annual total rainfall is between 1020 – 1270 mm (Manley 1979, 53), and at Stornoway the mean annual precipitation total in the period 1961-90 was 1173mm; the highest mean monthly precipitation total (138mm) being in October, and the lowest (61mm) occurring in May (Roy 1997, 241).

The Holocene climatic history of Scotland is poorly understood in general (Tipping *et al.* 2012), however a few significant changes are known.

There was a reversal of post-glacial warming at c.6200 BC, which would have lead to a temperature depression of c2-3°C. After c.5400 BC, temperatures were 1-2°C warmer than AD 1850-1950, although temperatures were cooler between c.4200 BC - c 3600 BC (Davies *et al.* 2003; Tipping *et al.* 2012).

This means that sites in the Western Isles will have developed in a climate that is damp and cool, with few extremes, but prone to stormy winds. The humidity of the climate is likely to have been beneficial for terrestrial molluscs, which are at risk of desiccation in dry conditions.

3.3 VEGETATION HISTORY

The Late Glacial flora of open heath and grassland vegetation was gradually replaced by a mosaic of grassland, tall herb, woodland and blanket bog communities (Brayshay & Edwards 1996, 16), the timing of the arrival of which varies from site to site. Of particular note, given the current widespread lack of trees (see Figure 4.5 for present day land cover), is that there were thriving birch (*Betula*) and hazel (*Corylus*) populations and the presence of a number of other tree species, in particular oak (*Quercus*), pine (*Pinus*), and elm (*Ulmus*) in the early Holocene (Brayshay & Edwards 1996, 16). The extent of woodland varied across the islands, but it probably covered half the land area (Smith & Mulville 2004, 49), despite the nutritionally poor nature of the post-glacial soils (Colls & Hunter 2010, 22).

Today, there is little woodland on the islands, although surviving plantations such as at Northbay on Barra demonstrate that the Western Isles are not outside the present limit of tree growth (Edwards & Brayshay 2000, 310). Initially, it had been thought that the difficulty for trees migrating from the mainland, the acidic and poor quality soils, and the windy and wet climate had been deleterious to trees becoming established on the islands, however pollen records have shown that trees played a significant role in the Hebridean past (Gilbertson *et al.* 1995, 24).

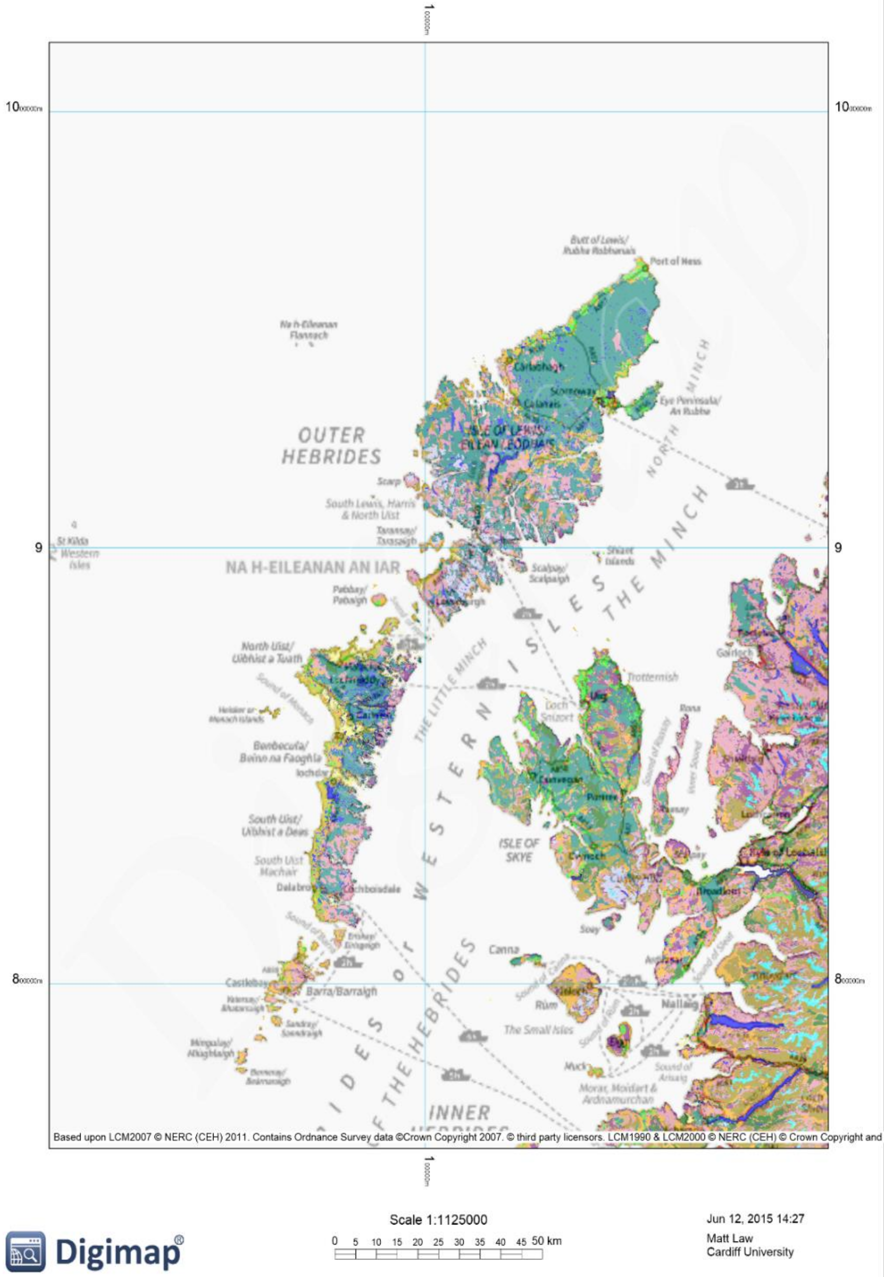

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Figure 3.5: Present day (2007) land cover in the Western Isles.

The extent of Holocene woodland in the Western Isles, and the timing and cause of its decline, are open for debate. Submerged forests are known along the coasts of the islands, as at Pabbay in the Sound of Harris, where intertidal tree stumps were recorded by Martin Martin on his 17th century tour of the islands (Elton 1938, 281). On the shore of the Quinish isthmus of Pabbay, Elton (1938, 282) recorded *in situ* birch stumps as well as fragments of bark. A survey of macrofossil tree remains from peat cuttings on Lewis revealed that willow (*Salix*) had been present on the island from 9140 to 8550 BP, birch from

7980 to 5030 BP and pine from 4870 to 3910 BP (Wilkins 1984, 241). Pine, represented by large stumps with spreading roots still in the position of growth, was mostly found across the centre of the island, with a few stands in the south, including one towards Harris (Wilkins 1984, 254). Some of the stands were quite extensive and, with preservation indicative of rapid peat accumulation, gave the "impression of an actual wood overtaken by a relatively sudden catastrophe" (Wilkins 1984, 254). Birch was the most abundant find, although it was represented only by branches and not *in situ* stumps. Willow was least common, although it was still widespread, and occurred as branches and as stumps (Wilkins 1984, 254).

Fossitt (1996) similarly examined macrofossil remains of trees from 40 sites across the Western Isles, as well as pollen profiles from lake sediment cores from Loch Buailaval Beag on Lewis and Loch a'Phuinnd in South Uist. These were accompanied by thirteen radiocarbon dates from macrofossils and ten from sediments. There were no confirmed reports of pine stumps from the Uists and Benbecula (Fossitt 1996, 176). At Loch Buailaval Beag, a relatively sudden reduction in birch-hazel woodland took place around 7900 BP along with a rise in ling (*Calluna*), grasses, sedge and other heathland species. The continued presence of some tree and shrub species in the pollen diagram suggests some localised tree growth after this time however (Fossitt 1996, 190). At Loch a'Phuinnd, a juniper (*Juniperus*)scrub with localised birch copses was present from early in the Holocene, giving way to open birch-hazel woodland after c.8500 BP. The woodland became more mixed, with pine among the species present, before beginning to decline shortly before 4000 BP. At this time, blanket bog taxa increase. Cereal pollen is first recorded at 1400 BP (Fossitt 1996, 188).

In western Lewis, Lomax (1997) examined five pollen profiles, three from small loch basins which cover the entire Holocene, and two from infilled coastal *machair* lochs which cover the late Holocene. At Loch Bharabhat, birch-hazel woodland is established at around 9600 BP and began a steady decline at around 5500 BP, being replaced by ling, heather (*Erica*), plantain (*Plantago*) and *Sphagnum*. At Loch na Muilne birch-hazel woodland is established at 9600 BP and declines from 6000 BP, and at Loch na Beinne Bige, woodland is established from 9500 BP and begins to decline at 5500 BP. The sudden loss of woodland and peat expansion recorded by Fossitt at Loch Buailaval Beag at c.7900 BP does not seem to happen elsewhere on Lewis (Lomax 1997, 225). Loch na Beinne Bige is only 5.5 km south of Loch Buailaval Beag, and yet substantial woodland cover persisted there. Declines in woodland between 7700 and 7650 BP at Loch na Muilne, Loch Bharabhat and Callanish are subsequently reversed (Lomax 1997, 225).

At Loch an t-Sìl, South Uist, birch and hazel began to be replaced by grasses and sedge at 7470 BP, with tree pollen reaching a minimum at c. 5240 BP (Brayshay & Edwards 1996, 20). At other sites, however, the decline is somewhat later, for example at Lochan na Cartach on Barra, where arboreal pollen reaches a minimum from 4140 BP (Brayshay & Edwards 1996, 20), and near Loch Portain on North Uist, where woodland ceases to be an important component of the flora from 4990 BP (Mills *et al*. 1994, 168). Writing in 1549, Dean Monro described extant woodland along the east coast of South Uist (Love 2009, 5). The decline was most likely due to climatic and pedogenic factors, for example changes in the frequency of westerly gales (Sharples *et al.* 2004, 33; Bell & Walker 1992, 156), although charcoal, implying deforestation, appears in the pollen profiles at North Locheynort, Loch an t-Sìl and Reineval (Brayshay & Edwards 1996, 17). Wilkins (1984) proposed a two-phase reduction of woodland, with a long period of decline from 9000-8000 BP initiated by peat development, and birch and pine remains from 5000-4000 BP suggesting a second period. A similar pattern was seen by Bohnke (1988 – cited in Lomax 1997) at Callanish (Lewis), where two phases of birch-hazel woodland were recorded at c. 8400 BP and again between c 5500 – 4000 BP. As Henley (2005, 319) indicates, similar patterns have been observed in the English Pennines, which might suggest that the changes were influenced by wide-ranging climatic changes in north-west Europe. The persistence of woodland into the 16th Century AD is likely to be due to the more sheltered conditions on the east coast.

Cooper (1988, 37) recounts the popular belief that Lewis has been treeless since the Viking Magnus Bare-leg (sic) burnt ‘everything that grew’ in 1098. This episode is recounted by Bjorn Krephende in the 13th Century Icelandic skaldic poet Snorri Sturluson’s Magnus Barefoot’s Saga, part of the *Heimskringla* or Chronicle of the Kings of Norway:

"In Lewis Isle with fearful blaze
The house-destroying fire plays;
To hills and rocks the people fly
Fearing all shelter but the sky.

(Sturluson tr. Laing 1996).

The combination of acidic soils, poor drainage due to the underlying gneiss, high precipitation and low evaporation has created perfect conditions for the formation of blanket bogs which cover most of the islands today. These conditions encourage the growth of acid-loving plants with high water-retaining properties, such as *Sphagnum* moss, cross-leaved heather (*Erica tetralix* L.), purple heather (*E. cinerea* L.) and ling (*Calluna vulgaris* (L.)) (Henley 2005, 307). Devegetation (especially loss of trees) affects soil moisture by reducing plant evapotranspiration, which raises the water table, reduces the soil biota and raises acidity, which favours the leaching of nutrients. Seasonal dehydration of exposed soil leads to dehydration of iron and aluminium oxides, forming subsoil hardpans which further impede drainage. Eventually infertile and waterlogged peats, heath soils and cultural podsols are created (Butzer 1982, 125-6).

Peat bogs in the islands developed as early as 9000 BP, but there is a marked expansion from Iron Age times (Gilbertson *et al*. 1999, 440). Across much of Harris, the peat has a thickness between 0.3 and 1.2 m (Colls & Hunter 2010, 22). The spread of peat may have placed significant agricultural pressures on the Iron Age inhabitants of the islands, especially when combined with the spread of wind-blown sand (Rennell 2010, 52; Armit 1992, 130; see chapter 3.4, below).

The earliest peat bogs may well have been mires rather than ombrogenic blanket bog, which develop in hollows in the landscape (Henley 2005, 307), such as the inland loch-margin peats discovered offshore at Borve, Benbecula (Ritchie 1985; Henley 2005, 308). Henley (2005, 308) argues that the hafted axe from Schulishader, Lewis, dated to 4470±95 BP (3588-2907 cal BC, OXA-3537) must have been preserved by being deposited in wet conditions, probably mire peat in a shallow pool rather than a spread of blanket peat.

The combination of acidic soils and peat bogs constrains the ability of molluscs (whose shells do not preserve well where pH is low) to act as indicators of past ecologies or human activities. A later development, the formation of the machair plain, is of particular importance to this study, however, as it leads to an increase in pH necessary for shell preservation.

3.4 THE MACHAIR

The other dominant landform on the Western Isles today is the machair, and this is the only environment in which mollusc shells are likely to be well-preserved. All but one (Guinnerso) of the sites in this study are found on the machair. The word machair is derived from '*Magh*', the Gaelic word for plain (Gilbertson *et al.* 1999, 440), a reference to the gently sloping landward aspect. In this section, I will discuss its distribution, the timing and mechanism of its formation, and the prevalent biotic and abiotic environmental conditions found there.

3.4.1 The formation and distribution of machair

The Ritchie criteria for identifying machair were published in 1976 (Ritchie 1976; Angus 2006, 7), with a seventh criterion added by Angus (2006, 7) based on Ritchie (1979). These are

> "1. a base of blown sand which has a significant percentage of shell-derived materials
>
> 2. lime-rich soils with pH values normally greater than 7.0
>
> 3. a level or low-angle smooth surface at a mature stage of geomorphological evolution
>
> 4. a sandy grassland type vegetation with long dune grasses and other key dune species having been eliminated. Core plants are red fescue *Festuca rubra*, common bird's-foot-trefoil *Lotus corniculatus*, white clover *Trifolium repens*, yarrow *Achillea millefolium*, lady's bedstraw *Galium verum*, ribwort plantain *Plantago lanceolata*, eyebright *Euphrasia officinalis*, daisy *Bellis perennis* and the moss *Rhytidiadelphus squarrosus*
>
> 5. biotic interference such as is caused by heavy grazing, sporadic cultivation, trampling and sometimes artificial drainage should be a detectable influence within the recent historical period
>
> 6. an oceanic location with a moist, cool climatic regime
>
> 7. machair plains flood or are at least marshy in winter" (Angus 2006, 8).

Angus (2006) identifies several problems with these definitions, such as the variable calcium carbonate content (and thus variable pH) of machair, and the different ratios of dunes to plain in some machair systems. He proposes a combination of a more detailed description of vegetation types and landscape forms –especially with respect to transition zones on the inland side of the machair - to determine what is machair, although acknowledges that even this is not completely satisfactory (Angus 2006, 20).

Sediment within the machair varies from being fairly coarse and/or clean to fine and/or humic. In the former case, sand is probably derived directly from foreshore deposits, while in the latter the sediments may either have undergone soil formation or be secondary deposits from older dune surfaces (Evans 1979, 16). It is primarily made up of the crushed shells of molluscs and crustaceans as well as quartz sand and other material derived from glaciofluvial deposits (Edwards *et al.* 2005, 435). The calcareous soils of the machair form part of the Frazerburgh series (Grattan *et al.* 1996b, 27).

Machair deposits are only found on the north and west coasts of Scotland, and the west coast of Ireland, with two thirds of the global machair resource being found in Scotland (Chapman *et al.* 2009, 2308). The machair environment began to form in the Bronze Age, when sea level change gradually stabilised, creating extensive dune systems along the Atlantic seaboard due to wave action and the prevailing westerly winds. The sand was mostly derived from comminuted shell, thus providing a well-drained and calcareous soil parent material, sharply in contrast to the peat-based and acidic soils otherwise found in the area. Soil formation and plant growth enabled the dunes to become stabilised, forming the machair plain.

The machair is believed to have originated as an off-shore sand bank which was subsequently blown inland. In the 1960s, William Ritchie proposed that the machair was derived from glacial sands and marine shell which were swept landwards by rising sea level in post-glacial times, from a sand bank located at the modern 40 fathom (c. 73m) mark, which was the contemporary shore line (Ritchie 1966; Mate 1992, 35), although Ritchie (1967, 163) does concede that the origin and age of the shell sand fraction are unknown. Subsequent studies, summarized by Mate (1992), have revealed that there is a carbonate-rich shell sand bed on the outer shelf of Scotland, which is Holocene in date, and which has processed eastwards under the prevailing direction of wind and waves, gradually building up the machair sands. Mate (1992) concludes that rather than forming early in the Holocene in a single event, machair sands have been accumulating throughout the Holocene.

In the Western Isles, machair deposits occur predominantly on the west coast, although on Lewis north of the Eye Peninsula, they occur on the east coast (Figure 3.1) (Ritchie 2003, 15), as they do at Rosinish on Benbecula (Vaughan 1976). The machair and associated dune cordon usually consist of a low ridge seaward and a gentle slope to landward, where it ends in peat areas, rocky outcrops and numerous small lochs (Dawson *et al.* 2004, 282; see Figure 3.4). The dunes may be up to 15 m thick (Gilbertson *et al.* 1996, 72), and 10 to 15 metres high (Gilbertson *et al.* 1999, 442). A distinction may be made between high machair, immediately leeward of the dune cordon, and low machair, the water-table controlled lower plain which extends towards the blacklands (Mate 2003, 17). The ratio of machair to dune area in the Western Isles is 7:1 (Ritchie 1979, 110).

With associated dune systems, the machair covers an area of approximately 120 square kilometres along the west coast of North Uist, Benbecula and South Uist (H. Smith 1994, 16). Across the entire Western Isles, it is some 161 km long and 4 km wide (Crawford 1978, 53). Soils on the machair have high pH values, 6.5 to 7.5 in top soils and 7.5 to 8.0 in subsoils (H. Smith 1994, 16), fresh blown sand having a calcium carbonate content in the order of 40-80% (Edwards *et al.* 2005, 435). This is by no means a uniform property of the machair, however. A survey of 30 machair sand samples from the Uists gave a mean value of 53% $CaCO_3$ and ranged from 6% to 84% (Ritchie 1974, 10). Typically, the machair has a lower $CaCO_3$ content inland as organic material in the soil increases (Randall 2006, 46). $CaCO_3$ leaches through time, although the lower specific density of comminuted shell relative to siliceous sand means that more shell is carried inland by wind which may mask the leaching process (Randall 2006, 52).

Machair soils are free-draining, and percolating water has contributed to the formation of lochs and fens in the slack behind the machair (H. Smith 1994, 16). The machair is subject to seasonal flooding, and in summer the water table may be estimated to be around 1m below ground surface. Other dune systems in Britain tend to be drier than the machair, which is typically subject to high rainfall, cool summers and mild winters (Ranwell 1974, 4).

Detrended Correspondence Analysis of data from a Scottish sand dune vegetation survey revealed two types of machair environment. ‘Core Machair’ includes most of the Western Isles machair as well as Tiree, whereas ‘Outer

Machair' includes the eastern Western Isles, western Inner Hebrides, Northern Isles, northern mainland and parts of Kintyre and Galloway (Dargie 2000). The sites studied here are thus all part of the 'Core Machair' environment.

The dune systems and machair are unstable, and particularly prone to wind erosion and sand-drift in winter (H. Smith 1994, 18). Exposures in the seaward side of the machair reveal buried soils and peat horizons which imply periods of stability (Dawson *et al.* 2004, 282; see Figure 4.6). The same processes which preserve archaeological deposits by burying them can also destroy them as storms may rapidly expose buried deposits, immediately risking their erosion (Chapman *et al.* 2009, 2308). The storm of January 11-12th, 2005 is reported to have removed up to 20 metres of coastline in some places in North Uist (Chapman *et al.* 2009, 2308; Dawson 2015, 90). Deposition can be particularly rapid: at Hornish Point, Baleshare and Balelone sets of deposits 2 - 3 m thick were deposited in time periods too short to be resolved by radiocarbon dating (Barber 2011, 50). Human activity is often detrimental to the stability of dune systems and excavation of sand for soil improvement, kelp collection, ploughing, grazing, and pulling up marram grass (*Ammophila arenaria* (L.)) for use in thatching are among the human activities which have contributed to sand instability in the Hebrides (Gilbertson *et al.* 1999, 443). Conversely, marram grass was occasionally deliberately planted to stabilise the machair (Clarke & Rendell 2009, 35).

Figure 3.6. Archaeological occupation horizon with abundant marine shell fragments buried beneath wind-blown sand and marram grass, south of Sloc Sabhaidh, Baile Sear, September 2010.

Biological remains may act as geomorphological tracers, enabling the origin of landforms to be investigated. Foraminifera are single celled protists, many species of which secrete a calcium rich-test. They are frequently preserved in the machair sand. Haslett *et al.* (2000) suggested that in fair-weather conditions, a beach would be provided with sediment from the seafloor, with larger benthic foraminifera being deposited. Under storm conditions, however there is more offshore than onshore transport of sediment, so planktonic species and smaller benthic species that are suspended in the water column are more likely to be deposited. Machair sand from samples from excavations at Cill Donnain III (South Uist) in 1989 (Parker Pearson & Zvelebil 2014) were analysed for forams (Table 3.1; Figure 3.7). The foraminifera were identified by comparison to the reference collection at Bath Spa University. The dominant foram was *Cibicidoides lobatulus* (Walker & Jacob, 1878), a small benthic shelf species, along with the very distinctive crushed shells of the gastropod *Tricolia pullus* (Linnaeus, 1758) – suggesting that although the sand was carried across the land in windy conditions, it was initially supplied to the shore in fair-weather. The foraminifera present included members of Murray's

(1991, Table 9.9) *Cibicidoides lobatulus* association, found on gravel, sand, mud and seaweed substrates at depths from 0 – 9000 metres, and temperatures from 0 to 30°C. The forams may not correspond in age with the date the sediment was laid down, however, as residence times for foraminiferid tests within sediments in highly dynamic depositional contexts may be high. Accelerator Mass Spectrometry (AMS) radiocarbon dates show samples of foraminifera were more than 1000–2000 cal years older than samples of bivalve shell dated from the same context in an archaeological shell matrix site at Thundiy, Bentinck Island, off the north coast of Australia (Nagel *et al.* 2016). Furthermore, as noted by Randall (2006, 52), shell fragments have a lower specific density than the quartz component of the sand, and so are more likely to progress landward through successive events, which may have lead to accumulations of tests of mixed ages at the site.

		Context Number	**6**	**6**	**4**
		Square	**15**	**16**	**16**
		Sample Number	**5**	**9**	**15**
		Context Description	Wheelhouse wall core	Wheelhouse wall core	Wheelhouse fills
		Period	Late MIA-Early LIA	Late MIA-Early LIA	Late MIA-Early LIA
TAXON	**Habitat**				
Cibicidoides lobatulus (Walker & Jacob, 1878)	Inner shelf, on firm substrates		56	12	22
Elphidium macellum (Fichtel & Moll, 1798)	Inner shelf		12	1	10
Homalohedra williamsoni (Alcock, 1865)	Inner shelf				1
Quinqueloculina seminula (Linnaeus, 1758)	Inner shelf				1

Table 3.1: Foraminifera from samples at Cill Donnain III (CD89). Ecological information derived from Murray (1979). Nomenclature follows WoRMS (2017). Context information from Parker Pearson & Zvelebil (2014).

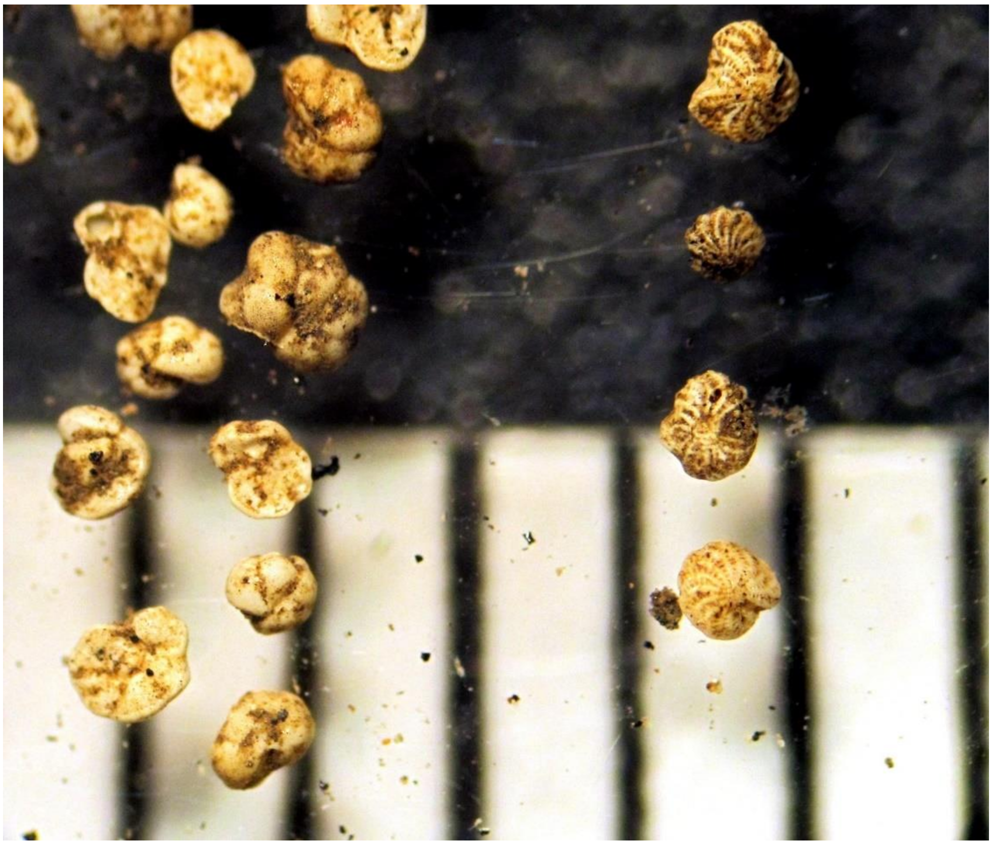

Figure 3.7: Cibicidoides lobatulus *(left) and* Elphidium macellum *(right) from Cill Donnain. Scale divisions are 1mm.*

3.4.2 Machair and archaeology

Land snails are abundant on the machair, and their shells preserve well due to the calcareous nature of the shell derived sand (Evans 1975, 120). Due to the soft and uncompacted nature of the machair sand, artefacts such as large pot sherds also survive very well (Barber 2011, 50). Occasionally windblown sand may protect features as ephemeral as hoofprints of cattle and other animals, as at Cladh Hallan (Parker Pearson *et al.* 2011, 65).

At the eastern margin of the machair, the juxtaposition of calcareous sand with acidic peat bogs – which preserve pollen, insects, wood and unburnt plant remains that do not survive on the machair – provides a rare opportunity to contrast a wide array of palaeoenvironmental indicators (Parker Pearson *et al.* 2011, 65). At Dun Vulan (CANMORE ID 9825), which was built as a broch on an islet in a freshwater loch that was later engulfed by sand, a particularly wide array of biological remains was preserved together (Parker Pearson *et al.* 2011, 66).

3.4.3 Climatic deterioration, sand invasion, storminess and volcanic activity

There are a range of markers that reveal significant impact on the Hebridean climate and local conditions during the Holocene. There are early records of increasing amounts of sand entering the sedimentary record at Port Caol, north of Borve on Barra, from c.9200BP (8802-8007 cal BC) (Edwards & Brayshay 2000, 316). The earliest records of dune formation in the Western Isles appear to be around 6000BP (Gilbertson *et al.* 1999). In Europe, this coincides with a climatic deterioration and instability in dune systems at Ballyreagh on the north coast of Northern Ireland (Wilson *et al.* 2004, Figure 6), and broadly with the commencement of dune formation at the Sefton coast in England (Provoost *et al.* 2011, Fig. 1).

There are sedimentary records of sand movement in the Western Isles around 3.7 – 3.3 kya, and again at 1.7 -1.3 kya – for example at Northton, Borve, Kallin on Grimsay, and, for the latter period, Struban Bog on North Uist and Hill Top Bog on South Uist (Clarke & Rendell 2009, 34; Edwards *et al*. 2005; Parker Pearson 2012a, 17; Orme *et al.* 2016). In the historical period, there is documentary evidence for sand invasions in North Uist in AD 1697, which deposited a body of sand 6 metres thick at the Udal in North Uist, (Gilbertson *et al.* 1999, 461). Two years earlier an Act of Parliament was passed in Scotland – the 1695 *Act for Preservation of Meadowes, Lands and Pasturages Lying Adjacent to Sand Hills* – which made the cutting of marram grass illegal (Clarke & Rendell 2009, 34-35). Historical records from the seventeenth and eighteenth centuries, such as the 1785 Anderson Report to the Lords of Treasury, the 1792 Statistical Accounts and the Clanranald Papers of 1668 all refer to areas of machair which are subject to significant movement of sand (Ritchie 1967, 172-3). Ritchie (1967, 173) is clear that over-grazing and over-cultivation of the machair resulted in the land being laid bare and subject to aeolian erosion into the twentieth century.

Sand invasion was also identified at around 0.6 – 0.2 kya (AD 1400 – 1800) using luminescence dating of both quartz and calcareous machair sands (Clarke & Rendell 2009, 35). These invasions (if they do represent different events), coincide with notable aeolian sand drift activity across Europe from AD 1500 – 1900, the time of the Little Ice Age (Clarke & Rendell 2009, 36). Further sedimentary evidence for high storminess has recently been identified in peat bogs at Hill Top Bog on South Uist, and at Struban Bog and Loch Hosta on North Uist, where there are peaks in the ignition residue (IR) following loss-on-ignition analysis, particularly at c. 780 and just after 500 cal years BP (Orme 2012; Orme *et al.* 2016). Further independent corroboration of increased storminess at this time is contained in the Na^+ (sea salt) ion concentration in the Greenland GISP2 ice core (Dawson *et al.* 2004, 281; Clarke & Rendell 2009, 37). From this record, it appears that North Atlantic storminess underwent a dramatic change at ca. AD 1400 – 1420 (Dawson *et al.* 2004, 281).

A key implication for archaeology is that between the 9th and 10th Centuries AD, climatic conditions were temperate and stable, and styles of land use may have been adopted which would not have been suitable for the deteriorating climate of the 15th Century (Dawson *et al.* 2011, 34), a less extreme version of the situation faced by the early 15th Century colonists in Greenland (e.g. Diamond 2005, 270). Viking settlements in the Western Isles may have evolved in conditions where active dune systems were not as common as they are today; although some of the dune system does have its origin in earlier Holocene storm activity (Dawson *et al.* 2011, 34). Orme *et al.* (2016, 23) found that storminess, evidenced by the increasing input of sand into bogs, increased dramatically after 1000 cal yrs BP, and that there was higher storminess during the Medieval Climate Anomaly than the Little Ice Age or the preceding 3000 years, however. This suggests that sand mobilization may have been familiar to the Norse period residents of the machair, although does not contradict the more general climatic decline of the early 15th century.

The Western Isles are subject to occasional sedimentary input from volcanic systems in Iceland, in the form of gravel or pebble-grade pieces of pumice which may wash up on beaches and were occasionally used as raw materials in tool manufacture; as well as very fine grained (< 50 μm) volcanic ash fallout from tephra clouds. This latter sediment can be related to specific eruptions, and so has the potential for use as a marker horizon for dating (Dugmore & Newton 1996, 45). Certain eruptions may also have profound climatic and environmental effects, for example the AD 1783 eruption of the Laki Fissure in Iceland, which resulted in acidic fallout that killed crops and fish on mainland Scotland (Grattan *et al.* 1996a, 53).

3.4.4 Machair site formation processes

The instability of the machair engenders some very specific archaeological site formation processes. 'Deflation' is the removal of deposits by wind, which may create features such as 'deflation hollows’. A 'deflation deposit' is formed when the material in a deposit comes to rest on an arbitrary surface rather than blowing away during episodes of deflation. This may result in artefacts of mixed date occurring together in the same deposit. Where this deposit is incorporated into a new deposit through bioturbation or fresh deposition of sand, it is known as a 'conflation deposit' (Barber 2011, 47). The heavier material left behind by deflation is known as a ‘lag deposit’ (Goldberg & Macphail 2006, 122). Lag material of different dates may be conflated after finer interstitial deposits have been blown away (Butzer 1982, 53). In the Gaelic language, terms exist such as *coileag* (a characteristically shell-shaped erosion bunker), *siaban* (light living-blown sand) and *tolamhaich* (sand that is becoming land) (Crawford 1980, 21).

3.4.5 Sand dune formation

As explored above, the machair deposits derive from dune systems, and many archaeological sites within the machair plain are now within active dune systems due to coastal erosion. In this section, I explore the formation of dune systems and the factors that cause their deflation.

The Hebridean sand dunes formed during a period of high sand availability in the shallow seas off the coast of the islands. A combination of abundant sand in shallow seas, onshore driving forces (waves and wind) and a gently sloping low-altitude coastal plain allowed for the removal of the sand from the sea to the beach, where part of it dried sufficiently to be carried by the wind beyond the reach of claw-back by the sea (Ritchie 2001, 2-3). Whereas fine sediments, such as silts and clays, can be lifted high into the air and carried for long distances, heavier sediments like sand travel relatively close to the ground (Allen 1970, 92; see Figure 3.8). They are deposited earlier than fine grained sediments, and accumulate towards the rear of the shore, forming dunes. This process of dune accretion was then followed, probably discontinuously, by a vegetation sequence through psammosere to later seral stages to a theoretical climax of deciduous woodland (Ritchie 2001, 3).

Exhaustion of the offshore sand source, or erosion due to changes in predominant currents, can isolate the dune system from its supply. Once there is no more sand being brought into the dune system from offshore, wind and waves become erosive forces. Where new sand is accreting in this scenario, this is redeposition from elsewhere in the dune system rather than primary deposition (Ritchie 2001, 4).

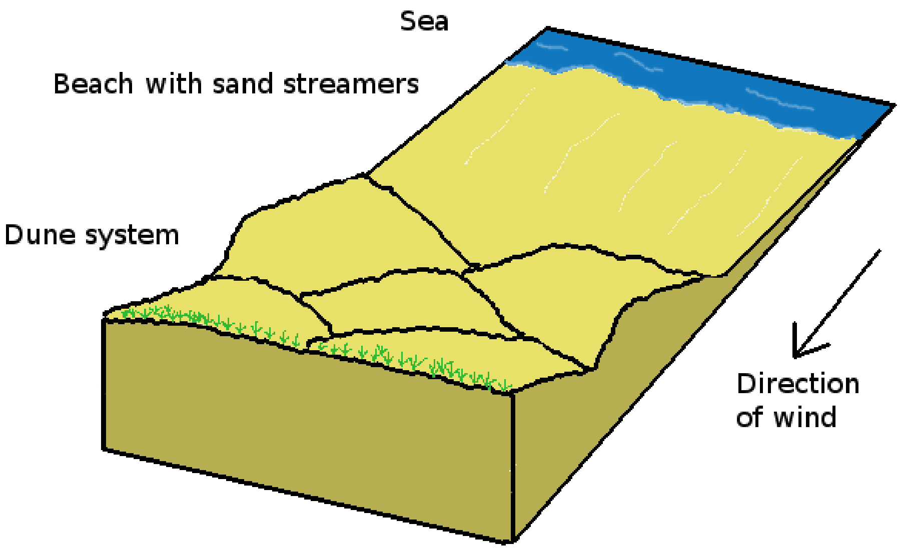

Figure 3.8: Sand dunes behind a coast affected by onshore winds

The wind carries sand by surface creep and saltation. Wind tunnel experiments have shown that saltating sand grains are initially lifted almost vertically before assuming a long and almost flat downward trajectory, eventually returning to the bed at an angle that is usually between 10° and 3°, where they may bounce up again after striking a stationary grain, or splash up other grains which are then wind transported by the same process (Allen 1970, 98).

3.4.6 Stabilisation

Sand dunes may be stabilised by vegetation – for example marram grass (*Ammophila arenaria*) (see Figure 3.6). Blown sand loses velocity in the vegetation and becoming deposited (Goldberg & Macphail 2006, 159). The calcareous fragments of mollusc shells and foraminiferid tests improve fertility on the dunes, with the result that soils develop quickly on stabilised dunes. This is accompanied by decalcification, however, especially where there are high percolation rates, with the result that older dunes may be associated with sand rankers and an acid flora (Goldberg & Macphail 2006, 160).

3.4.7 Deflation

Changes in precipitation can affect aeolian transport of sand grains, since the moisture content of the surface sand influences both the wind velocity threshold required to initiate transport and the health of dune vegetation, while changes in groundwater table levels influence the base level of deflation (wetter sand being less susceptible to wind transport) (Pye 2001, 19). Warmer temperatures may be expected to enhance the rate of aeolian transport on bare dune surfaces by drying the sand faster, conversely on vegetated surfaces they may slow it down by encouraging plant growth. Warmer, wetter periods such as the Atlantic period from 7.5 to 5 kya are associated with sand dune stabilisation and soil formation, while colder periods with low precipitation are associated with sand blowing and dune mobility, for example during the Little Ice Age (Pye 2001, 19, 21).

3.5 THE ARRIVAL OF THE HEBRIDEAN FAUNA

The origins of much of the Hebridean fauna, including the freshwater and terrestrial molluscs, is unclear. Certainly, the depth of the Minch between te Western Isles and Inner Hebrides makes it unlikely that a land bridge existed at any time during the Quaternary period (D. Smith 1996, 207). Although areas of the Western Isles may have been free from ice during the last glaciation (see Chapter 4.1), the climate would still have been cold, making the islands unviable for the temperate or boreal fauna which is now present. This means that most of the species of animal currently living in the Western Isles are post-glacial arrivals (Dinnin 1996, 179). It is likely that many of the insects now found in the islands are accidental human introductions, for example (Dinnin 1996, 180-1), although there is also the possibility that some may have rafted across the Minch on spindrift and flotsam (D. Smith 1996, 207-8). In comparison to the Scottish mainland, the insect fauna of the Western Isles is relatively low diversity, with an estimated total of around 700 species (D. Smith 1996, 207); indeed, the wild terrestrial fauna as a whole is impoverished (Smith & Mulville 2004, 49). This is a general trait in islands worldwide, recognised by island biogeography theory, that terrestrial diversity tends to decrease with distance from source populations, and with area of land available (Cox & Moore 1993, 140; Spellerberg & Sawyer 1999, 63).

The non-marine Mollusca of the Western Isles are all likely to be post-glacial arrivals. The rate of this recolonization is likely to have been slow. Late Glacial to Holocene sequences have not been studied for the Western Isles (these may not exist for molluscs in any case owing to the acidic soils). At Crudale Meadow, Orkney, however, cores from a small freshwater basin showed a complete extinction of molluscs during the Younger Dryas (12.9-11.7 kya), attributed to year-round ice cover. Molluscs reappear at 491cms, the corresponding pollen zone, dominated by *Betula* (birch) and Poaceae (grasses) with an expansion of *Corylus avellana* L. (hazel) and decline of cold-open country species, occurs at 504cms (Whittington *et al*. 2015, 118-121). The molluscan revival thus took place in a timescale that would allow hazel and birch to have been mature enough to produce pollen for several years, suggesting an interval of at least several decades.

Berry (1979, 34) states that only two of the terrestrial mammals can be asserted to have arrived without the intervention of humans: red deer (*Cervus elephas* Linnaeus, 1758) and the pygmy shrew (*Sorex minutus* Linnaeus, 1766). Mulville (2010, 44) contests this in relation to red deer, pointing out that they are unlikely to have been able to cross the Minch unaided.

Domestic mammals begin to appear in the archaeological record at Neolithic sites, with sheep (*Ovis aries* Linnaeus, 1758) and cattle (*Bos taurus* Linnaeus, 1758) present at Udal and at Northton (Smith & Mulville 2004, Table 1). The newly arrived domesticates may have contributed to the decline of trees on the islands, helping to suppress tree growth through grazing, trampling in the case of cattle, or grubbing in the case of pigs (*Sus scrofa domesticus* Erxleben, 1777) (Wood 2009, 50).

Rabbits (*Oryctolagus cuniculus* (Linnaeus, 1758)) were imported in recent times for food, but undermine the stability of the sand dune cordon and machair (Love 2009, 9), as well as extensively disturbing archaeological remains (Parker Pearson *et al.* 2011, 62). Ferrets (*Mustela putorius furo* Linnaeus, 1758), which were imported to manage the rabbit population (unsuccessfully as it turns out), and American mink (*Neovison vison* (Schreber, 1777)) which have escaped from fur farms, prey on nesting bird populations (Love 2009, 9). Hedgehogs (*Erinaceus europaeus* Linnaeus, 1758), which were introduced to South Uist as recently as 1974, are also responsible for a severe decline in ground nesting birds on the machair plain (Jackson & Green 2000). Hedgehogs are also likely to control populations of larger snail species.

3.6 TERRESTRIAL RESOURCES - AGRICULTURE AND ANIMAL HUSBANDRY

The environmental history of the islands is closely tied to human use of the land and ecological interactions, and so it is appropriate to discuss the history of agriculture, animal husbandry and the exploitation of natural resources. In contrast to much of the West Highlands, the machai*r* provides good arable and grazing land (Crawford 1978, 53). That said, on the low machair excessive wetness in winter and wind erosion when the land surface becomes dry in summer are problems for cultivation, while the high machair plain dries very quickly. Weed competition is also particularly severe on the low machair (Mate 2003, 18). Machair soils are typically deficient in phosphates, nitrates and potash, and in some areas in copper and manganese (Dickinson 1977, 5). Mineral deficiencies in the machair have implications for husbandry as well as for agriculture. A lack of cobalt can cause pine in sheep and cattle, and a lack of copper causes swayback in sheep, while oats (*Avena sativa* L.) succumb to “grey speck” through manganese deficiency (Knox 1974, 19).

The area of the blacklands, with its peaty neutral-acid soils, tendency to waterlogging and intermittent rockiness is difficult to manage, but does produce good crop returns if fertilized and well drained (Smith & Mulville 2004, 57). Unlike the machair, which becomes unproductive without fallow periods, the blacklands are able to support continual cropping (H. Smith 2000, 181).

There was a continued exploitation of wild fauna in the Neolithic, suggesting that the population supplemented a farming economy with use of wild resources (Smith & Mulville 2004, 51). Terrestrial resources appear to abruptly replace marine resources in the Neolithic, however, judging from lipid residues preserved in ceramic sherds (Cramp *et al.* 2014). It is worth noting, however, that *contra* the claim that the evidence is unequivocal (Cramp *et al.* 2014, 6) the analysis of lipid residues does not rule out the possibility that marine resources such as fish and marine molluscs were cooked without the use of pots, as they clearly were during the pre-ceramic Mesolithic. There is no suggestion that there was a delayed uptake of farming on the islands, as there is also evidence for cereal cultivation, especially naked six-rowed barley (*Hordeum vulgare* L. var. *nudum* Hook), at a number of Neolithic sites in the islands, alongside wild foods such as hazelnuts, crab apple (*Malus sylvestris* (L.))

and wild strawberry (*Fragaria vesca* L.) (Smith & Mulville 2004, 51). At Eilean Domnhuill on North Uist barley was present from 3710-3520 cal BC (4830 ±45 BP, OxA -9079) (Mills *et al.* 2004). Saddle querns, suggesting cereal processing, are also present at this site

By the Bronze Age, domestic animals dominate the assemblages, although red deer are important at Beaker period Northton where cattle and sheep decline compared to the Neolithic (Finlay 2006, 149; Smith & Mulville 2004, 51). Pigs are relatively uncommon in Bronze Age contexts (Smith & Mulville 2004, 51). Plant remains occur in low numbers at Bronze Age sites. There is evidence for cereal cultivation in the Bronze Age at Dalmore and at Barvas Machair, both on Lewis, and at Rosinish on Benbecula (Boyd 1988, 102); as well as Allt Chrisal on Barra and Cladh Hallan on South Uist (Smith & Mulville 2004, 53). In this period, there was a replacement of naked barley with hulled barley (*Hordeum vulgare* L.) (Smith & Mulville 2004, 51). Early cereal crops are accompanied by remains of weeds associated with the heavier wetter ground at the back of the low *machair* plain and the blacklands rather than drier areas, suggesting that agriculture was most practiced away from the sandy machair in the Neolithic and Bronze Age (Smith & Mulville 2004, 57).

Dairying was established by at least the 1st Millennium BC, as suggested by distinctive kill-off patterns in the assemblage of cattle bones, and the detection of milk proteins on a large number of ceramic vessels from Cladh Hallan and Dun Vulan (Craig *et al.* 2005, 101). Other domestic species became more important in the Iron Age, with horse (*Equus ferus caballus* Linnaeus, 1758) being frequent at Iron Age Udal and especially at Late Iron Age Bostadh, where they reach over 10% of the total mammal remains (Smith & Mulville 2004, 54; Serjeantson 2013, 68). Horses were historically used for traction in the islands on the light machair soils, a practice which Serjeantson (2013, 63) says may have its origin in the mid first millennium AD. There appears to be a difference in the type of animals consumed at broch and wheelhouse sites (see Chapter 4.4), with pigs being more significant at brochs such as Dun Vulan (Smith & Mulville 2004, 56).

In terms of crops, barley – usually hulled six-row barley, is the dominant cereal in the Iron Age, with lesser quantities of oats, rye and wheat (H. Smith 2000, 181). In Iron Age deposits at Alt Chrisal and Allasdale, both on Barra, barley was the only cereal recorded in archaeological samples (H. Smith 2000, 179; Wessex Archaeology 2008, 23).

In the Norse period emphasis appears to have shifted towards meat production (Parker Pearson *et al.* 2011, 68), and evidence for consumption of horse occurs at Cille Pheadair, where two bones bear cut marks (Smith & Mulville 2004, 55), and at Udal North (Serjeantson 2013, 68). New crops such as rye (*Secale cereale* L) and flax (*Linum usitatissimum* L.) appear, and more weeds associated with sandy soils start to appear in plant assemblages (Smith & Mulville 2004, 57), suggesting an increase in the range of areas used as arable land.

In the windy conditions of the Western Isles, desiccation of fields in summer can lead to wind erosion, which farmers discourage by setting their ploughs very shallow to try to preserve the root mat (Barber 2011, 50). Ploughing tends to be carried out in late March at the earliest to further reduce the risk of encouraging erosion (Owen *et al.* 2000, 156). Exposure to sea spray also damages seeds and crops (H. Smith 2012, 379).

Goats (*Capra aegagrus hircus* Linnaeus, 1758) appear at Mound 1 at Bornais in the Late Iron Age, and are present in Norse deposits at Bornais Mound 1, Bostadh, and Cille Pheadair (Serjeantson 2013, 67). Marine resources become more prominent in the Norse period, and herring (*Clupea harengus* Linnaeus, 1758) fishing becomes an important activity (Parker Pearson 2012b, 417).

Wild animal resources continued to be exploited throughout the past. Red deer bones are present from the Neolithic sites at Udal and Northton (Mulville 2010, 46), and at Cladh Hallan in the Late Bronze Age a large number of skinned and butchered juvenile red deer were recovered. These may have been 'collected' from their hiding place rather than hunted (Mulville 2010, 48).

In contrast to the relatively poor terrestrial fauna, the islands have a particularly rich birdlife, and birds have been consumed throughout the history of occupation on the islands. At Bronze Age to Iron Age Allasdale, on Barra, bird remains among food waste included guillemot (*Uria aalge* (Pontoppidan, 1763)) and large gull (Laridae sp.) (Wessex Archaeology 2008, 21). At the Iron Age and Viking settlements on Rough Island in the Shiant Islands, puffin (*Fratercula arctica* (Linnaeus, 1758)) dominated the assemblage of animal bones (Best & Mulville 2011, 88). Birds which have been exploited during the past also include extinct species such as great auk (*Pinguinis impennis* Linnaeus, 1758), which is found from the Neolithic but declines in the Iron Age (Serjeantson 2010, 148; 2013, 90-91), and the north-western palaearctic crane *(Grus primigenia* (Milne-Edwards, 1869)) (Serjeantson 2003, 150). Nine bones of Fea's petrel (*Pterodroma feae* (Salvadori, 1899)), whose closest breeding ground today is the Desertas Islands near Madeira, were found at Udal in Late Iron Age and Norse deposits (Serjeantson 2013, 90). Bird bone impressions are also found on pottery until the post-medieval period in the Outer Hebrides (Best & Mulville 2011, 91).

Initial work on herbivore carbon and nitrogen isotope ratios reveals that cattle, sheep and red deer in the Western Isles do not have a substantially higher marine input (for example through use of seaweed as fodder) than other Holocene herbivores in the UK; however pigs – based predominantly on Late Iron Age animals – show a trophic-level increase in $\delta\ ^{13}$C and $\delta\ ^{15}$N ratios, suggesting either a mixture of isotopic signal in the plant materials they ate (e.g. seeds and forage), or consumption of some animal protein, for example scraps of meat or excrement (Mulville *et al.* 2009, 52; Jones *et al*. 2013, 506).

Important inland resources would have included peat, which may be cut and dried for use as fuel or animal bedding (Powers-Jones 1994, 42; H. Smith 2000, 179). Fresh water may have been taken from inland lochs (Powers-Jones 1994, 42). In the historic period, cattle dung was recycled through use as a fertiliser or dried and burnt as a fuel (Powers-Jones 1994, 47). Machair lochs without access to the sea support a very limited range of freshwater fish, but these include eel (*Anguilla anguilla* Linnaeus, 1758) and trout (*Salmo trutta*, Linnaeus, 1758) (R. Campbell 1977, 10). Because of relatively poor rates of recruitment, machair loch trout are short-lived, but fast-growing (R. Campbell 1977, 10). Freshwater mussels (*Margaritifera margaritifera* Linnaeus, 1758) occur in the archaeological record at Northton and are likely to have been consumed (Evans 1971, 60).

There are few mineral resources in the Western Isles, and the prevalent gneiss is a poor building material (Barber 2003, 21), which gives rise to acidic soils. These factors, together with the climate, place considerable constraints on the people who live on the islands in terms of natural resources and agricultural land. The open sea provides a source for some raw materials, for example pumice, flint and wood (Newton & Dugmore 2003; Finlay 2003; Dickson 1992).

3.7 MARINE RESOURCES

In contrast to much of north-west Europe, there was a continued importance of marine resources throughout Hebridean prehistory and into the Norse period (Smith & Mulville 2004, 56). Fish remains from Late Bronze Age and Early Iron Age contexts at Baleshare and Hornish Point include sharks, but are dominated by Gadiformes such as hake and cod (Jones 2003, 149), and Gadidae (the family which includes cod, pollock and whiting) are prominent throughout most Hebridean assemblages (Smith & Mulville 2004, 56). Fish remains become especially prominent in the Iron Age, accounting for around 40% of total bone NISP (number of identified specimens present) at Hebridean sites (this is in contrast to a slight decline in relative importance from the Bronze Age at sites in the Northern Isles) (Jones & Mulville 2015, 5). A specialised herring industry emerged in the Norse period in the later 10th century AD, but collapsed at the end of the 13th century, probably due to changing ocean temperatures (Smith & Mulville 2004, 56; Oram 2015, 12).

Marine shell assemblages are commonly dominated by limpets (*Patella* spp.), with lesser numbers of periwinkles (*Littorina littorea* (Linnaeus, 1758)), razor shells (*Ensis* sp.) and scallops (*Pecten* spp.) (e.g Wessex Archaeology 2008, 22). Shellfish represent more than an important food resource: limpets were also used for bait in fishing. In post-medieval times, limpets would have been shelled and put directly onto hooks for use as bait, or chewed or part-boiled and used for fishing from rocks with lines or with the poke-net or '*tabh*'. In some areas, limpets were crushed and spread over the sea in certain rocky areas, a type of bait known locally as *soll*. Special holes or 'leepits' would be carved off rocks to keep a supply of *soll* while fishing (Cerón- Carrasco 2005, 42). Crustaceans, especially crabs, are also readily available (Barber 2003, 23).

Seal bones are present in relatively low numbers in Neolithic contexts at Northton and at Udal, and continue to be present through the Norse period; along with Cetacea, which are absent from the Neolithic sites but present at Beaker period Northton (Smith & Mulville 2004, 50). In the Iron Age, Atlantic or grey seals (*Halichoerus grypus* (Fabricius, 1791)) which are large and relatively easy to catch are dominant on most sites, although at Pabbay the common seal (*Phoca vitulina* Linnaeus, 1758) predominates (Smith & Mulville

2004, 54). In addition to food, Cetacea provide useful raw materials. Whale bones are used structurally at both Dun Vulan and at Cille Pheadair (Mulville 2002, 40), and are often used in artefact manufacture. In fact, very few whale bones from the Western Isles are not modified (Mulville 2002, 41). The fat in whale bone also makes it a useful fuel source (Mulville 2002, 43).

The use of seaweed as animal fodder and as a fertiliser is historically attested in the Western Isles (H. Smith 1994, H. Smith 2012). Two main types of seaweed were used – tangle or ware (*Laminaria* spp.), and wrack (*Fucus vesiculosus* L.), the former being washed up in vast quantities on the west coast after winter storms (H. Smith 2012, 390-1). Seaweed is rich in nitrogen and potassium (H. Smith 2012, 390), and a recent experimental study has shown that kelp has a positive effect on germination and rooting in some crops and native plants of machair (Thorsen *et al*. 2010). It is also slow to break down, and can therefore confer some stability to the sandy machair soil which is prone to aeolian erosion (Bell 1981, 119).

The shores of sea lochs in particular are rich in fucoids such as knotted and flat wrack, which may be used as fertiliser or fodder (Barber 2003, 23). On his seventeenth-century tour of the Hebrides, Martin Martin also recorded the use of seaweed ash to preserve fish, meat and cheese (Cerón-Carrasco 2005, 33). Seaweed was sometimes used as a fertilizer in the construction of *feannagan* or lazy beds, where it was spread in parallel 1m wide strips, covered with overturned turf pared from either side, and then the newly exposed soil was spread on top of the turf and fertiliser (H. Smith 2012, 386).

From around AD 1800, the kelp industry became especially prominent in the Western Isles. Seaweed was collected, then dried and milled, before being transported to the mainland where it was used in products as diverse as toothpaste, cosmetics, perfume and nylon (Knowlton 1977, 73). This may have led to a decrease in the use of seaweed as a soil stabiliser (Mather 1980, 12). The best seaweed for the kelp industry was bubble weed (*Ascophyllum* spp.) which grows in sheltered locations on the eastern side of South Uist, rather than the tangles of *Laminaria* spp. that wash up on the west coast, although tangle was collected and dried in winter while bubble weed was cut in late spring and summer (MacLean 2012, 367).

As the Western Isles became almost treeless, water-borne timber would also have been an important marine resource (Powers-Jones 1994, 42). Much of the wood at Iron Age Dun Vulan on South Uist, Dun Bharabhat on Lewis, and much of the charcoal at Late Iron Age Mound 1 at Bornais are spruce or larch, most likely driftwood from North America (Taylor 1999; Gale 2012).

3.8 CONCLUSIONS

The Western Isles are a harsh environment compared to much of mainland Britain. It is generally wet, prone to being windy, and natural resources are scarce. The geology, predominantly gneiss, does not make a good building material, and gives rise to acidic soils. Trees are largely absent, and appear to have been so since later prehistory. The formation of the machair plain gives rise to calcareous, free draining soils, however there is a risk of aeolian deflation. As will be shown in Chapter 4, this plain has been a focus of settlement since it started forming, although it has also been almost completely abandoned, perhaps because of adverse climate. This chapter has explored the natural environment of the islands, and in combination with the archaeological background in Chapter 4, gives us context with which to reflect on the archaeomalacological analyses already undertaken in the Western Isles.

4 ARCHAEOLOGICAL BACKGROUND

Date (approximate)	**Period**
9500-4000BC	Mesolithic
4000-3500BC	Early Neolithic
3500-3000BC	Middle Neolithic
3000-2500BC	Late Neolithic
2500-1600BC	Early Bronze Age
1600-1200BC	Middle Bronze Age
1200-600BC	Late Bronze Age
600-200BC	Early Iron Age
200BC-AD400	Middle Iron Age
AD400-795	Late Iron Age/ Pictish
AD795-1266	Norse
AD1266-1600	Gaelic Lordships
AD1600-1750	Post-Medieval
AD1750-2018	Modern

Table 4.1: Archaeological periods in the Western Isles. Adapted from Parker Pearson et al. 2008, with amendments by Niall Sharples (pers. comm. 2015).

The assemblages of mollusc shells that form the focus of this study exist as part of a broader archaeology of the Western Isles, and the results will be discussed in relation to the wider narrative. This chapter summarises the known archaeology of the islands in chronological order, starting with the earliest known evidence, dating to the Mesolithic. Date ranges for archaeological periods used in this text are given in Table 4.1. All sites mentioned in this chapter are mapped in Figure 4.1.

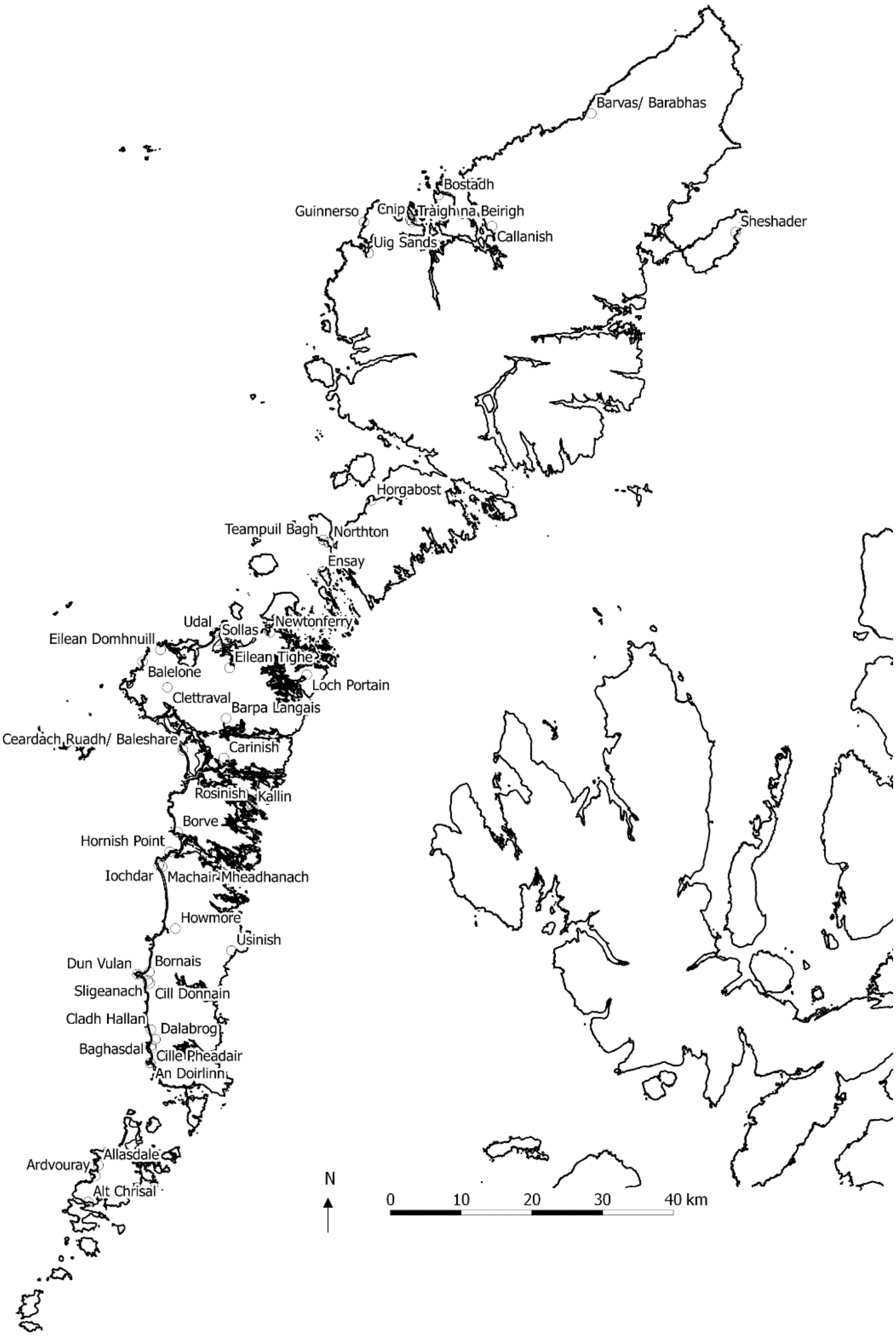

Figure 4.1: Map showing the location of sites discussed in the thesis.

4.1 RADIOCARBON DATES

Pre-2000 radiocarbon dates are available for the Western Isles, and where these have been used in support of a line of evidence, they have been recalibrated using OxCal 4.3 (Bronk Ramsey 2017), which uses the IntCal13 atmospheric calibration curve (Reimer *et al.* 2013) for terrestrial samples and CALIB Rev 7.0.4 (Stuiver *et al.* 2018), which uses the MarineCal 13 calibration curve (Reimer *et al.* 2013) for marine samples. Details of radiocarbon dates used in this thesis are presented in Table 4.1.

Site and Lab Code	**Radiocarbon result**	**Material**	**Original Calibrated Date Range (95% confidence)**	**Reference**	**New Calibrated Date Range (95% confidence)**
Allasdale, Barra NZA 28254	3342±30	Human bone	1730-1520 cal BC	Wessex Archaeology 2008	1731-1532 cal BC
Point J, Borve, Benbecula	5700±170BP	Wood	Not given	Ritchie 1966	4996-4179 cal BC
Borve, Benbecula	3750±170BP	Wood	Not given	Spencer 1975	2832-1693 cal BC
Cill Donnain III, South Uist. Layer 1-1 SUERC-37606	1735±30	Carbonised grain, *Hordeum vulgare*	cal AD 230-400	Marshall and Cook 2014	Cal AD 240-385
Cill Donnain III, South Uist. Layer 1-2 SUERC-37607	1755±30	Carbonised grain, *Hordeum vulgare*	cal AD 210-390	Marshall and Cook 2014	Cal AD 180-385
Cill Donnain III, South Uist. Layer 15-3 SUERC-38628	1430±30	Carbonised grain, barley	cal AD 570-660	Marshall and Cook 2014	Cal AD 575-657
Kinloch, Rum (Canmore ID 22202)	8590±95BP	Not given	Not given	Edwards and Mithen 1995	7940-7484 cal BC
Loch Portain, N Uist (Canmore ID 10442)	2630±110BP	Not given	Not given	Mills *et al.* 1994	1011-416 cal BC
Port Caol, Barra	9200±130BP	Not given	Not given	Edwards and Brayshay 2000	8802-8007 cal BC
* Rosinish, Benbecula (midden) (Canmore ID 10197)	3850±75BP	Marine shell	Not given	Shepherd 1980	1954-1746 cal. BC
*Rosinish, Benbecula (ploughsoil)	3920±60BP	Marine shell	Not given	Shepherd 1980	2037-1886 cal. BC
Schulishader Axe	4470±95BP	Wood	Not given	Henley 2005	3488-2907 cal BC

Table 4.2: Recalibrated radiocarbon dates used in this study.

Samples marked with an asterisk were calibrated using the Marine 13 curve.

4.1 MESOLITHIC

Despite harsh environmental conditions, the Western Isles have been continuously inhabited for at least 8000 years (Craig *et al.* 2005, 91). Evidence for Mesolithic (9500-4000 BC; Table 4.1) occupation is scarce, however. Many of the post-glacial beaches of the islands, which may have been centres for Mesolithic marine exploitation, have been submerged by a rise in relative sea level, which is a combination in the Western Isles of both eustasy and isostasy (Sharples *et al.* 2004, 33; Gilbertson *et al.* 1996). As yet, no Mesolithic settlement has been discovered in the Western Isles, although a recently excavated site at Northton on Harris has been interpreted as a buried Mesolithic land surface with disturbed hearth deposits containing fuel remnants, lithics and food waste (Bishop *et al.* 2011;). Mesolithic sites have also been detected at Teampuil Bagh on Harris (CANMORE ID 10502) and Tràigh na Beirigh on Lewis (CANMORE ID 348338) (Church *et al.* 2011; Church *et al*. 2012) and possibly at Barpa Langais on North Uist (CANMORE ID 296389) (Holderness 2007), although analysis of the lithic assemblage suggests this might in fact be Early Neolithic (Ballin 2014).

In contrast, Mesolithic settlement is well-attested in the Inner Hebrides, the archipelago to the east of the Western Isles, for example the concentration of midden sites on Rum (Mithen 1999, 47). The earliest unequivocal evidence for human occupation in the Inner Hebrides is at Kinloch, on Rum, where Mesolithic deposits are dated to 8590±95 BP (7940-7484 cal BC) (GU 1873, quoted in Edwards & Mithen 1995). A Lower Palaeolithic handaxe is in the collections of the Museum of Island Life on Islay, where it had been miscatalogued as Neolithic, although this may well have arrived on the island as an antiquarian's collectible (Edwards & Mithen 1995, 350-1).

In this study, the Mesolithic is represented by samples from the site at Northton on Harris.

4.2 NEOLITHIC

The only Neolithic settlements on the *machair* belt in the Western Isles are at Northton on Harris and the Udal on North Uist (CANMORE ID 10325), and in both cases the original settlements on mineral soils were later engulfed by shell sand (Sharples *et al.* 2004, 33). At Northton, blown sand was stratified between two occupation horizons (Spencer 1975). At Borve, Benbecula, sand dunes cover an intertidal peat deposit, wood from which has been dated to 3750 ± 170 BP (2832-1693 cal BC)(Spencer 1975, 103). There was Neolithic settlement away from the coastal plain, however evidence for this may be difficult to detect due to its burial under the widespread peat deposits. The Neolithic site of Alt Chrisal on Barra, for example, was only discovered during excavation of a later blackhouse, a traditional type of thatched house (CANMORE ID 69639/86262) (Parker Pearson *et al.* 2011, 67). Chambered tombs are features of the high ground overlooking valleys, and are perhaps indicative of seasonal movement of animals and people between the low and high ground (Sharples *et al.* 2004, 34; see Figure 4.2). There are finds of Unstan Ware pottery at Alt Chrisal, Eilean Domhnuill (North Uist) (CANMORE ID 10069), Eilean Tighe (North Uist) (CANMORE ID 10372), An Doirlinn (South Uist) (CANMORE ID 9797), and Northton. Garrow and Sturt (2011, 67) suggest this may imply active seaborne links with the Northern Isles in the Neolithic, although the Hebridean and Orcadian Unstan Ware are not the same (Niall Sharples, pers. comm.) The Western Isles appear to have fallen within the range of a second Neolithic expansion in Scotland, most likely in the late 38th Century BC, and are lacking evidence of the earlier Carinated Bowl Neolithic (ScARF 2012, 76), although earlier settlements may yet be discovered.

In this study, the sequence of deposits from Northton on Harris encompasses the Neolithic.

Figure 4.3: The Neolithic chambered tomb at Barpa Langais, North Uist in September 2014.

4.3 BEAKER TO MIDDLE BRONZE AGE

The earliest sites on top of the *machair* sand are Beaker period (2400 - 1700 BC) settlements, preserved as low mounds, such as Iochdar on South Uist (CANMORE ID 9950) (Parker Pearson *et al.* 2011, 67). It may be that prior to this period, the *machair* was still too unstable a surface to permit extensive settlement. At Sligeanach on South Uist, the earliest features of occupation are traces of ard cultivation, but there is evidence that these cultivation soils were repeatedly buried by sand (CANMORE ID 104904) (Sharples *et al.* 2004, 35). At Rosinish on Benbecula, cultivation was apparently able to continue despite sand blow, possibly because of the use of midden material as a consolidant (CANMORE ID 10197) (Guttmann *et al.* 2005, 70). It is likely that *machair* settlement was, initially at least, seasonal and related to settlement on the blacklands (Sharples *et al.* 2004, 35). In total, eighteen Beaker and Early Bronze Age settlements are known from the Outer Hebrides (Sharples 2009, 147).

One interesting aspect of Beaker period land use is the scattering of pot sherds into the soils on the *machair*. It may be that this represents the spread of general domestic waste as manure, although an argument has been advanced for a deliberate cultural purpose to this action, the deliberate enculturation of the land through the planting of highly decorated, readily recognisable pot sherds (Sharples 2009, 156).

Middle Bronze Age occupation is elusive, and it may be that activity was centred on the blacklands, the *machair* being abandoned after the initial Beaker phase (Sharples *et al.* 2004, 35). Middle Bronze Age burials have been found at Northton, Harris, including two foetal burials and an adult from an earlier corbelled cist (Murphy *et al.* 2004, 167). From the evidence at Northton, where inhumations truncate a Beaker period settlement horizon, and similar relationships between Early-Mid Bronze Age burials and Beaker occupation at the Udal, at Cnip (Lewis) (CANMORE ID 4009), at Rosinish and at Barvas (Lewis) (CANMORE ID 4271), it appears that there is an ancestral link in the location of burial sites in the Early-Mid Bronze Age (Murphy *et al.* 2004, 169).

Early Bronze Age deposits are analysed in the current study from Sligeanach on South Uist and Allasdale on Barra (CANMORE ID 9718).

4.4 LATER PREHISTORY

The beginnings of major permanent settlement on the *machair* are in the Late Bronze Age and Early Iron Age, and at the beginning of the first millennium BC, three very substantial sites developed on the *machair* on South Uist at Machair Mheadhanach, Sligeanach and Cladh Hallan (Sharples *et al.* 2004, 37). The central roundhouse at Cladh Hallan was occupied for an especially long period, from c.1100-200 cal BC (CANMORE ID 108429) (Parker Pearson *et al.* 2005, 532). Iron Age settlement on the *machair* takes the form of *wheelhouses*, for example at Cladh Hallan and at Cnip on Lewis (Armit & Dunwell 1992, 137), although some also existed on the blacklands, such as at Usinish on South Uist (CANMORE ID 10153) and at Clettraval on North Uist (CANMORE ID 10118) (Sharples *et al.* 2004, 40). Wheelhouses are semi-subterranean roundhouses characterised by the use of stone piers as internal divisions (Sharples *et al.* 2004, 38). The largest known is at Sollas on North Uist (CANMORE ID 84337) (E. Campbell 1991). Armit (1992, 130) has suggested that the emphasis on display in settlement design might be a result of increased pressure on resources due to adverse environmental conditions, with timber, for example, wantonly displayed in roundhouses.

From the Middle Iron Age, *brochs* are also common. These are apparently single-family dwellings usually situated in lochs on the rocky ground between the *machair* and the moorland (Sharples *et al.* 2004, 39). They have tower-like proportions and a complex internal architecture. Smaller thick-walled stone structures without the specific architectural features designed for height are called *duns* (Rennell 2010, 50).

Sites and landscapes sealed by peat are likely to be better preserved than those in open, intensively farmed areas (Mills *et al.* 1994, 155), however as suggested above they are also less visible and consequently less frequently recorded. Evidence for late Bronze Age or Iron Age farming activity has been recorded on the peat near Loch Portain on North Uist, where a low stone bank overlay peat that has been radiocarbon dated to 2630 ± 110 BP (1011-416 cal BC) (CANMORE ID 10442) (Mills *et al.* 1994, 161). The precise purpose of this is uncertain as palynological evidence suggests it was not an arable field boundary, and grazing would have been very poor (Mills *et al.* 1994, 167). Approximately contemporary walls on peat have been excavated to the south of Callanish on Lewis, near Sheshader on Lewis, and at Bharpa Carinish on North Uist (Mills *et al.* 1994, 168).

Later prehistoric sites within this study are Sligeanach, Cladh Hallan and Cill Donnain on South Uist, Allasdale on Barra, Horgabost on Lewis, and Ceardach Ruadh on Baile Sear.

4.5 NORSE

The Outer Hebrides are situated along the sea route from Scandinavia to Dublin, and it is clear that contact with or provisioning from the islands was likely on Viking voyages (Sharples & Parker Pearson 1999, 43). The islands were known to the Norse as *Suðreyjar* or the Southern Islands, reflecting their position in the Norse world relative to Orkney and Shetland (Etheridge *et al.* 2014a, 6). The first Viking raids in the Western Isles began around AD 800 (Serjeantson 2013, 4), and there may be an early Viking site on Colonsay in the Inner Hebrides at Machrins dating to that time (Serjeantson 2013, 8; CANMORE ID 78317). In the Uists, Norse settlements are fairly evenly distributed across the *machair* plain, sometimes on top of Iron Age settlements, as at Bornais on South Uist (CANMORE ID 108290) (Sharples *et al.* 2004, 41). This perhaps suggests a continuity of population despite Viking colonisation (Sharples *et al.* 2004, 420). A cultural tradition of the Western Isles that continues into the Viking period involves continued occupation of houses at the same location (Sharples 2005, 6), although architecturally the houses are radically different, taking the form of longhouses rather than curvilinear structures (Parker Pearson 2012b, 417). This continuity of location is not the case at Cille Pheadair, also on South Uist (CANMORE ID 139161). Here the Norse settlement is built on top of sterile sand. The settlement there is 500 m south-southwest of two Iron Age mounds, however, and other mounds have been reported close by but subsequently lost to coastal erosion (Sharples & Parker Pearson 1999, 50).

Only two Norse settlement sites are known from Lewis, Barabhas (CANMORE ID 334733) and Bostadh, despite a preponderance of Norse place names (Etheridge *et al.* 2014b, 8). Perhaps the most iconic finds of the Western Isles are the walrus ivory Norse chessmen from Uig Sands on Lewis, probably found in 1831, although the exact timing and location of the find were kept secret (CANMORE ID 4058) (Robinson 2004; Caldwell *et al*. 2009; Etheridge *et al.* 2014a, 5). Also striking is the well-furnished burial from Ardvouray on Barra, discovered in 1862, which was associated with a standing stone that is believed to be older (CANMORE ID 9715) (Carroll *et al.* 2014, 80).

In this study, Norse period assemblages from Bornais on South Uist and Guinnerso on Lewis (CANMORE ID 109409) will be analysed.

4.6 GAELIC LORDSHIPS, POST-MEDIEVAL AND MODERN

At around the fourteenth century AD, the *machair* plain appears to have been abandoned, with both Bornais and Cille Pheadair on South Uist being deserted in the fourteenth of fifteenth century (Sharples *et al.* 2004, 42), although the settlement at Udal on North Uist continued to be occupied through the post-medieval period (Sharples *et al.* 2004, 42), becoming the dwelling place of a senior tenant known as a tacksman. This too was subsumed by sand in 1697 (Wood 2009, 79). On South Uist, Baghasdal (CANMORE ID 117871) remained inhabited until the 19th Century, and Machair Mheadhanach until the 17th Century (Parker Pearson 2012b, 419). From the fifteenth century, settlement was centred to the east of the *machair* plain. This abandonment has been attributed to a combination of climate deterioration at the onset of the Little Ice Age, and also to changing political systems, with the islands falling under the control of the Scottish crown and traditional connections with Ireland, Western Britain and Scandinavia being constrained by the new regime (Sharples *et al.* 2004, 43). Another possible factor may have been the decline of the herring trade with towns in Ireland (Sharples 2005, 196).

The abandonment was not total, however, as small structures interpreted as seasonal shelters were built within the kiln/ barn at Mound 3, Bornais; the final house at Cille Pheadair, and on Mounds 2 and 2A Bornais. These are likely to have been seasonal shelters for people watching animals grazing on the machair or for use during ploughing, sowing, weeding or harvesting of crops on the machair (Sharples 2005, 196). The shelter within the kiln/ barn on Mound 3 showed no evidence for occupation however, and it may be that these structures served as a symbol of remembrance for the displaced people now living on the blacklands (Sharples 2005, 196).

Settlement eventually returned to machair, with modern crofts and houses found along the plain, perhaps most notably the township of Dalabrog on South Uist (CANMORE ID 126012).

4.7 CONCLUSIONS

Settlement in the Western Isles in the Mesolithic has proven elusive, although sites of that period do exist. It seems likely that the main foci of settlement lie in areas that are now either offshore or buried by blanket bog (see Chapter 3.3, above). There is limited settlement on the machair in the Neolithic at Northton and Udal, however sites are largely in the upland area or associated with lochs. The machair becomes an important area of activity in the Bronze Age, and largely remains so (with an apparent hiatus in the Middle Bronze Age) until the fourteenth century AD, when many sites are abandoned. The effect of this is that archaeomalacology, which can be expected to work best in the high pH machair environment, is largely constrained to sites from the third millennium BC or later, although there are rare, and potentially valuable exceptions, most notably Northton (see Chapter 5.1.1, below).

Having set out a brief overview of human history in the islands, I will now set out the molluscan work carried out to date in the Western Isles.

5 MOLLUSCAN DATA

Having established a methodological framework for analysis, and the archaeological and environmental context, I will now turn my attention to previous archaeomalacological research in the Western Isles. To place this research in context, I will also include discussion of sites with archaeomalacological data from the Inner Hebrides, Northern Isles and coastal sites in mainland Scotland. This chapter begins with an account of these assemblages, broadly in date order (Table 5.1).

The contribution of this research to the key research questions identified in Chapter 1 will then be considered with sections that discuss how previous research has informed our understanding of biostratigraphy and relative dating, the taphonomy of Hebridean land snail assemblages; the role of land snails in reconstructing vegetation; climate; middening; seaweed and other imported materials; sea level change and coastal environments; marine molluscs and diet; and other uses for marine molluscs.

5.1 PREVIOUSLY REPORTED ASSEMBLAGES

Previous work has included studies of both terrestrial and marine mollusc assemblages. Studies of sub-fossil terrestrial molluscan assemblages from the Hebrides were carried out in the 1970s and 1980s, notably by John Evans, his students Penny Spencer and Michael Vaughan, and by Nigel Thew. A great deal of the work by Evans and his team remains unpublished, with the only record being the undergraduate dissertations of Spencer and Vaughan, and the notebooks of Evans (currently held in the Bioarchaeology Laboratory, School of History, Archaeology and Religion, Cardiff University). Since the 1990s work on assemblages of terrestrial molluscs from the Western Isles has largely ceased. John Evans did return briefly to working on material from Sligeanach on South Uist in 2003. This inspired a paper on the relationship between *Pupilla muscorum* and *Lauria cylindracea* (da Costa, 1778) (Evans 2004). The analysis from Sligeanach has been completed as part of the present project and has been published (Evans *et al*. 2012). Several themes have emerged from this work. These are outlined in detail in Law & Thew (2015), but are summarised below.

Marine molluscs are present at most archaeological sites, often in great numbers. In contrast to non-marine molluscs, little analysis or broader synthetic work has been carried out on marine molluscan assemblages from the

Western Isles. John Evans (1971) discussed marine shell results from Northton on Harris, and smaller shells from the Farm Mounds project were published alongside the non-marine Mollusca (Pain and Thew 2003). Much of the latter project’s radiocarbon dating was based on dates obtained from common periwinkle (*Littorina littorea*) shells (Sharples 2015, 9).

Table 5.1 presents a summary of non-marine molluscan assemblages reported from the Western Isles before the present study. The table details the types of samples taken (i.e. whether they are in a vertical sequence or not), processing methodology, archaeological periods, the nature of the fauna recovered and aspects of interpretation. The sites appear on the map in Figure 4.1.

Site	**Reference**	**Sampling**	**Processing**	**Period**	**Fauna**	**Interpretation**
Northton, Harris	Evans 1971; Canmore ID 10502	1 sample column + 1 spot sample of lowest clean sand	Sieved for molluscan analysis	Neolithic to Iron Age	Rich and diverse, 30 spp. in total	Shaded conditions between Neolithic I and II horizons and in Beaker II horizon. Arrival of *Cochlicella acuta* and *Helicella itala* between Iron Age I and II, *Helicella* slightly earlier. Several phases with damp conditions.
Rosinish, Benbecula	Vaughan 1976; Canmore ID 10197	4 sample columns + 6 spot samples	Sieved for molluscan analysis	Beaker, Iron Age, Norse	19 spp. in total	Richer vegetation and midden material during Iron Age
Ensay	Spencer 1974; Evans 2004; Canmore ID 10471	1 sample column	Sieved for molluscan analysis	Beaker period to Early Bronze Age	26 spp. in total	Evidence for sporadic flooding, and for fallow periods
Baleshare, North Uist	Thew 2003; Canmore ID 10026	191 samples taken by context	Processed by flotation	Late Bronze Age to Iron Age	20 spp. in total	Flooding in lowest levels of Block 22. Evidence for middening, + the use of seaweed, increasing during Iron Age
Hornish Point, North Uist	Thew 2003; Canmore ID 9913	171 samples taken by context	Processed by flotation	Iron Age	22 spp. in total	Flooding throughout most of the sequence; evidence for middening + abundant seaweed molluscs
Cnip, Lewis	Cerón-Carrasco 2006; Canmore ID 4009	21 samples taken by context	Processed by flotation	Iron Age	?14 spp. in total – some identifications are	Occasional flooding; dampness and shade associated with buildings

Site	**Reference**	**Sampling**	**Processing**	**Period**	**Fauna**	**Interpretation**
					questionable: material needs checking[1]	
Balelone, North Uist	Thew 2003; Canmore ID 10122	? samples taken by context[2]	Processed by flotation	Iron Age	12 spp. in total, but small assemblages	Some evidence for middening + the use of seaweed
Udal, North Uist	Spencer 1974; Canmore ID 10319	1 sample column	Sieved for molluscan analysis	Norse to Medieval	19 spp. in total	Occasional flooding; evidence of middening + for fallow periods
Newtonferry North Uist	Thew 2003; Canmore ID 10315	30 samples	Processed by flotation	Post-Medieval	14 spp. in total	Dampness in earlier levels. Occasional flooding in later levels. Abundant seaweed molluscs
Howmore, South Uist	H. Smith 1994; Canmore ID 234521	22 samples from 11 contexts	Sieved for molluscan analysis (11 samples) and processed by flotation (11 samples)	Post-medieval	16 spp. In total	Very low numbers of snails. Snails broadly represent the byre structure, with some snails introduced through cutting of turves for stabling.

Table 5.1: Non-marine molluscan assemblages analysed before the current project.

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[1] The specimens identified as *Catinella arenaria* and as *Candidula intersecta* are likely to be incorrect

[2] No table showing snail species count per sample was presented in the publication of this site

In total, 9 sites from the Western Isles had been analysed encompassing a range of dates from the Neolithic to Post-Medieval period; Most of the material derives from flotation samples with only four of the sites employing columns of samples to detect change through time. All the samples are characterised by low numbers of species, however there are indications of changes in the structure of vegetation at sites, wider climatic changes, along with evidence of past human activity. The sites are considered individually below, before themes that emerge from these analyses are unpicked.

5.1.1 Northton (Evans 1971)

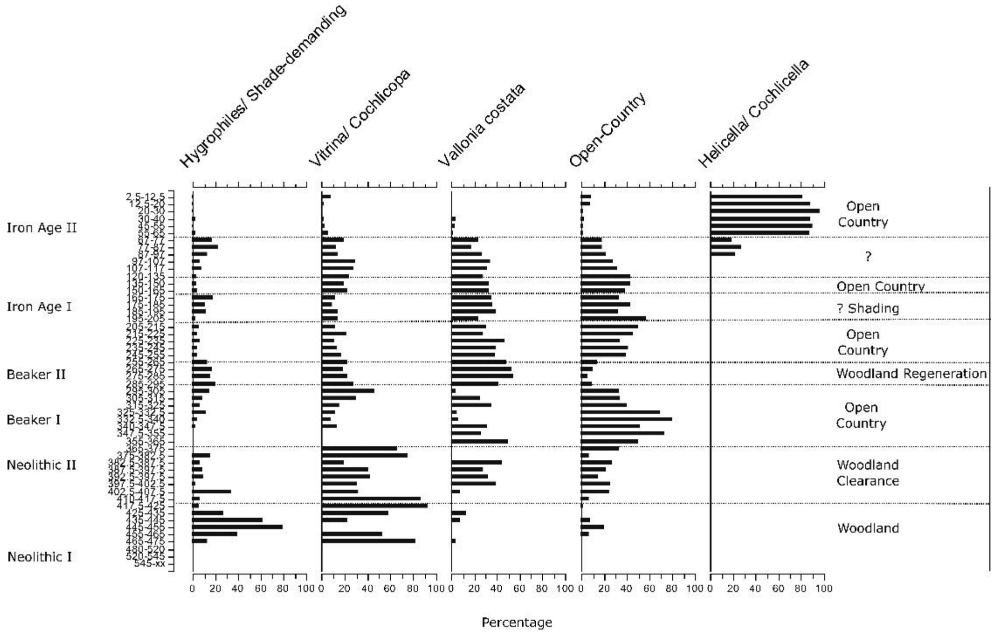


Figure 5.1: Percentage of snails by group from Northton, redrawn from Evans (1971).

The seminal work which established a baseline for studies of Hebridean land snail assemblages is that of Evans from Derek Simpson's excavations at Northton on Harris. Here, Evans was able to examine a vertical sequence of deposits dating from the Neolithic through to the Iron Age (Figure 5.1). The earliest layer, the Neolithic I horizon, which consisted of a boulder clay, was devoid of land snails (Evans 1971, 57), although this was overlain by clean, calcareous sand in which shells began to appear, albeit in low numbers. The fauna at this level reflected a shaded environment, which Evans felt was likely to be a forest environment (Evans 1971, 58). The relatively high numbers of

Carychium tridentatum, as well as the presence of *Vertigo pusilla*, and *Vertigo substriata* indicate wet, as well as shaded, ground.

In the overlying Neolithic II horizon, there was a marked rise in the open country fauna, with *Vallonia excentrica*, *Vertigo pygmaea* and *Pupilla muscorum* becoming more frequent. As well as increased openness, this fauna is indicative of a more stable depositional environment (Evans 1971, 58).

There was a horizon of clean, sterile sand, indicative of increased storminess, above the Neolithic II horizon, and then there appears to have been a phase of continued openness during the Beaker I horizon, with the first appearance in the sequence of *Vallonia excentrica* as well as high numbers of *Pupilla muscorum*.

The Beaker II horizon is marked by a change to more organic machair deposits, perhaps suggesting that the sand being laid down is a secondary deposit derived from erosion elsewhere (Evans 1971, 58). There is also a rise in the number of shells, suggesting a decreased rate of deposition. The horizon is dominated by shade-demanding and hygrophile species, which Evans (1971, 59) suggests implies a return to forest conditions.

Sand accumulation resumes above this layer, with *Vertigo pygmaea*, then *Pupilla muscorum* and finally *Vallonia excentrica* reappearing, in the same order in which they first appeared in the sequence (Evans 1971, 59), while the hygrophiles and shade-loving species decline. Alternating phases of stability and instability follow, with a fairly constant snail fauna. The Iron Age I horizon is marked by a slight increase in the number of hygrophiles and shade-demanding species.

After another phase of rapid sand accumulation during which *Helicella itala* arrives, the Iron Age II horizon is marked by the arrival of *Cochlicella acuta*, which becomes the dominant species very quickly. Overall, stability is implied for this horizon (Evans 1971, 59).

Northton is the longest vertical sequence available for the Western Isles, and provides a picture of environmental change encompassing both periods of greater or lesser storminess, and the decline, regrowth, and further decline of wooded conditions.

5.1.2 Ensay (Spencer 1974; Evans 2004)

A sequence of samples was taken through a Beaker period to Bronze Age midden during Derek Simpson's excavations at Manish Strand on Ensay. The molluscan sequence commenced with a non-calcareous buried soil which did not preserve shells, followed by an initial phase of grassland succeeded by a phase of higher diversity reflecting richer vegetation and evidence of ponding. This was then followed by either midden accumulation or broken ground with accumulating sand. Increases in *Vallonia costata* seemed to coincide with decreases in *Vallonia excentrica*.

5.1.3 Borve, Benbecula (Evans unpublished, summarised in Evans 1979)

At this coastal section, samples from layers of blown sand interspersed between intertidal peat and wood deposits revealed a freshwater fauna, dominated by *Galba truncatula*, *Gyraulus crista* and *Pisidium* spp. This is a rare example of a freshwater assemblage from the Western Isles.

5.1.4 Rosinish, Benbecula (Vaughan 1976, Shepherd 1980)

The site of Rosinish, investigated by Ian Shepherd in the 1970s, was an eroding machair hillock sealing a settlement containing finds of Beaker to medieval date. Land snails from an area of Beaker period cultivation were examined by John Evans and Michael Vaughan. This fauna had a limited diversity, and it was suggested that the organic content of the sediment may derive from manuring rather than soil development. Other sections investigated included surfaces underneath Iron Age and medieval middens. The Iron Age midden samples in particular contained snail species which indicate shade, with *Clausilia bidentata* and *Discus rotundatus* present in low numbers, suggesting that rock rubble or scrubby vegetation were present. The site of Rosinish is unique among the previously studies assemblage as it is a machair site on the east coast of the islands. As such, it is part of Dargie's (2000) Outer Machair group, although this does not appear to have had an appreciable effect on the range of snail species present at the site.

To provide a dating framework for the site, two radiocarbon results provided by Shepherd (1980, 25) were recalibrated (Table 4.2), although it should be noted that the dated material was limpet (*Patella vulgata* Linnaeus, 1758) shell, which is likely to give an erroneously early date.

5.1.5 Balelone, North Uist (Thew 2003)

Samples from a Bronze Age midden mound at Balelone showed evidence for fixed-dune pasture as well as seasonal flooding. A broadly open environment was indicated by the low number of 'non-wet' species present.

5.1.6 Baleshare, North Uist (Thew 2003)

Samples from Bronze Age and later occupation layers and middens showed a broadly open environment, with evidence for some winter flooding. In particular, the northern part of the site may have had richer marsh vegetation, based on the confinement to that area of *Vertigo antivertigo*. Thew concluded that flooding at Baleshare was severe enough for the site to have initially been in use only seasonally.

5.1.7 Hornish Point, South Uist (Thew 2003)

Samples from Iron Age middens were examined. Results indicated that the site was situated in a broadly open environment, with evidence for flooding, in particular from marshes at the south and north of the site. A correlation between organic content of the soil, archaeological material and the presence of *Oxychilus alliarius* was detectable.

5.1.8 Cnip, Lewis (Cerón- Carrasco 2006)

Samples from an Iron Age wheelhouse at Cnip contained snails interpreted as typical of contexts associated with stone buildings and rubble or sand. Several unusual species were noted. *Candidula intersecta* was recorded in five samples, uniquely for a pre-modern site in the Western Isles, as it is thought to be a late arrival to the Hebridean fauna (Waterston 1981, 315-6). While it may be intrusive in these contexts, it is likely to be a misidentification (probably of *Helicella itala*). Similarly, *Catinella arenaria*, which is not present in the Western Isles, is more likely to be *Oxyloma elegans* (Waterston 1981, 317).

5.1.9 Newtonferry, North Uist (Thew 2003)

Samples from post-medieval midden deposits were examined. Results indicated that the site environment was broadly open, with evidence for some winter flooding. Zonitid snails, in particular *Oxychilus alliarius*, were closely associated with archaeological evidence for midden deposits.

5.1.10 Udal, North Uist (Spencer 1974)

Samples from sections at the Udal, ranging from a 15th century midden and occupation layer to the present day, were examined by Spencer. The fauna was overwhelmingly open country throughout, dominated by *Cochlicella acuta* with high numbers of *Helicella acuta* and *Vallonia costata*. It is interesting to note that the 15th century midden layers do not show the same diversity as the majority of prehistoric or post-medieval middens analysed by Thew, and are rather more like the Iron Age midden at Baleshare which was lacking in typical midden species. This may suggest that the deposits were rapidly sealed before a 'midden' fauna could become established.

5.1.11 Howmore, South Uist (H. Smith 1994)

Samples from the byre and kiln at Howmore revealed a fauna associated with damp grassland condition and presence of walled structures, such as *Lauria cylindracea*. Snails associated with machair grassland (*Cochlicella acuta* and *Helicella itala*) are also present and may have been introduced to the site when turves were cut for animal bedding in the byre. *Hydrobia* sp. (sic), was interpreted as a modern contaminant, likely to have been introduced by the use of loch water for sample processing. This may be a misidentification of *Potamopyrgus antipodarum* (see Chapter 6.1 for details about the ecology of this species).

5.1.12 The Inner Hebrides

Few land snail analyses have been carried out in the Inner Hebrides, where there is a much smaller area of machair, however there is a report from Ardnave on Islay.

5.1.12.1 Ardnave, Islay (Evans 1983)

John Evans analysed a small land snail assemblage recovered from excavations at a Bronze Age settlement at Ardnave, however much of the material had been lost as the mesh size used for sieving the samples (2 mm) was too large, although some unprocessed material from Layer 13 (a limpet midden) was available. This was sieved with a 500µm mesh. The recovered assemblage was too species-rich to be a normal sand dune fauna, and suggested a stable, well-vegetated ground surface with plentiful tall plants. Evans drew special attention to the presence of *Vertigo angustior*, a rare species entirely absent from Scotland in modern times, but which is also quite common in prehistoric deposits at Northton.

5.1.13 Orkney

Rather more sites have been reported for Orkney, most which are to be found on the north-west coast of Mainland. Unusually, the molluscan assemblages include Pleistocene faunas not encountered in the Western Isles.

5.1.13.1 Crudale Meadow, Mainland (Whittington et al. 2015)

Coring through a series of gyttja (nutrient-rich peat or organic mud (Goudie 1994, 245)) and marl deposits gave a sequence extending over 5.9 metres into what are thought to be Late Glacial deposits. This contained low numbers of molluscs in general, with all species indicative of pond conditions. The absence of molluscs between 521 and 496 cms probably indicates the persistence of winter ice through summer, making molluscan life impossible. This is most likely the Younger Dryas ice advance. Above this, pond conditions resumed, but always with low diversity,

5.1.13.2 Bay of Skaill, Mainland (de la Vega Leinert et al. 2000)

A sediment sample series through early Holocene freshwater-lain deposits exposed at the coast near Skara Brae suggested a freshwater loch, perhaps with some brackish inputs, dominated by *Pisidium nitidum* and *Gyraulus laevis*, in the Mesolithic. This is succeeded by a fauna dominated by *Lymnaea peregra* (=*Radix balthica*) and *Armiger crista* (= *Gyraulus crista*) suggesting that the habitat is changing perhaps as a result of vegetation development and increased sedimentary inputs. Calcareous marsh deposits, dominated by *Carychium minimum* and *Lymnaea truncatula* (= *Galba truncatula*) follow. By the Neolithic, wet grassland conditions predominated, with the main species present being *C. minimum* and *Vallonia pulchella*.

5.1.13.3 Buckquoy/ Birsay Bay, Mainland (Spencer 1974; Evans & Spencer 1977; Rackham et al. 1989)

Analysis of a buried soil, dominated by *Carychium tridentatum* and *Discus rotundatus*, suggested that it formed under damp shaded conditions, which were succeeded by sand blow dating to the Middle Bronze Age. Shade-loving faunas diminished after this, and low diversity open-country species dominated through the Iron Age deposits and into the Norse period.

5.1.13.4 Knap of Howar, Papa Westray (Spencer 1974; Vaughan 1976; Evans & Vaughan 1983).

The sequences at Knap of Howar begins in the Neolithic, with damp open scrub woodland dominated by *Discus rotundatus*, although *Discus* is replaced by *Lauria cylindracea* towards the top of the soil, suggesting clearance. Further up the sequence, marl deposits associated with snails such as *Galba truncatula* suggest the formation of dune slacks.

5.1.13.5 Skara Brae, Mainland (Spencer 1974; 1975)

The buried soil near the Neolithic settlement at Skara Brae, Mainland, contained a rather more open fauna than Knap of Howar or Buckquoy, suggesting that clearance had begun here during the Neolithic. Periods of instability were detected, however, with layers of clean windblown sand at several points in the sequences examined.

5.1.13.6 Tofts Ness, Sanday (Milles 1991; 1994)

The lowest layers at Tofts Ness, which dated from the Early to Late Bronze Age, feature a fauna reflecting grassland with taller herbage offering some shade. There is an increase in both diversity and numbers of shells in the overlying 'plaggen' soil and sand, where relatively high numbers of *Clausilia bidentata* would perhaps suggest that some shrubby vegetation was available. The more recent grassland contexts overlying the Iron Age midden tips are associated with a very high number of *Lauria cylindracea*, as well as large numbers of *Vitrina pellucida*, *Cochlicopa lubrica* and *Punctum pygmaeum*.

5.1.13.7 Quoyloo Meadow, West Mainland (O' Connor & Bunting 2009)

A core through Holocene wetland deposits was dominated by *Radix balthica* (formerly *Lymnaea peregra*) and *Pisidium casertanum*, suggesting an ephemeral wetland habitat. A phase of particularly stagnant conditions was indicated by the replacement between 104 and 112 cms of *P. casertanum* with *Pisidium personatum*.

5.1.13.8 Quoygrew, Westray (Law, unpublished)

As a prelude to the present study, James Barratt of the University of Cambridge made snails from flots from the 11th - 13th century farm mound midden at Quoygrew, Orkney available for study. In general, there were very few snails within the samples, and many of the samples examined did not contain any shell. The shells that were found were quite poorly preserved and some were fragmentary. None of the shells examined showed signs of having been burned. Results are presented in Appendix 4.

Extremely few shells of non-marine snails were recovered. This may be indicative of poor conditions for preservation or of a highly unstable surface in the past. It is not possible to draw any inferences about the palaeoecology of the farm mound midden from such a poor assemblage, however it is worth noting that the presence of *Discus rotundatus* is indicative of shaded conditions, possibly rank grassland rather than woodland.

The presence of the button ram's horn snail *Anisus leucostoma* in relatively high numbers is of some interest. It is a freshwater amphibious species, commonly associated with marshy conditions and tolerant of seasonal drying out. It could be indicative of flooding episodes, although it may be derived from plant material imported to the site from a marshy location.

The assemblage was dominated by small marine snails, and especially the flat periwinkle *Littorina obtustata* and the flat skenea *Skeneopsis planorbis*. These snails live on rocky shores in association with seaweeds, and are likely to have been introduced to the midden with seaweed collected from the shore. *S. planorbis* is a low shore species, usually associated with small weeds and more commonly found in summer than in winter (Graham 1971, 72; Hayward *et al.* 1995, 524; Chambers 2009, 52), as is *Rissoa parva* (Graham 1971, 68; Hayward *et al.* 1995, 520). *L. obtusata* is also a lower shore species (Hayward *et al.* 512). This would suggest that seaweed, and particularly fine seaweed, was being collected from the lower shore and brought into the midden. It might be that finer seaweed was selected as it would decompose faster than the larger fucoid species, and so provide a convenient and immediate fertiliser. Smith and Foreman (1984) looked at rates of decomposition along a beach in British Columbia, and found the slowest species to decompose was a fucoid, *Fucus* *distichus*, which took up to 70 days to decompose compared to 6 days for the lamina of the fastest species to decompose, *Nereocystis luetkeana*.

5.1.14 St Kilda

Excavations at House 8 on Hirta revealed an assemblage exclusively composed of Zonitids, dominated by *Oxychilus alliarius* (Butterfield 1996). The highest number (71) were found among the small rounded pebbles laid down to form a bed for a cement floor, perhaps suggesting that they were attracted by rock rubble type conditions, or that there was organic refuse in the deposit. Alternatively, the species may be the dominant taxon of grassland on acidic soils on Hirta.

5.1.15 Coastal Sites in Mainland Scotland

5.1.15.1 Morton, Fife (Evans, unpublished)

Samples from a shell midden at Morton in Fife (on the east coast of mainland Scotland, but in a blown sand environment) showed shaded conditions dominated by *Discus rotundatus* and *Vallonia costata* prior to the onset of sand blow. The relative paucity of snails such as *Carychium tridentatum, Oxcyhilus spp.* and *Retinella* (=*Aegopinella/ Nesovitrea*) *spp*. suggests conditions were rather dry, however.

5.1.15.2 Freswick, Caithness (O' Connor 1989; 1995)

A Norse site at Freswick, Caithness showed much in common with the Hebridean sites, with periods of sand blow dominated by *Vallonia excentrica* and *Cochlicopa lubrica*. Areas of ponding were associated with *Galba truncatula* and *Oxyloma elegans*, and the midden deposits dominated by *Oxychilus alliarius* (O' Connor 1989, 209).

5.1.16 Studies of Modern Snails in the Western Isles

From the description of the principles of archaeological land snail analysis outlined in Chapter 2.2, it will be clear that knowledge of modern distributions of snail species with respect to different habitats is essential. As recently as 2008, however, Davies (2008, 158) commented that modern studies targeting specific small-scale environmental changes, and even more general studies in the case of sand dune faunas, are still needed. A few surveys of modern snails are available from the islands, as well as less structured observations made by travellers, including John Evans.

At the start of the eighteenth century, Martin Martin, who travelled to the Western Isles in 1695, remarked on the freshwater 'black mussels' (*Margaritifera margaritifera*) of Lewis, however systematic investigations of the non-marine molluscs found on the islands did not begin until the nineteenth century. Incomplete lists of the non-marine molluscs of the islands began to be published from the late 1860s (Waterston 1981, 314). A systematic checklist, including sub-fossil records, was published by A.R. Waterston of the (then) Royal Scottish Museum in 1981. A more recent survey of the southernmost island of the archipelago, Mingulay, was published by Robinson *et al*. in 2015, which added four new records to the island's recorded fauna: *Candidula intersecta*, *Potamopyrgus antipodarum*, *Milax gagates* (the greenhouse slug), and *Galba truncatula*.

5.1.16.1 John Evans

During the course of his PhD research in the late 1960s, John Evans visited the Western Isles and the excavations of Derek Simpson. He kept his field notebooks through his life, and these are now in the care of Cardiff University Bioarchaeology (CUBA) at Cardiff University.

In his PhD Notebook 3 (Evans 1965, 35-6), he records a 10km^2 survey on Harris:

"10 kilometre square
    1) Toe Head, south to Northton 900900
    2) Northton Village 900800
    3) Leverburgh and Rodel 000800
    4) South Harris 000900

Snails to date – 5/9/65
    Sand dunes
        Helicella itala
        Helix hortensis – subfossil only (= *Cepaea hortensis*)
        Helix aspersa – one dead shell – modern (=*Cornu aspersum*)
        Cochlicella acuta
        (? *Arianta arbustorum* – subfossil – no. does not occur)
        Vitrina pellucida"

Other notes follow, typically lists of species rather than counts, with some details about locales. The list is reproduced in Appendix 1.

These modern records, although often lacking any description of the habitats in which the snails were found, give us a sense of the range of species that are currently living in the Western Isles and their distribution. This provides a useful starting point for discussing the archaeological evidence with respect to relative dating and biostratigraphy, looking at the arrival or disappearance of certain species in the island fauna.

5.2 RELATIVE DATING AND BIOSTRATIGRAPHY

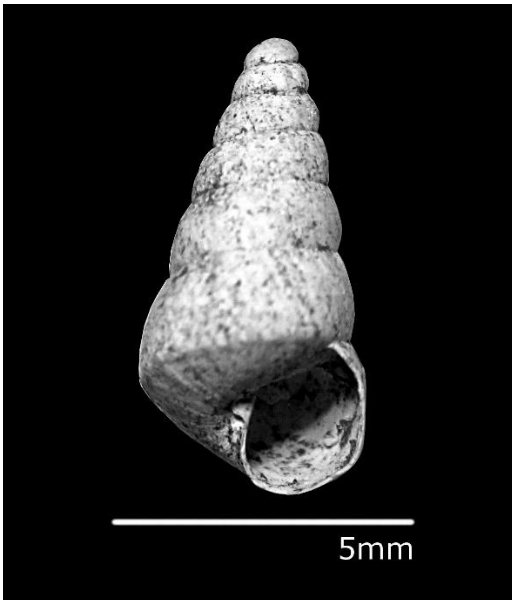


Figure 5.2: Cochlicella acuta *from Bornais, South Uist.*

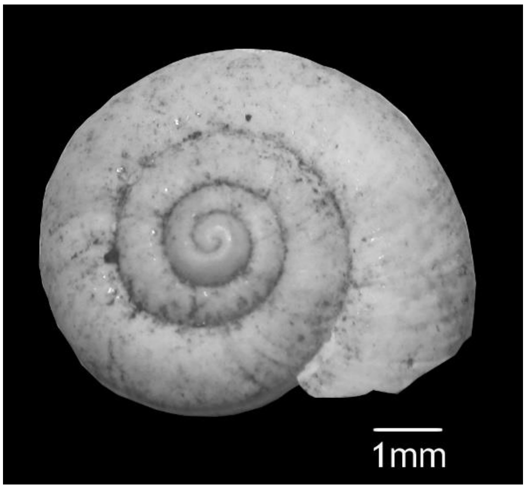


Figure 5.3: Helicella itala *from Bornais, South Uist.*

Molluscs have a role in relative dating of archaeological deposits, as the arrival of new species occurs at different times and can act as clear biostratigraphic markers. The following section looks at the patterns of arrival for terrestrial species on the islands and considers their use for relative dating of sediments.

Few studies of Pleistocene Mollusca have been carried out in the Western Isles, although Knowlton (1977, 55) notes that the boulder clay of western and northern Lewis has been found to contain the bivalve *Astarte semisulcata* and the gastropod *Boreotrophon* (=*Trophonopsis*) *clathratus*, both of which have an Arctic distribution in the present day, as well as *Colus* (=*Sipho) jeffreysianus*, a warm water gastropod, suggesting that there has been some mixture of glacial and interglacial Pleistocene deposits. This suggests that preservation conditions do not necessarily preclude the survival of mollusc shells of Pleistocene date, and that, if they can be recovered, and their temporal context resolved, they may aid interpretation of the Quaternary history of the islands.

In the Holocene, two species are of particular note. Absent in the earliest levels they appear in the islands during later prehistory. *Helicella itala* is a Late Glacial arrival in mainland Britain, where it tends to be associated with dry grasslands. *Cochlicella acuta* is a late prehistoric arrival to the British fauna and apparently restricted to coastal grasslands, appearing at Gwithian in Cornwall in the early Bronze Age (Thew 1989, 209). At Brean Down, Somerset, both Vaughan (1976) and Bell and Johnson (1990) record *Cochlicella acuta* in the late Bronze Age – although Bell and Johnson (1990, 249) express doubts about the stratigraphic integrity of the assemblage. *C. acuta* and *H. itala* are present in Bronze Age contexts in Evans's (1983) Inner Hebrides samples from Ardnave, although Thew (1989, 210; 2003, 167) notes this is only in low numbers.

Cochlicella acuta (Figure 5.2) and *Helicella itala* (Figure 5.3) represent clear biostratigraphic markers. *Helicella* first appears in the Late Bronze Age, with *Cochlicella* arriving in the Early Iron Age (Thew 2003, 167; Evans *et al.* 2012, 252). Both come to dominate most contexts on the machair, especially where there is marked evidence for aeolian transport of sand. Both species were absent in Late Bronze Age deposits at Baleshare, and by the Early Iron Age *Helicella itala* was well established. At Hornish Point, *Helicella itala* was already well established in the Early Iron Age, however *Cochlicella acuta* becomes more dominant in subsequent Iron Age levels (Thew 1989, 210). Their arrival (and with it, an increase in interspecies competition) also seems to have caused a decline in an earlier open country fauna, which was dominated by *Pupilla muscorum*, *Vallonia costata*, and *Cochlicopa* spp. It has been suggested that many of the molluscs now common on the *machair* were introduced by humans with imported straw and hay (Dinnin 1996, 181).

Although both species arrived in the Western Isles, neither reached the Northern Isles during prehistory. *Cochlicella acuta* is still absent from Orkney (Evans 1979, 20).

Other species of interest for relative dating include *Potomopyrgus antipodarum,* present today in machair lochs, where it can occur in great densities (R. Campbell 1977, 9). It is a recent arrival in the British Isles (Davies 2008, 167) and has colonized freshwater habitats rapidly, having spread from the Thames to Shetland within 120 years (Waterston 1981, 316), aided by its ability to reproduce parthenogenetically (Graham 1971, 62).

Other late arrivals in the Hebridean fauna are *Cornu aspersum*, *Arianta arbustorum*, *Trochulus hispidus*, *T. striolatus*, *Ashfordia granulata*, *Zenobiella subrufescens*, *Candidula intersecta*, and possibly *Bathyomphalus contortus* (Waterston 1981, 315-6), all of which appear to have arrived too late to be present in the archaeological samples studied thus far.

5.3 SITE FORMATION PROCESSES AND HEBRIDEAN MOLLUSCAN ASSEMBLAGES

Taphonomy is especially an issue with regard to the instability of the machair land surface leading to mixing of deposits. As machair systems develop, they tend to bury earlier land surfaces, so buried soil surfaces can typically be found under the sand (see Figure 3.6 for an example). Sometimes there are also standstill horizons within the sequence of sands. Shells from these types of context can usually be considered autochthonous, although some allochthonous material may be introduced through manuring or flooding. Rapidly accumulated wind-blown deposits may be subject to high degree of temporal and spatial mixing, as described in Chapter 3.4, above. In these circumstances, shell can be blown both from sand surfaces elsewhere, and from older deposits that are eroding. Additionally, an accumulating sequence may itself be subject to wind erosion, and so may be truncated, not continuous.

As Davies (2008, 131) has noted however, in practice there is a coherent ecological sequence in most of the published sequences, and many of these problems do not appear to be present, and Thew (2003) has previously argued that taking a variety of samples spatially separated across a site will reduce this problem by making anomalies easier to detect. Assessing variation in the state of preservation of shells may make mixture easier to detect (for example, more recent intrusive shells may still maintain their periostracum, while residual shells which are older than the target context may be more abraded or have endured more chemical weathering). In this study, I will include an evaluation of the preservation of individual shells where their condition is noticeably different from most of the other shells in a sample, in an attempt to identify assemblages of mixed date.

5.4 VEGETATION

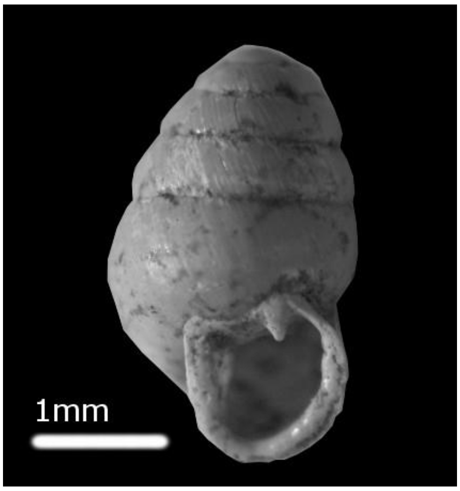


Figure 5.4: Lauria cylindracea *from Cladh Hallan.*

One of the key themes which arose from Evans's (1971; 1972) early work in the Western Isles was the ability of molluscs to provide a vegetation history at the site scale. At Northton he revealed evidence of Neolithic or Beaker age woodland clearance, followed by woodland regeneration in the Beaker period and then further clearance (Evans 1971). Church (2006, 16) later commented that an element of caution must be exercised with Evans's suggestion that woodland was present as two of the shade-loving species (*Lauria cylindracea* and *Oxychilus alliarius,* Figure 5.4 and 5.5) were subsequently found to be present in the normal grassland fauna of the *machair* in a later ecological survey, and may also be found in contexts associated with settlements (Evans 1971). As Thew (2003) has previously noted, usually phases of true shade, either woodland or long, stable grassland, are accompanied by higher numbers of different non-wet ground species, with true shade species coinciding with values higher than 15 non-wet ground species. At Northton, the woodland phases are marked by the presence of up to 23 non-wet species (Evans 1971), and at Buckquoy in Orkney up to 20 (Evans & Spencer 1977), whereas at Baleshare, Hornish Point, Newtonferry and Balelone non-wet species counts were lower than 15 in all the samples, suggesting open environments (Thew 2003).

The physical appearance of the shells of some species of snail may also be an indicator of vegetative cover. In life, *Cochlicella acuta* shows a great deal of polymorphism, with shell colouring tending to reflect its habitat, partly as a response to visual predation by birds such as rooks (*Corvus frugilegus* Linnaeus, 1758) (Berry 1979, 32). In archaeological contexts, most shell has lost its periostracum, the coloured protein layer on the surface of the shell, however uncommon cases where swift incorporation into subsequently stable deposits that allow the periostracum to persist do occur. Shells of the polymorphic species *Cepaea hortensis* have stripes that often remain visible when the periostracum is eroded. This was the case with the *Cepaea* shells from Mound 2 at Bornais, considered in Chapter 6.10.

5.5 CLIMATE

Molluscan studies can also shed light on periods of climatic variation. There are pronounced periods of sterile, windblown sand in the vertical sequences examined, in particular between the Neolithic I and II horizons at Northton (Evans 1971), and below the Beaker I horizon at Northton, which may correlate to sand deposition between 70 to 50 cms in Section 1 at Rosinish (Vaughan 1976) although correlation of periods of higher wind activity between the two sites may be problematic as Rosinish is on the opposite coast of the island chain and somewhat more protected from westerly winds by the hilly terrain of the interior. A second, slightly later episode of sand movement is detectable between 35 to 20 cms in Section 1 at Rosinish.

Small numbers of wet ground and freshwater aquatic species were reported at Baleshare, Hornish Point, Newtonferry, and Balelone (Thew 2003). These may be due to flooding from nearby freshwater marshes. In particular, the northern part of the site at Baleshare may have had richer marsh vegetation, based on the confinement to that area of *Vertigo antivertigo*. Thew (2003, 168) suggests that the flooding at Baleshare was severe enough that the site is likely to have initially been in used only seasonally.

Evidence for flooding between 265 and 305 cms at Northton (Evans 1971) may correlate with dampness (but not flooding, so alternatively this may be due to very local conditions) at the top of the sequence from Section 1 at Rosinish (Vaughan 1976), suggesting a wetter period during the Bronze Age, which may also coincide with strong indications of flooding at in earlier levels of Block 22 at Baleshare (Thew 2003, 168), as well as a peak in *Oxyloma elegans* between 58 and 70 cms at Ensay (Spencer 1974, Table 16).

5.6 MIDDENING

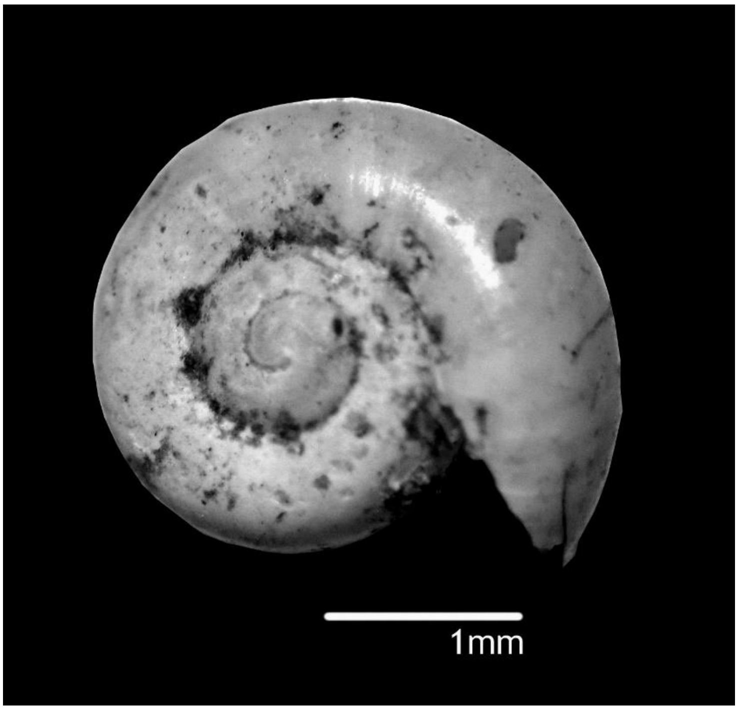


Figure 5.5: Juvenile Oxychilus alliarius.

Middens are areas of dumped refuse material, which in the Western Isles often seem to have been subsequently reused as a fertiliser or soil consolidant (this practice is referred to here as middening). Thew (2003, 171) states that although agrarian activity has generally restricted the diversity of molluscan faunas, around sites, new microenvironments are established which may be exploited by omnivorous rapid colonisers such as *Oxychilus alliarius* (Figure 5.6) and others such as *Vitrina pellucida*, *Nesovitrea hammonis* and *Vitrea contracta*. Middens are particularly suitable for these species, as they require dampness and shelter, and are able to exploit both plant and animal waste, and household food waste is likely to be present. Similarly, *Cochlicopa lubrica* and *Cochlicopa lubricella*, which are both tolerant of a wide range of habitats, are able to take advantage of moister conditions and taller herbage, with the former preferring damper locations and the latter somewhat drier.

At Baleshare, Hornish Point, Balelone, and Newtonferry (Thew 2003), *Oxychilus alliarius* becomes relatively more important in contexts where there is dumping of domestic organic refuse. Movement of midden material to fields may thus be detectable through the presence of *Oxychilus* (Thew 2003), although at Baleshare Thew reported several sub-blocks containing peaks in the concentration of preserved archaeological refuse and soil organics without a concomitant rise in numbers of *Oxychilus.*

The sequence of molluscan samples through a Beaker period to Bronze Age midden at Manish Strand on Ensay showed grassland succeeded by a phase of higher diversity reflecting richer vegetation and evidence of ponding (Evans 2004; Spencer 1974). This was then followed by either midden accumulation or broken ground with accumulating sand. Increases in *Vallonia costata* seemed to coincide with decreases in *Vallonia excentrica*, suggesting that the former species (more tolerant of damp conditions) was favoured by middening. Here, peaks in *Oxychilus alliarius* were obtained in the potential occupation deposit at the base of the section, in the blotchy sand with midden material between 58-70cms depth, and in the modern dune grassland at the top of the sequence. Midden material, and *Oxychilus*, were present throughout most of the sequence, suggesting a link between the two.

Land snails from an area of Beaker period cultivation at Rosinish, Benbecula, were examined by Michael Vaughan (Vaughan 1976; Shepherd 1980). The fauna had a limited diversity, and it was suggested that the organic content of the sediment may derive from manuring rather than soil development. *Oxychilus alliarius* is only present at this site in the brown humic sand that precedes the midden deposits in Section 1. Also examined were surfaces underneath Iron Age and medieval middens, the Iron Age samples in particular containing *Clausilia bidentata* and *Discus rotundatus,* two shade demanding taxa, in low numbers.

The 15th century midden layer at Udal (Spencer 1974) did not contain a high number of species, and lacked typical midden species.

Relationships between species may be very revealing. In a review of studies from wind-blown sand contexts throughout the British Isles, Evans (2004) suggested that the relationship between *Pupilla muscorum* and *Lauria cylindrace*a may provide a useful indicator of prehistoric farming practices, with *Lauria* favoured by, and *Pupilla* disadvantaged by, middening and the formation of *plaggen* soils.

5.7 SEAWEED AND OTHER IMPORTED MATERIAL

Seaweed was an important resource for Hebridean agriculturalists. Seaweed is collected for the purpose of manuring the land to improve its fertility and surface stability. It may have been used to stabilise the machair, which is particularly prone to wind erosion, as it can take more than four months to decompose (Bell 1981, 119). Seaweed can also be used as fodder for animals or even food for humans, and in recent history on Lewis seaweed for fodder was stored in a special building, the *tigh-an-fhaomainn*, or seaweed house (Bell 1981, 118). More recently kelp was harvested to produce chlorides and other salts by burning and drying the seaweed. Kelp has been used in the manufacture of glass, soap and munitions (Evans 1978, 33).

Species present among the molluscs on modern seaweed collected by Bell (1981, 121) from Saltdean, Sussex also included *Rissoa parva*, *Littorina littorea* and *Littorina saxatalis*. These species as well as several others have been used as a proxy for seaweed within archaeological contexts. A range of molluscs associated with seaweed, *Gibbula cineraria*, *Calliostoma zizyphinum*, *Patina pellucida (=Patella pellucida)*, *Chlamys distorta* (=*Talochlamys pusio)*, *Hiatella arctica*, *Littorina neritoides* (=*Melarhaphe neritoides)*, *Littorina saxatalis* and *Littorina littoralis (=Littorina obstusata*) were recovered from Norse or pre-Norse soil at Brough of Birsay, where carbonised seaweed was present in pits in a kitchen area (Donaldson *et al.* 1981, 78 -79).

At Buckquoy, Mainland (Orkney), Evans and Spencer (1977, 216) reported finding blue-rayed limpet *Patina pellucida* (now called *Patella pellucida*) in the topsoil and argued that in this context it most likely derived from seaweed used as fertiliser.

Seaweed being imported onto the site was the interpretation for the presence of small marine gastropods at Hornish Point, Baleshare, Balelone, Newtonferry (Pain & Thew 2003), and at Bostadh Beach (Cerón- Carrasco 2005,

32) and Cnip (Cerón- Carrasco 2006, 182). The seaweed snails at Newtonferry often occurred in the highest number in contexts that were lacking land snail assemblages indicative of middening, suggesting that seaweed was primarily collected as a fertiliser and soil stabiliser.

Evans and Spencer (1977, 216) attributed the occurrence of the blue-rayed limpet *Patella pellucida*, which lives on seaweed, at the Norse site of Buckquoy, Orkney, to the spreading of seaweed as manure; and Evans and Vaughan (1983, 113) drew the same conclusion about *Patella pellucida* and *Littorina littoralis* (= *L. obtusata*) at Knap of Howar, Orkney.

Other botanical material that may be imported to sites which may contain snail shells includes reeds and other vegetation from lochs, as well as turves. Even where snails may not be expected in the archaeological record, such as in the acidic blacklands, economic practices may create conditions suitable for preservation. This was the case at Howmore, South Uist, where Smith (1994) attributed the presence and preservation of open ground species in the byre to the cutting of turves from the *machair* for use as animal bedding. The absence of snails often indicative of dung, such as *Oxychilus alliarius* or *Vitrina pellucida*, was attributed to poor preservation.

5.8 SEA LEVEL CHANGE AND COASTAL ENVIRONMENTS

Within the Western Isles molluscs have been linked to sea level change. At Borve although no identification to species level has been published, freshwater shells were recorded within the submerged profile at Point J, within the 'many fine organic layers' some 12- 13 cms above a piece of wood radiocarbon dated to 5700±170 BP (4996-4179 cal BC) (Ritchie 1966, Figure 4). The sequence appears to indicate a body of open fresh water which was infilled prior to being inundated by the sea.

Evans (1971) linked variation in the marine shell assemblage to environmental changes related to sand deposition at Northton, suggesting a change in the nearshore marine environment. The Neolithic II horizon contained frequent cockle (*Cerastoderma edule*) shells, suggesting that large tracts of intertidal sand were available to be exploited. There are very few cockles in the Beaker horizons, however, and a change to exploitation of rocky shore species, suggesting a rise in sea level had occurred, destroying the cockles' preferred habitat. Cockles become popular again in the Iron Age II horizon, suggesting a fall in sea level. Evans noted that when cockles are most abundant, the most machair sand accumulates in the section, implying a larger area of intertidal sand was available (Evans 1971, 61-2). Thomas (1981, 58) has criticized this interpretation, however, noting that changes in the abundance of cockles are also mirrored in changes in the abundance of mussels (*Mytilus edulis*), dog whelk (*Nucella lapillus*) and common periwinkle (*Littorina littorea*), all of which live on rocks on the shore. There may instead have been some environmental change that was particularly detrimental to limpets, or the changes may reflect changes in the tastes of humans at the site.

5.9 MARINE MOLLUSCS AND DIET

Unlike the Inner Hebrides, substantial Mesolithic shell middens are absent from the Western Isles. At present, the only such site is at Temple Bay on Harris (Church *et al.* 2011), although this is much smaller than those on the Inner Hebrides. A few factors do mitigate against our finding such sites though. Besides the acidic soil conditions that may destroy smaller shell assemblages, the Western Isles, unlike the rest of Scotland, have been sinking relative to sea level because of post-glacial isostatic readjustment. The Mesolithic coastline of the Western Isles is now submerged (Sharples *et al.* 2004, 33). Recent offshore work has begun mapping this submerged landscape, especially on the east coast of the islands (Benjamin *et al.* 2014), but as yet no monumental middens have been forthcoming. The same problem of acidic soils and changing coastlines bedevils the Neolithic of the Western Isles. With the exception of Northton, significant deposits of marine shell that have been investigated in the Western Isles at present date from the Bronze Age or later (see Table 5.2).

Site	Reference	Period	Summary Methods	General observations
Northton, Harris	Evans 1971; Canmore ID 10502	Neolithic - Iron Age	Not described	Cockles important in Neolithic levels. Decline by Beaker II levels, where limpets predominate. Resurgence in cockles in Iron Age levels.
Sligeanach, South Uist	Law 2012; Canmore ID 140904	Early Bronze Age	Flotation of samples (>10mm residues examined)	Limpets predominate, except for two samples in Trench X which are dominated by winkles.
Cill Donnain III, South Uist	Bell and Godden 2014; Canmore ID 75832	Early Bronze Age - Late Iron Age	Hand collection and sieving of spoil with 10mm mesh	Winkles dominate in all phases, limpets decline through time.
Cnip, Lewis	Cerón-Carrasco 2006; Canmore ID 4009	Iron Age	Sieved through a 1mm mesh	Limpets predominate
Bornais Mound 1, South Uist	Sharples and Light 2012; Canmore ID 108290	Late Iron Age - Norse	Hand collection and flotation of samples (>10mm residues examined)	Preference in Late Iron Age for limpets, with growing significance of winkles in Norse period.
Bornais Mound 3, South Uist	Sharples 2005; Canmore ID 108290	Norse	Hand collection and flotation of samples (>10mm residues examined)	Dominated by winkles and limpets (predominantly winkles)

Table 5.2: Summary of marine shell assemblages from archaeological sites in the Western Isles

The rocky shores that break up the sandy stretches of the west coast of South Uist are the ideal habitat for limpets (*Patella* spp.) and common periwinkles (*Littorina littorea*). Limpets are the principal grazers of seaweed on the rock surfaces between low and high tide in temperate waters. Whether limpets were eaten in the past has been subject to question. Limpets are not commonly eaten in modern Britain, although they remain a delicacy farther afield, such as in the Azores (Cunliffe & Hawkins 1988, 37). On sheltered shores, a large part of the diet of limpets is the holdfast and sporelings of young fucoid seaweeds, which contain polyphenolic compounds that are likely to make the limpets taste quite unpleasant (Cunliffe & Hawkins 1988, 37-38), although they have been invitingly described by Sharples (2005, 159) as 'not unpleasant eating'. Furthermore, limpets are not especially calorific. Evans and Vaughan (1983, 114) calculated that 100 shells = 0.15 kg cooked meat weight = 97.5 calories. Put differently, Bailey (1978, 39) states that a person would need to eat 400 limpets to satisfy their recommended calorific intake for one day. In archaeological sites on South Uist, vast numbers of limpet shells are present in midden deposits, however, especially in prehistoric contexts. The dominance of limpets in prehistoric contexts is also a feature of larger midden sites in the Inner Hebrides and west coast of Scotland, previously known as 'Obanian' assemblages (although the midden at Raschoille Cave is dominated by the common periwinkle *Littorina littorea*) (Pickard & Bonsall 2014, 256).

The presence of limpets in archaeological deposits is sometimes attributed to their use in bait (e.g Simpson *et al*. 2005, 368), a practice which is historically attested in the Western Isles. At the Norse site of Quoygrew, Orkney, it was suggested that some of the limpets were used for bait, especially as they were found in association with cod and saithe bones, which are species traditionally fished with limpet bait in Orkney, while isotope evidence from the human bone suggests that marine protein was primarily derived from animals at high trophic levels (e.g. cod) (Milner & Barrett 2012, 113). Crushed limpets would be used to create a bait called *soll*, which was used in rocky shore fishing. Special limpet holes or leepits would be carved into rock to keep a supply of *soll* (Cerón-Carrasco 2005, 42). In other cases, limpets would be shelled and put directly onto hooks, or chewed or part boiled and used for fishing with lines or that *tabh* or poke-net (Cerón-Carrasco 2005, 42). Sharples (2005, 159) has previously argued, however, that large deposits of relatively intact limpet shells in inland sites are unlikely to be waste from use in fishing, as limpets used in this way are unlikely to be taken far from the shore.

A third possibility is that the limpets may be fodder for pigs (Sharples 2005, 159), an idea perhaps supported by the lower δ^{13}C values and elevated δ^{14}N isotope values in some of the pig bone collagen from Middle Iron Age and Norse Dun Vulan compared to other omnivorous mammals from Scottish islands (Jones *et al.* 2013, 605). Pigs would not necessarily require limpets to be removed from their shells, however (indeed, doing so is likely to be an unnecessary expenditure of effort), and few fish or shellfish remains were found at Dun Vulan (Jones *et al*. 2013, 507). Food waste remains the most likely scenario in most cases, given the close association with domestic refuse such as pots, plant macrofossils and animal and fish bones.

Recent historical records from the islands attest to the status of limpets as a food source. The great naturalist Thomas Pennant (1772, 192) describes the floor of the ruined castle at Arran as "strewed with the shells of limpets, the hard fare of the poor people who occasionally take refuge here". He also described passing a boat en route to the Small Isles of Jura from Jura filled with women and children 'to collect their daily wretched fare, limpets and periwinkles". On Skye, when bad weather has damaged the crops, "... the poor are left to Providence's care: they prowl like animals along the shore to pick up limpets and other shellfish, the casual repasts of hundreds during part of the year in these unhappy islands" (Pennant 1772, 243).

The Rev. James Hall, writing in 1807, describes the abundance of shellfish in the Western Isles:

"At Barra, as at most, and I believe all the Western Islands, there is the utmost abundance of shell fish, such as limpets, muscles, oysters, clams, spout fish (razor shells), lobsters, crabs, and, above all, cockles. Upon the great sand on the north end of Barra, cockles are found in such quantities, that, in times of great scarcity, all the families on the island, which are about two hundred, resort to this for their daily subsistence. In two summers of very great scarcity, not less than from one hundred to two hundred horse-loads of cockles were taken off the sands at low water every day of the spring tides during the months of May, June, July, and August. Shell fish is a great resource, I understand, to the people of the islands, at all times. They are in the habit of boiling limpets, clams, and other species, and making use of the broth, mixed, or boiled up, with a little oatmeal" (Hall 1807, 543-4).

At the Norse settlements at Bornais, limpets remain abundant in samples, but are only dominant in Block FB at the south end of Mound 3(Sharples 2005, 89). In later phases at Mound 1, and the rest of Mound 3, periwinkles are the dominant taxon (Sharples & Light 2012; Sharples 2005; see also Chapter 7.4). This rise in popularity of periwinkles appears to be a feature of Scottish islands and occurs just before, or at the start of, Norse occupation. At Buckquoy, Orkney, periwinkles overtake limpets in abundance during the Pre-Norse phases. Evans and Spencer (1977, 215) state that the situation is reversed during Norse occupation, but this is only true during one of the three Norse phases. At Kilellan Farm, Ardnave, on Islay, winkles dominate the latest samples, which are from the Middle Iron Age site, except for the lower midden which has higher numbers of both limpets and cockles, although this is not necessarily a meaningful temporal trend, as winkles also dominate one of the Early Bronze Age midden samples (Evans 2005a, Table 52). Hardy (2013, 130) states however that in general in the Inner Hebrides, periwinkle-dominated middens tend to be early medieval in date.

Measurement of periwinkles at Quoygrew, Orkney, showed a slight increase in size through time. This was interpreted as being indicative of an effort to increase yield by collecting a second-choice species more widely (Milner *et al.* 2007, 1470).

On the Scottish mainland, the Mesolithic site at Morton in Fife yielded a shell assemblage that was dominated overwhelmingly by cockles, reflecting their ready availability on the nearby sandy shores, although rocky shore species such as limpets and winkles were consistently present throughout the assemblage (Coles 1971, 353-359).

At the Iron Age hillfort of Broxmouth in East Lothian, limpets start out as the dominant taxon, especially in Phase 1 but decline to be replaced by winkles in the later phases such as the Phase 6 interior, a fact which Sloan (1985, 145) attributed to over-exploitation of limpets as a famine food. Armit *et al.* (2013, 477) note that in specific contexts, the patterns are much more variable, and suggest that this may reflect naturally fluctuating populations of the two species, or short-term effects of over-exploitation.

The early medieval shell middens at Sands of Forvie, Aberdeenshire, were largely dominated by mussels, with lesser numbers of winkles and clams (Noble et al. in press). This is comparable to Iron Age and early medieval coastal shell middens of Denmark (Noble et al. in press)

Other shellfish represented in insular archaeological sites include razor shells (Solenidae spp.), mussels (*Mytilus edulis*), cockles (*Cerastoderma edule*), scallops (*Pecten maximus*), whelks (*Buccinum undatum*) and oysters (*Ostrea edulis*), although none of these are present at any site in significant numbers, except for cockles at Cill Donnain and Cille Pheadair, where they appear to decline in significance through the Iron Age (Bell & Godden 2014, 155).

Smaller, inedible taxa are occasionally recorded from sediment samples, and may derive from seaweed deliberately brought onto a site (see Chapter 5.7). Late Iron Age deposits at Mound 1, Bornais, contain a greater variety of lesser species than Norse deposits. This may be due to the use of seaweed, but Sharples (2012, 228) notes that many of the shells may have been collected as ornaments, and indeed some of the shells are worked or perforated (Sharples 2012, 271).

In modern times, the shellfish industry is based predominantly in lobsters (*Homarus gammarus*) and Norwegian lobsters (*Nephrops norvegicus*), with lesser exploitation of crabs (*Cancer pagurus*), scallops (*Pecten maximus*), periwinkles and cockles (Boyd & Boyd 1996, 74).

5.10 OTHER USES FOR MARINE MOLLUSCS

In the absence of limestone, shells are a useful source of lime which have been used to make mortar by burning the shell with peat fuel. Marine mollusc shell has been used as a raw material in medieval and later structures in the Western Isles. For example, burnt cockle shells are readily visible in the mortar matrix of various medieval buildings on Barra, including Kisimul Castle (Thacker 2015).

Artefacts are also occasionally manufactured from mollusc shells. The earliest modified shell from the Western Isles is a perforated oyster shell, perhaps an item of adornment, from the late Mesolithic midden at Tràigh na Beirigh (Church *et al.* 2012, 190). At Late Iron Age Mound 1, Bornais, there are discs, possibly gaming counters, made of scallop (*Pecten maximus*) and whelk (*Buccinum undatum*) shell (Sharples 2012, 271). Interest in shells as curios appears to die away in the Norse period, with no evidence for worked shell in Norse deposits (Sharples 2012, 228).

The use of perforated scallop shells as cheese strainers is attested into recent times, with examples on display at Cill Donnain Museum (Figure 5.6).

*Figure 5.6: Scallop (*Pecten maximus*) shell perforated for use as a cheese strainer, Cill Donnain Museum.*

5.11 CONCLUSIONS

Analysis of non-marine and marine mollusc shell assemblages began in the Western Isles in the 1960s with the work of John Evans. Since then, there has been rather more work on non-marine than marine assemblages, despite the fact that marine shells are such a ubiquitous and visible component of the archaeological resource in the islands. The SEARCH project, which introduced standard methodologies, has begun to redress the balance.

The non-marine assemblages studied thus far range in date from the Neolithic to the Post-Medieval period and include assemblages from Lewis, Harris, Ensay, North Uist, Benbecula and South Uist. They are primarily the work of John Evans or Nigel Thew. A number of key points emerge from these assemblages. Two species, *Helicella itala* and *Cochlicella acuta* arrive on the islands in late prehistory and become dominant in unstable machair contexts. This provides a biostratigraphic marker which can be used for relative dating.

Evan's work at Northton appears to show that there were phases of woodland at the site, including a phase of woodland regeneration in the Early Bronze Age. The presence of snails associated with marshy conditions may be evidence of seasonal flooding, which Thew's work suggests is likely to have been a particular problem at Baleshare. At some sites, periods of storminess are detectable through hiatuses in the molluscan sequence associated with sterile sand deposition.

The inherent instability of sandy soils in a storm-prone environment has been mitigated with the use of consolidants such as seaweed and midden material. Through Thew's work, it is clear that these are associated with particular species of mollusc in machair deposits.

The marine assemblages studied range in time from the Neolithic to the Norse period. There is a site each located on Lewis and Harris, however most are on South Uist. At Northton, Evans saw fluctuations in the presence of cockles as evidence of sea level change, as cockles become scarcer during the Bronze Age when the rate sea level rise was at its highest.

The assemblages are largely dominated by limpets and winkles, a reflection of the rocky shores close to many sites. Limpets decline in popularity with time, in particular in the Norse period, a pattern which may also be seen in the Inner Hebrides and Orkney. As well as food, shells can be raw material for the manufacture of lime, and worked into artefacts.

Over the next two chapters, I will present results of the new analyses carried out as part of this study. I will discuss results in relation to the themes identified in this chapter, evaluating the contribution new data makes to the archaeomalacological narrative.

6 RESULTS: NON-MARINE MOLLUSCS

The following chapter presents the results of analysis of non-marine molluscs from sites in the Western Isles. Sites studied (Figure 6.1) are presented in a broadly chronological order from oldest to youngest, although the transect for recent molluscs at Cladh Hallan is presented first. In each case, a short text about the site accompanies the description, as well as detail about what kinds of samples were analysed, for example whether it was a vertical sequence or laterally distributed samples of archaeological layers and features, as well as whether the whole sample was analysed or just the flot.

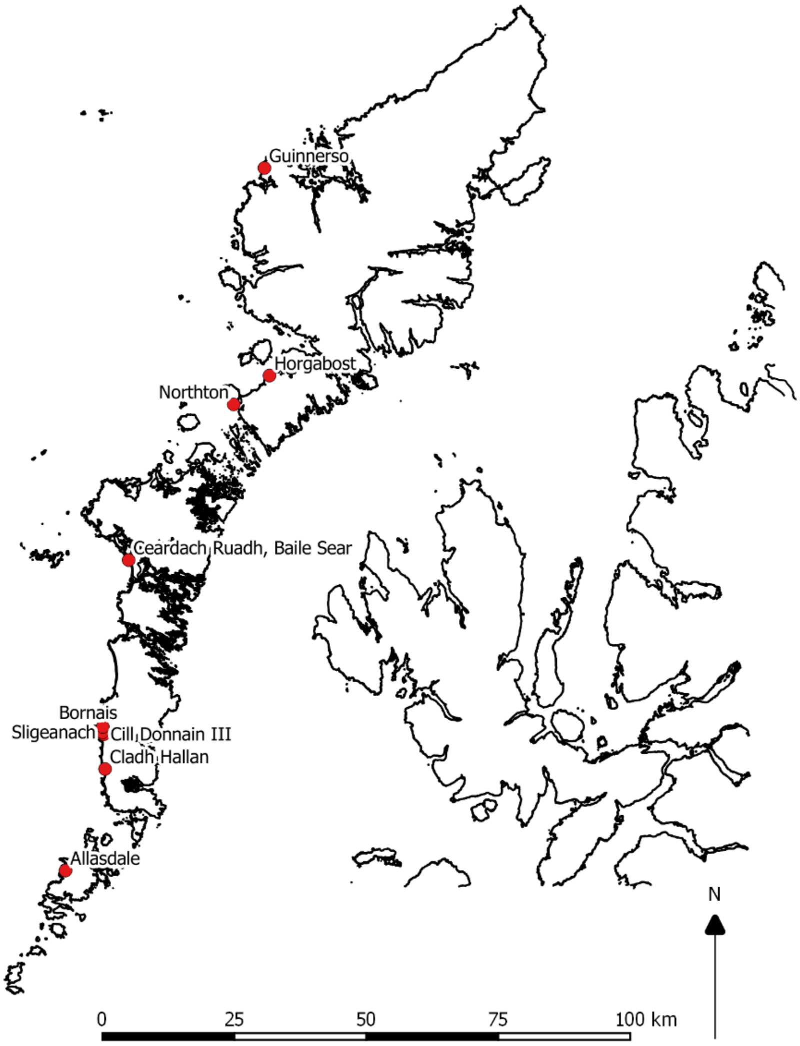


Figure 6.1: Archaeological sites studied (the modern mollusc transect is at Cladh Hallan). Contains Ordnance Survey data. Crown © and database right 2017.

Most of the samples are either taken laterally across extensive deposits, or from discrete archaeological features. Five new vertical sequences, from three sites (Northton, Ceardach Ruadh and Sligeanach), are also examined. The combination of two approaches was intended make issues of temporal fidelity (such as intrusive shells and conflation deposits) easier to detect.

The aims of this part of the study can be summarised as

1. To assess the contribution that analysis of non-marine shells can make to wider archaeological narratives at sites in the Western Isles.
2. To explore the role of non-marine molluscs in relative dating of archaeological deposits.
3. To construct site-specific land use histories from molluscan assemblages.

The specific objectives were

1. To use the availability of assemblages of non-marine molluscs from recent excavations to contribute to broader archaeological narratives.
2. To determine the presence of species that are now locally extinct and species that are later arrivals to the fauna at each site.
3. To assess the prevalence of snails indicative of shaded conditions, of flooding, of midden materials and of seaweed at each site.
4. To use statistical methods to explore patterns in the composition of assemblages within and between sites.

Samples from Northton (NT10), Sligeanach, Cladh Hallan, Allasdale, Horgabost, Cill Donnain, Bornais and Guinnerso had been taken and processed before the commencement of this project. Samples from Northton (NT11) and Ceardach Ruadh, as well as the modern mollusc transect, were taken specifically for this project.

At all sites all complete shells, apical fragments and diagnostic body whorl or aperture fragments were extracted for identification. Shells were identified to species level where possible using a binocular microscope, with help from the mollusc reference collection at Cardiff University. Most identifications have been checked by Nigel Thew. The condition of preservation of the shells was also noted. Obviously intrusive shells (generally glossy in appearance with the proteincaceous periostracum preserved) were not included in statistical analyses. The minimum number of individuals (MNI) for each taxon within a sample was calculated by counting the shell apices or other non-repeating elements following the recommendations of Giovas (2009). Notes on the ecology of the species were generally taken from Evans (1972), Kerney and Cameron (1979) and Davies (2008). Nomenclature follows Anderson (2008).

As an aid to interpretation, snails have been organized into the ecological groups adapted from Evans (1972) for terrestrial taxa, and Evans (1991b) for freshwater and wet ground taxa. These groups indicate a range of conditions from shade, to grassland and open areas and include indicators of water types. Some of the groupings are very specific whilst others are more general. Broadly the groups are organized along a gradient from shaded places to open places, and then to increasingly well-developed freshwater habitats.

In the present study, these are:

1a. **Gastrodontoidea** (Zonitidae of earlier authors), comprising *Aegopinella nitidula*, *Aegopinella pura*, *Nesovitrea hammonis*, *Oxychilus alliarius*, *Oxychilus cellarius*, *Vitrea contracta* and *Vitrina pellucida.* These are broadly indicative of shaded conditions.

1b. ***Carychium tridentatum*.** A species usually found in woodland among leaf litter, but also known from long grassland.

1c. ***Discus rotundatus.*** Typical of shaded habitats

1d. **Other shade-loving species**, comprising *Vertigo pusilla*, *Vertigo substriata*, *Lauria cylindracea*, *Leiostyla anglica*, *Acanthinula aculeata*, *Clausilia bidentata*, *Punctum pygmaeum*, *Euconulus alderi*, and *Euconulus fulvus*. This group contains a broad range of tolerances, but usually snails in this group avoid dry, open conditions.

(2. ***Pomatias elegans*** Not found in the Western Isles)

3. **Catholic/ intermediate**, comprising *Cochlicopa lubrica*, *Cochlicopa lubricella*, *Arianta arbustorum, Cornu aspersum,* Arionidae spp., *Cepaea* *hortensis* and Limacidae spp. These species are tolerant of a wide range of habitats.

4. **Open country**, comprising *Cochlicella acuta*, *Helicella itala*, *Pupilla muscorum*, *Vallonia costata*, *Vallonia excentrica* and *Vertigo pygmaea*.

5a. ***Galba truncatula.*** An amphibious species found in wet grassland and poor freshwater habitats

5b. **Marsh**, comprising *Oxyloma elegans, Vertigo antivertigo*, *Vertigo angustior* and *Zonitoides nitidus*

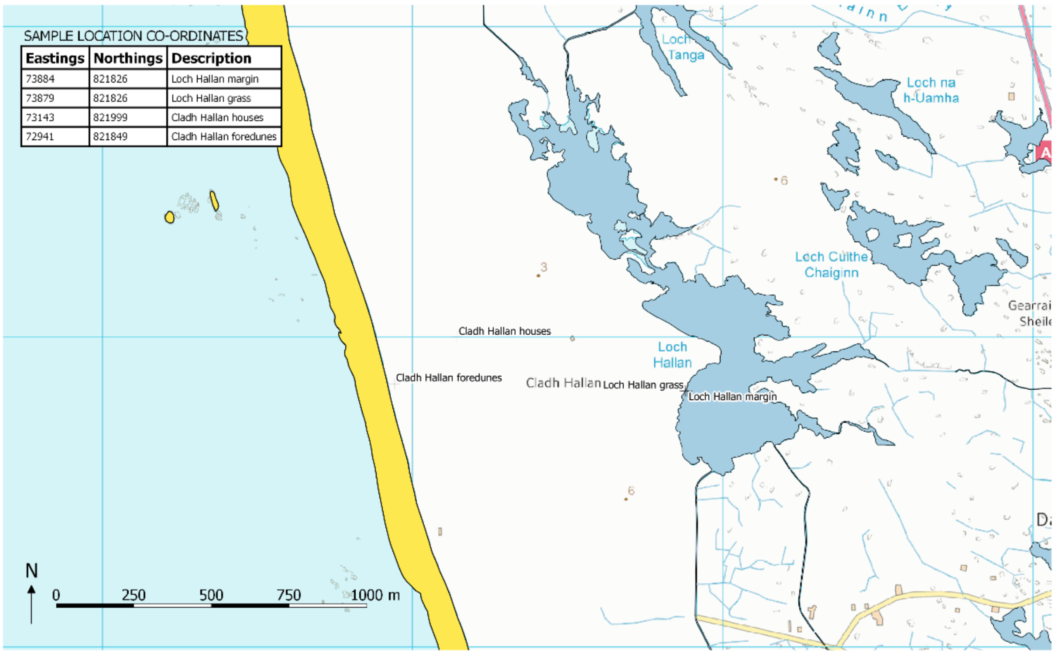
5c. ***Carychium minimum.*** Found in wet habitats.

6a. ***Freshwater 'slum'*** Mostly found in poor freshwater habitats, includes *Anisus leucostoma*.

6b. **Freshwater catholic**, comprising *Gyraulus crista* and *Gyraulus laevis*. These are true freshwater species that need permanent water. *Potamopyrgus antipodarum*, which is a late introduction to the British fauna that was not considered by Evans (1991b) is also included here

Although useful for general discussion, the use of ecological groups does tend to mask details of individual species, and the position of species is not absolute as individual snail species may behave quite differently in ecological terms due to various environmental pressures. Much of the work that led Evans to categorise these groups was carried out in southern England, and ecological tolerances of individual species may be somewhat different in the Western Isles.

6.1 *ESTABLISHING A BASELINE: MODERN MOLLUSC TRANSECT*



SAMPLE LOCATION CO-ORDINATES

Eastings	Northings	Description
73884	821826	Loch Hallan margin
73879	821826	Loch Hallan grass
73143	821999	Cladh Hallan houses
72941	821849	Cladh Hallan foredunes

Figure 6.2: Map showing the location of modern mollusc transect samples.

Figure 6.3: The first sample location, Cladh Hallan dunes, looking north.

A base line transect was established to provide knowledge of modern distributions of snail species with respect to different habitats. In September 2014, a transect was sampled at four locations from the dunes at Cladh Hallan, South Uist, back to the margins of Loch Hallan (Figure 6.2), taking in the eroding dunes (Figure 6.3), stabilised machair close to the site of the Cladh Hallan houses (Figure 6.4), damp grassland close to Loch Hallan, and the bottom of the loch itself at its western margin. The location was chosen as many of the assemblages available for study are situated on the machair plain, and so the transect is likely to take in locations similar to those in which sites are located. In each location, approximately 1kg of sediment was sampled, to a depth of approximately 5cms below the ground surface. Co-ordinates were recorded using a handheld GPS, and are given using the British National Grid. Samples were washed through a 250µm mesh sieve. Molluscs were identified with comparison to a reference collection. Results (number of complete shells) are presented in Table 6.1.

Figure 6.4: Turf sampled immediately north of the Cladh Hallan houses.

The first location sampled, at 072941E/821894N, was the eroding face of the top of the sand cliff above the beach, with tall marram grass. This was an exposed location, subject to aeolian activity (Figure 6.3). The second location, at 073143E/821999N, was immediately north of the Cladh Hallan houses (see

Chapter 6.4). This location was somewhat sheltered by a stabilized dune cordon between it and the shore. The sediment was machair sand, and the vegetation was relatively short, cattle grazed, grassland (see Figure 6.4, above). At the time of the visit, cattle had recently been present, indeed through using it to scratch themselves, they had destroyed the interpretation panel for the Cladh Hallan houses.

Figure 6.5: Modern snails from Cladh Hallan: (from left) Vallonia excentrica*,* Punctum pygmaeum*,* Cochlicopa lubrica*, and* Lauria cylindracea*.*

Figure 6.6: Grass growing at the edge of Loch Hallan, looking north.

Two other locations were sampled at the rear of the machair plain. Grass growing at the margin of Loch Hallan was sampled at 073879E/821826N (Figure 6.6). The sediment here was sandy peat. Finally, a sample was taken from under the water at the margin of Loch Hallan at 073884E/821826N. The sediment here was also sandy peat. Freshwater lochs at the landward edge of the machair plain often have an acidity gradient, being more acidic farther inland, but more alkaline where they abut machair sands (Angus & Hansom 2006, 29). This sample was taken from the margin of the loch closest to the machair, so may be assumed to be from more alkaline waters, although this was not tested.

		Cladh Hallan dunes	Cladh Hallan c.10m N of houses	Grass beside Loch Hallan	Loch Hallan margin
		072941E/821849N	073143E/821999N	073879E/821826N	073884E/821826N
Ecological Group	**Taxon**				
1d	*Lauria cylindracea*		13		
	Punctum pygmaeum		2		
3	*Cepaea hortensis*		1		
	Cochlicopa lubrica	2	8		
	Limacidae sp.				1
4	*Cochlicella acuta*	77	7		
	Helicella itala	5	4		
	Vallonia excentrica	1	10		
	Vertigo pygmaea	2	4		
5a	*Galba truncatula*				3
5b	*Vertigo antivertigo*				1
5c	*Carychium minimum*				13
6a	*Anisus leucostoma*				2
6b	*Gyraulus crista*				2
	Gyraulus laevis				2
	Potamopyrgus antipodarum			5	37
	Pisidium subtruncatum				1
	Total	87	49	5	62
	Taxa	5	8	1	9
	MARINE SNAILS				
	Rissoa parva	1			
	Tricolia pullus	1			

Table 6.1: Snails from the Modern Mollusc Transect.

A total of 17 species were found, along with two species of marine mollusc (Table 6.1) Waterston (1981) lists all the species occurring in the samples as having previously been recorded on South Uist.

6.1.1 The Ecology of the Species Recorded

The following section briefly examines the species present in the samples, their characteristics and considers how they reflect the modern ecological conditions observed.

Lauria cylindracea

Associated with woods, rocks and grassland, not usually very wet places (Kerney & Cameron 1979, 93), generally western in its distribution in Britain, perhaps due to susceptibility to winter cold (Evans 1972, 151). *Lauria cylindracea* is notable in having undergone an ecological expansion into more open habitats in the Western Isles in recent centuries (Thew 2003; Evans 2004), a finding which is borne out by its occurrence here in relatively high numbers in stable grassland close to the Cladh Hallan houses (Figure 6.5).

Punctum pygmaeum

This Palaearctic species is usually found in deciduous woodlands or well vegetated wet-ground environments, but can also be present in long rank grassland if sufficiently moist (Evans 1972, 183; Davies 2008 176). It is likely to have been advantaged by the high degree of humidity in the Western Isles. Shown in Figure 6.5.

Cepaea hortensis

This species is very common in a wide variety of habitats ranging from open dunes to damp woodlands (Davies 2008, 179). It has a more northerly range in Britain than the closely related *Cepaea nemoralis*, in places where their range overlaps *C. hortensis* does not occur in dune grassland (Evans 1972, 171).

Cochlicopa lubrica

This species is found in a wide range of habitats though it is absent from very open, dry habitats (Davies 2008, 174). Davies (2008, 174) gives the example of dune grasslands as one such open, dry habitat from which *C. lubrica* is absent. The machair grassland is rather more damp than many dune systems in the British Isles, however. This snail is illustrated in Figure 6.5.

Limacidae sp.

A family of slugs, common in a variety of habitats, but generally favoured by damp conditions.

Cochlicella acuta

Associated with bare and vegetated dunes and coastal grassland (Evans 1972, 183; Davies 2008, 178). On Coll, in the Inner Hebrides, Tattersfield (1981, 77) found that *C. acuta* predominates in semi-fixed or mobile dune habitats, which is also the situation here.

Helicella itala

Found in very dry, open, exposed habitats such as short-turved grassland, vegetated dunes and scree (Evans 1972, 180; Davies 2008, 178). Restricted to coastal areas in northern Britain. Cain *et al.* (1969, 273) found that in northern Scotland, *H. itala* was most prevalent in less mature habitats in sand dunes. Tattersfield (1981, 77-78) found that the distribution of *H. itala* on Coll was not related to marram density, incline of the site, grazing pressure, degree of bare ground or soil colour.

Vallonia excentrica

Associated with dry, open environments such as short-turved grassland and vegetated dunes (Davies 2008, 176). Evans (1972, 163) records its presence in the Western Isles in damp dune areas and pastures, and notes that it is absent in the driest situations where the ground is unstable and sand actively accumulating. Shown in Figure 6.5.

Vertigo pygmaea

Found in dry, open, calcareous habitats such as grassland and dune grassland, although sometimes occurring in open wet-ground areas (Davies 2008, 174).

Galba truncatula

An amphibious species, living in wet grassland and poor freshwater habitats (Davies 2008, 168).

Vertigo antivertigo

A terrestrial snail which lives on dead leaves of sedges and under flood rubbish in lake margins (Kerney & Cameron 1979, 70). In the Western Isles, it is only present in the southern islands (Kerney & Cameron 1979, 264).

Carychium minimum

A terrestrial snail found in damp places ranging from water meadows to wet woodlands (Davies 2008, 173).

Anisus leucostoma

An amphibious snail, found in all freshwater habitats. Tolerant of seasonal drying out (Davies 2008, 168).

Gyraulus crista

Found in most lowland freshwater habitats, not tolerant of drying out (Davies 2008, 168). Common in weed beds in machair lochs (Waterston *et al*. 1979, 344).

Gyraulus laevis

Lives in clean water in closed water bodies such as lakes and ponds (Davies 2008, 168).

Potamopyrgus antipodarum

Found in all freshwater habitats. This is a very late arrival to the Hebridean fauna. It is native to New Zealand, and was first recorded in brackish water ditches of the Thames estuary in 1859 where it is believed to have arrived in barrels of drinking water stored on ships, although it may have first arrived up to twenty years previously (Chambers 2009, 65). It was first recorded in brackish lochs in North Uist in 1933 and machair lochs in Barra in 1937 (Waterston 1981, 220). Its presence in the grass beside Loch Hallan may be an artefact of winter flooding.

Pisidium subtruncatum

Figure 6.7: Pisidium subtruncatum *from Loch Hallan. Scale is in 1mm gradations.*

A bivalve pea mussel (Figure 6.7) which occurs predominantly in flowing water but also in lakes and ponds although seldom in standing water (Killeen *et al.* 2004, 104). Waterston *et al.* (1979, 344) record it as occurring in silt in Hebridean machair lochs.

A few observations may be made about the distribution of species across the different samples. Firstly, the dune sample is low diversity, as might be expected from an unstable environment. The ability of *Cochlicella acuta* to thrive in unstable dune environments is clear. There is higher diversity in the grassland sample from north of the Cladh Hallan houses. It is clear that species generally associated with dry, open habitats, especially *Helicella itala* but also *Vallonia excentrica* and *Vertigo pygmaea*, are able to live in the relatively damp machair grassland, alongside species more classically associated with shaded places, such as *Lauria cylindracea* and *Punctum pygmaeum*. This further confirms the findings of Thew (2003) and Evans (2004) about *L. cylindracea* in the Western Isles. A possible scenario is that the habitats remain damp enough, probably as a result of year-round high atmospheric humidity, to enable *Lauria* and *Punctum* to live in open grassland, but also that *Helicella*, *Vallonia excentrica* and *Vertigo pygmaea* are tolerant of dampness in the Western Isles, where true dry habitats do not exist. *Cochlicella acuta* does not appear to enjoy the same competitive advantage here as it does in the dunes.

Secondly, the absence of any terrestrial snails from the grassland sample beside Loch Hallan is puzzling, especially as the loch margin sample itself (a grab sample of submerged mud) contained snails that would be expected in grassland prone to flooding (*Carychium minimum* and *Anisus leucostoma*). This is perhaps a result of the small sample size used. The *Potamopyrgus* shells in this sample are likely to be relics of winter flooding.

The Loch Hallan margin sample contains a fauna that is representative of a calcareous marsh as well as a lake margin fauna. This may reflect seasonal waxing and waning of the shallow margins of the loch. Both *Carychium minimum* and *Vertigo antivertigo* are generally viewed as thermophiles, close to the northern limit of their present-day range in the Western Isles (Kerney & Cameron 1979, 260, 264). This sample contains the species reported by Evans (1979; see Chapter 5.1.9) from the sandy peat deposit at Borve on Benbecula (*Galba truncatula*, *Gyraulus crista* and *Pisidium* sp.), meaning they are likely to be analogous. The loch margin sample gives some indication of the kinds of species that may be found in archaeological samples from areas subject to flooding.

These findings contribute to an understanding of the range of habitats occupied by snails in the Western Isles, and will assist in the interpretation of archaeological assemblages in this study.

6.2 NORTHTON

Molluscan analysis of the two sets of samples from Northton represents the earliest material presented here. The samples were taken during two seasons of fieldwork, and represent both lateral variation across the site and a vertical sequence. The methodology varies between the two sets (snails from the earlier year had been extracted from flots at Durham University), and so the two seasons are discussed separately.

6.2.1 Introduction and Methods

A buried Mesolithic land surface at Northton, Isle of Harris, Western Isles, was investigated in 2010 by a team from Durham University led by Dr Mike Church. Shells were extracted from the flots of 5 bulk sediment samples. A Harris matrix for the excavation is presented in Figure 6.8.

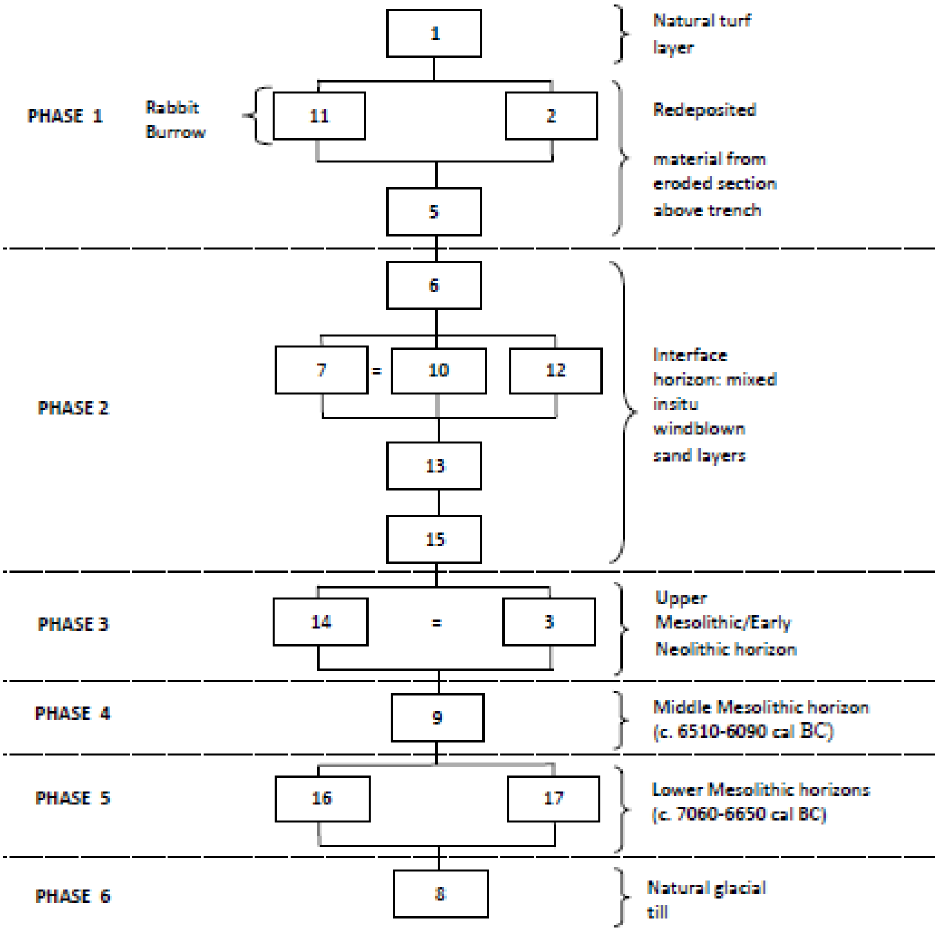


Figure 6.8: Matrix for excavation at Northton in 2010, courtesy of Dr Mike Church.

In August 2011, the Durham University team returned to Northton to carry on their investigation of the Mesolithic horizon. A vertical sequence of samples was taken by Angela Perri specifically for this study from the ground surface down to the bedrock, encompassing two deposits, blown sands (context **22** – 0-24cms below ground surface), and the buried organic horizon (context **18**- 25-41cms). A total of 9 samples, each of 1kg of sediment were taken, in 5 cm spits. These were then washed through a 500µm mesh sieve. A drawing of the section that was sampled is presented in Figure 6.9.

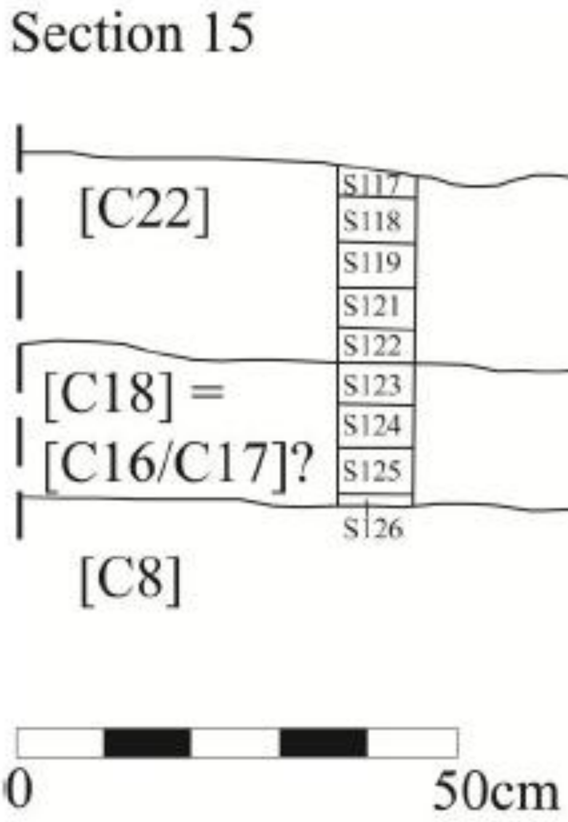


Figure 6.9. Section drawing showing snail samples from Northton, 2011.

Comparison is made to previous work by John Evans on a vertical sequence of samples from earlier excavations at Northton directed by Derek Simpson (Evans 1971; Evans 1972; Evans 1979; see also Chapter 5.1.1).

6.2.2 Results – NT10

MNI values for all species from the 5 samples from NT10 are presented within ecological groups in Table 6.2. Shells were generally well-preserved, white and opaque with the usual loss of the proteinaceous periostracum seen in sub-fossil shells. Several of the shells, including all those from Context **9** (Sample **21**) and the single shell from Context **17** (Sample **23**), maintained well-preserved periostraca and rather translucent shells, however, and so appear to be recent intrusions.

	Sample number	**S16 C3**	**S17 C14**	**S21 C9**	**S23 C17**	**S30 C13**
	Context description	**Brown layer**	**Dark brown layer**	**Midden deposit**	**Dark brown sandy soil**	**Basal horizon overlying till**
	Phase	**3a**	**3a**	**3b**	**4**	
	Date	**Mesolithic**	**Mesolithic**	**Mesolithic**	**Mesolithic**	**Mesolithic**
Ecological Group	**Taxon**					
1a	*Aegopinella pura*	1	4	0		1
	Aegopinella nitidula	1				
	Nesovitrea hammonis		7			
	Oxychilus alliarius	3	8	1		
	Oxychilus cellarius			1		
	Vitrea contracta	1				
1b	*Discus rotundatus*		5			
1d	*Euconulus fulvus*		1			
	Lauria cylindracea	1	11	2		
	Leiostyla anglica	1				
	Punctum pygmaeum		1			
	Vertigo pusilla	1				
	Vertigo substriata	1				
3	*Cochlicopa lubrica*	5	16	1		
	Cochlicopa lubricella		4	2		
4	*Pupilla muscorum*			1		
	Vallonia costata			1		
	Vallonia excentrica			1		
	Vertigo pygmaea			1		
	Cochlicella acuta		2	12	1	
	Helicella itala			3		
	Total	15	57	26	1	1
	Taxa	9	9	11	1	1

	Sample number	**S16 C3**	**S17 C14**	**S21 C9**	**S23 C17**	**S30 C13**
	Context description	**Brown layer**	**Dark brown layer**	**Midden deposit**	**Dark brown sandy soil**	**Basal horizon overlying till**
	Phase	**3a**	**3a**	**3b**	**4**	
	Date	**Mesolithic**	**Mesolithic**	**Mesolithic**	**Mesolithic**	**Mesolithic**
Ecological Group	**Taxon**					
Marine mollusca	*Rissoa parva*		1			
	Littorina sp.	1				
	Anomia sp.	1				
Marine polychaeta	*Spirorbis*			1		

Table 6.2: MNI values for snails from Northton (NT10). The shaded cells are shells judged to be recent, intrusive, snails. Marine species (three molluscs plus the calcareous tubes of Spirobis, a worm) are listed at the bottom.

6.2.2.1 Context 3 (Sample 16)

This sample has a relatively high number of taxa (9), although there is a low number of individuals of each. The high number of species present is likely to be indicative of a relatively stable environment. None of the snails appear to be modern intrusions. The assemblage is dominated by snails that are broadly indicative of shaded conditions, especially *Cochlicopa lubrica* and *Oxychilus alliarius*, most likely indicating relatively moist conditions with tall vegetation. *C. lubrica* is reasonably ubiquitous in assemblages from the Western Isles, appearing in both machair samples in the modern mollusc transect at Cladh Hallan (see Chapter 6.1, above). while *O. alliarius* is often present in low numbers.

Individual specimens of *Aegopinella pura* and *A. nitidula* are present. These are not common in Hebridean assemblages, although they do appear intermittently in Evans's (1971) Northton sequence, especially in the Beaker II horizon and within the sandy layer below the Iron Age II horizon. They indicate fairly damp, rather stable shaded locations. *Leiostyla anglica* also suggests a damp and shaded environment, and occurs at various points in Evans's Northton sequence. *Vertigo substriata* similarly suggests damp, shaded habitats. Evans (1972, 295) describes it as rupestral, living on walls and rocks, although he also notes that it also lives under stones and logs. In the 1960s Northton sequence, it appears to be favoured by periods of tall herbage, *Vertigo angustior* taking its place at times when there was short-sward grassland (Evans 1971; Nigel Thew, pers. comm.). *Vertigo pusilla* which is also present in this sample, however, prefers shaded conditions that are stable and rather dry (Davies 2008, 174-5).

Vitrea contracta is found in shaded locations as well as in fairly moist, stable short-turf grassland (Thew 2003, 171). *Lauria cylindracea* commonly lives in rupestral or woodland habitats, however it is part of the fauna of machair grassland in the present day, as seen in the modern machair grassland at Cladh Hallan (see Chapter 6.1, above, and Thew 2003, 163; Evans 2004).

Two juvenile marine shells, a juvenile winkle (*Littorina sp.*) and a jingle shell (*Anomia sp.*) were also present in this sample. They most likely represent elements of beach sand transported by wind, especially as the overlying sands are comprised heavily of comminuted fragments of marine shell.

In Evans's sequence from Northton the basal layers were sterile (Evans 1971) and this evidence, together with the low numbers of shells suggests that this assemblage is intrusive, with the shells becoming incorporated within the brown organic layer of Mesolithic age at some later time, possibly during the period of the Beaker II horizon, when after an interval with clearance and instability the area was colonised by tall herbs with trees and shrubs. This is likely to be due to biological activity within the soil.

6.2.2.2 Context 14 (Sample 17)

Sample **17** has both the highest number of individual snails (59) and the greatest number of species (10) from the samples analysed. Species broadly indicative of a shaded environment, notably *Cochlicopa lubrica* and *Oxychilus alliarius*, but also a single specimen of *Punctum pygmaeum,* are dominant. *Nesovitrea hammonis*, *Euconulus fulvus* and *Discus rotundatus* all indicate rather stable and shaded conditions. *Lauria cylindracea* typically occurs in shaded habitats among rocks or under logs (Evans 1972, 151), however as noted above at some point during the Norse or even post-medieval period, it largely replaced *Pupilla muscorum* and *Vallonia excentrica* in dry grassland habitats (Thew 2003, 163; Evans 2004). At earlier sites, however, it either points to the presence of nearby structures (e.g. Thew 2003, 170) or indicates stable conditions with denser, taller vegetation, as at Sligeanach on South Uist (Evans *et al.* 2012, 251; see also Chapter 6.3). *Cochlicopa lubricella* is reasonably common in Hebridean assemblages alongside *C. lubrica*, but usually favours slightly drier habitats.

There are also two shells of *Cochlicella acuta* present, but both have well preserved periostraca, and so appear to be recent and therefore intrusive. One of the specimens of *Lauria cylindracea* is also recent.

Overall, this assemblage, which is dominated by Group 1 taxa, is indicative of damp, tall vegetation, probably with some shrubs and trees. Despite the larger numbers of snails from this sample than **16**, above, this is again likely to be an intrusive assemblage.

A shell of the marine snail *Rissoa parva* is also present. Once again, this is likely to be a wind-blown or otherwise chance introduction from the shore.

6.2.2.3 Context 9 (Sample 21) and Context 17 (Sample 23)

All of the snails within samples **21** and **23** have well-preserved periostraca, and are therefore recent intrusions. This assemblage is dominated by Group 4 taxa typical of rather stable, dry, low-sward machair grassland, and seems likely to have become incorporated through biological action within the midden layer of Mesolithic age and the underlying dark brown organic soil at a relatively recent date, probably within the last few centuries.

The most frequent species is *C. acuta*, a species which now dominates rather dry grassy habitats on the sand dunes of western Britain, including the machair of the Hebrides (Evans 1972, 183). It was a late arrival in the British fauna, and in Evans' Northton sequence, first appears in the blown sand below the Iron Age II horizon. In addition, there are three shells of *Helicella itala* in Sample **21**, another late arrival to the Hebridean fauna, appearing in Evans' Northton sequence slightly before *C. acuta* in the blown sand between the Iron Age I and II horizons. *Pupilla muscorum*, *Vallonia excentrica*, *Vallonia costata*, and *Vertigo pygmaea* are typical of relatively stable short-sward dry grassland on the machair of the Western Isles, a habitat to which *Lauria cylindracea* also appears to have adapted relatively recently and in which *Cochlicopa lubricella* can also be found. *Pupilla* and the *Vallonias* are xerophilous in calcareous grasslands of southern England, and are adapted to conserve moisture in the exposed habitats by virtue of their relatively thick shell (Vincent 1990, 152). *Oxychilus cellarius* can also be found in low frequencies in stable grassland, but can also be indicative of middening.

Spirorbis are marine polychaete worms which build calcareous tubes on the fronds of seaweeds and on shells and stones. The single specimen of a *Spirorbis* worm tube may again have been blown in from the shore or represent the gathering of seaweed, either way it is likely to be intrusive in this context.

6.2.2.4 Context 13 (Sample 30)

Sample **30** contains only a single shell of *Aegopinella pura.* Due to its preservation in acidic basal sediment, this is clearly intrusive, and seems likely to have become incorporated within this basal layer at a similar time to the assemblages from the brown Mesolithic layers of Phase 3a.

6.2.2.5 General observations

The well-preserved snails of samples **21** and **23** are clearly recent intrusions, and will not be discussed further.

The older shells of samples **16** and **17** are also likely to be intrusions, as the basal organic layers at Northton were sterile in Evans's (1971) sequence, and are not usually conducive to the preservation of mollusc shells as they are acidic. The molluscan faunas derive from a time that there was a well-vegetated, undisturbed environment, and have presumably become conflated during a later period of aeolian activity. Open country, xerophile species such as *Vallonia excentrica*, *Vallonia costata* and *Pupilla muscorum* are absent here except as intrusions in Sample **21**. These snails tend to dominate later prehistoric assemblages in the Hebrides before the arrival of *Cochlicella acuta* and *Helicella itala*, such as Cladh Hallan (see Chapter 6.4) Sligeanach (Evans *et al.* 2012, see also Chapter 6.3); Baleshare, Balelone and Hornish Point (Thew 2003); Horgabost (see Chapter 6.6); and the Beaker I and Midden I phases of Simpson's Northton excavation (Evans 1971), which suggests that the assemblage dates from a time before the arrival of *Cochlicella* and *Helicella*.

Evans's examination of a sample series from Simpson's excavations suggested that the sandy layer below the Neolithic II horizon, rich in shade-demanding species, was indicative of a woodland environment, which was subsequently cleared – probably by humans - as evidenced by a marked rise in open-country species. Church (2006, 14) has urged caution attributing the early Northton snails from Evans's study to a woodland environment, however, as some of the species present have been found to be common in modern machair grassland, and in archaeological contexts where there are walled structures. This matches subsequent findings from prehistoric archaeological contexts in the Western Isles (Thew 2003; Evans *et al.* 2012), where the taxa judged by Evans to represent woodland conditions are more likely to be indicative of undisturbed, damp conditions with relatively tall herbage. The high number of shade-demanding taxa in these phases, however, suggests that this is more than just damp, rank vegetation.

Context **9** appears to have suffered some aeolian deflation with subsequent redeposition of later sands. The fauna from Context **9** appears to be derived from relatively dry machair grassland of Iron Age or later date – indeed the preservation of the shells would suggest relatively recent date.

6.2.2.6 Diversity indices

The assemblage in context **14** was large enough, with the intrusive *Cochlicella acuta* removed, to permit diversity indices to be calculated. These are presented in table 6.3 below. The difference between the Shannon and Brillouin indices is larger than Walker's (2014) 'break point' of 0.1, suggesting incompleteness of the sample. This reinforces the idea that the molluscs in this context are intrusive.

	S17 C14
Taxa s	9
Individuals	57
Shannon	1.935
Brillouin	1.718
Shannon-Brillouin	0.217
Simpson 1-D	0.831
Fisher's Alpha	3.006

Table 6.3: Diversity indices calculated for Context 14, Northton (NT10).

6.2.3 Results – NT11

In general, the samples contained few snails. Preservation was good, with snails towards the top of the profile maintaining their proteinaceous periostraca, which is interpreted as meaning they are intrusive. Results are tabulated in Table 6.4. The sampled contexts took in a buried organic horizon, the lower Mesolithic horizon, which was possibly analogous to Context **17** in the NT10 samples, which was unconformably overlain by windblown shell sand.

	Depth	0-5cm	6-10cm	11-15cm	16-20cm	21-24cm	25-29cm	30-34cm	35-39cm	40-41cm
	Spit Number	Spit 1	Spit 2	Spit 3	Spit 4	Spit 5	Spit 6	Spit 7	Spit 8	Spit 9
	Context	22	22	22	22	22	18	18	18	18
	Sample	S.117	S. 118	S.119	S.121	S. 122	S.123	S.124	S.125	S.126
	Context Description	Turf and sand	Turf and sand	Sand	Sand	Sand	Lower Mesolithic horizon	Lower Mesolithic horizon	Lower Mesolithic horizon	Lower Mesolithic horizon
Ecological Group	**Taxon**									
1a	*Oxychilus alliarius*						3			
	Vitrea contracta						1			
1b	*Carychium tridentatum*				1					
1d	*Lauria cylindracea*				1					
3	*Cochlicopa lubrica*				1	2	1			
4	*Vallonia excentrica*	2		1	3					
	Vertigo pygmaea				1	2				
	Cochlicella acuta	18	3		2		1			
	Total	**20**	**3**	**1**	**9**	**4**	**6**			

	Depth	0-5cm	6-10cm	11-15cm	16-20cm	21-24cm	25-29cm	30-34cm	35-39cm	40-41cm
	Spit Number	Spit 1	Spit 2	Spit 3	Spit 4	Spit 5	Spit 6	Spit 7	Spit 8	Spit 9
	Context	22	22	22	22	22	18	18	18	18
	Sample	S.117	S. 118	S.119	S.121	S. 122	S.123	S.124	S.125	S.126
	Taxa s	**2**	**1**	**1**	**6**	**2**	**4**			
	MARINE SNAILS									
	Rissoa parva					2				

Table 6.4: Snails from the vertical sample series at Northton (NT11)

The following sections describe the results in detail, starting from the earliest deposits at the base of the sequence.

6.2.3.1 Context 18, The Lower Mesolithic Horizon (25-41 cms)

The lower Mesolithic horizon was a dark greyish-brown silty sand deposit with frequent small angular fragments of gneiss. Below 30 cms depth (Spits 7, 8 and 9), this lacked any snails, and so was comparable to the basal level of Evans's (1971) Northton sequence. Between 29 and 25 cms, the first snails appear, a fauna indicative of moist tall herbage. *Oxychilus alliarius* and *Cochlicopa lubrica* were among the first taxa to arrive in Evans's (1971) sequence, *Vitrea contracta* is a slightly later arrival but still present by his Neolithic II horizon (see Chapter 5.2, above). The shell of *Cochlicella acuta* has a relatively intact periostracum and is certainly intrusive, however apart from this specimen the shells in this layer appear to represent an adventive population in a damp environment with tall vegetation.

In addition to snails, the horizon contained charcoal, two calcined fragments of fish vertebrae and, above 29 cms, a limpet (*Patella* sp.) shell, suggesting that food waste was being incorporated into the deposit.

6.2.3.2 Context 22, The Shell Sand (0-24cms)

Above 24 cms, the NT11 profile is dominated by a wind blown sand deposit. This was rich in comminuted marine shell fragments with occasional foraminifera and very rare echinoderm spines and barnacle plates. Between 24 and 21cms, this contained just 4 identified specimens, two each of *Cochlicopa lubrica* and *Vertigo pygmaea*, perhaps suggestive of open grassland. From 20 to 16cms, a more developed fauna appears, with *C. lubrica* and *V. pygmaea* joined by *Vallonia excentrica*, also indicative of open grassland, and *Lauria cylindracea* and *Carychium tridentatum*, both suggestive of moister conditions or taller vegetation. Molluscan numbers are still low, however, so this is likely to have been an unstable environment. The two shells of *Cochlicella acuta* may be intrusive at this level, indeed as there are is relatively high diversity of species compared to the number of individual snails, it seems probable that this layer has suffered some degree of conflation with other deposits.

Above 15cms, up to 11cms, there is just one shell of *Vallonia excentrica*, suggesting a very unstable deposit with rapid accumulation of sand. Between 10 and 6 cms, there are only 3 shells, all *Cochlicella acuta*, so rapid sand accumulation is likely to have been ongoing. The modern turf, from 5cms up to the present-day ground surface, affords some stability, and so rather higher numbers of *C. acuta* are found, along with 2 specimens of *Vallonia excentrica*, a situation closely analogous to the dune sample from the modern mollusc transect (Chapter 6.1).

Aside from snail shells, context **22** contained a small number of limpet (*Patella* sp.) shells and, between 11 and 15 cms, a fragment of animal bone, again suggesting that food waste was being discarded while the sediment was accumulating

6.2.3.4 General Observations

There is a low number of snails throughout the sequence, suggesting rapid accumulation. Relatively shaded, and damp, conditions are implied by the taxa present in the buried organic horizon, context **18**. Open conditions seem to predominate during the accretion of the shell sand, context **22**, overall there is a sense that the snails were living among marram grass in a windy environment where sand was frequently removed (hence the conflation between 24 and 22 cms) or deposited. At the top of the sequence, the late prehistoric arrival *Cochlicella acuta*, which is well-adapted to life among aeolian dunes, predominates, in common with the modern dunes at Cladh Hallan (Chapter 6.1)

6.3 SLIGEANACH

6.3.1 Introduction and Methods

Excavations of the Beaker period to early Bronze Age settlement at Sligeanach (South Uist) were directed by Niall Sharples. In 1998, columns of samples were taken from sections in two of the trenches. After extraction, the snail shells from columns **9071**, **9072** and **9076** were counted, grouped into Faunal Zones, and the molluscan diagrams plotted by Dan Stansbie and the late

Professor John Evans in 2003 (Figures 6.5 and 6.6). Evidence from Sligeanach was discussed in Evans (2004), which presented the molluscan diagram for sample Column **9076** from Trench G (Figure 6.11), however Evans never completed a report on the assemblage. This was written as part of the present study, in collaboration with Nigel Thew, and published as Evans *et al.* (2012). The following description of the results is largely reproduced from that report. Results are presented in the form of the two molluscan diagrams, Figure 6.11 and Figure 6.12.

Several trenches were excavated through a settlement mound, designated Mound 18 (Figure 6.10). The overall sequence consisted of four or five darker, more organic horizons, separated by layers of clean wind-blown sand. The second horizon was associated with ard marks and small sherds of Beaker period pottery, the third with ard marks and the fourth with Early Bronze Age occupation material, including pottery, and pit structures (Sharples 2012). The earliest deposits were excavated in Trench G, while Trench A cut through the latest deposits within the mound. Contexts **102** and **103** of Column 9076, in Trench G, are equivalent to Context **71**, which lay immediately below the earliest sampled context, **19**, in Column 9071, Trench A. A Harris matrix representing the stratigraphy in Trench A is presented as Figure 6.13.

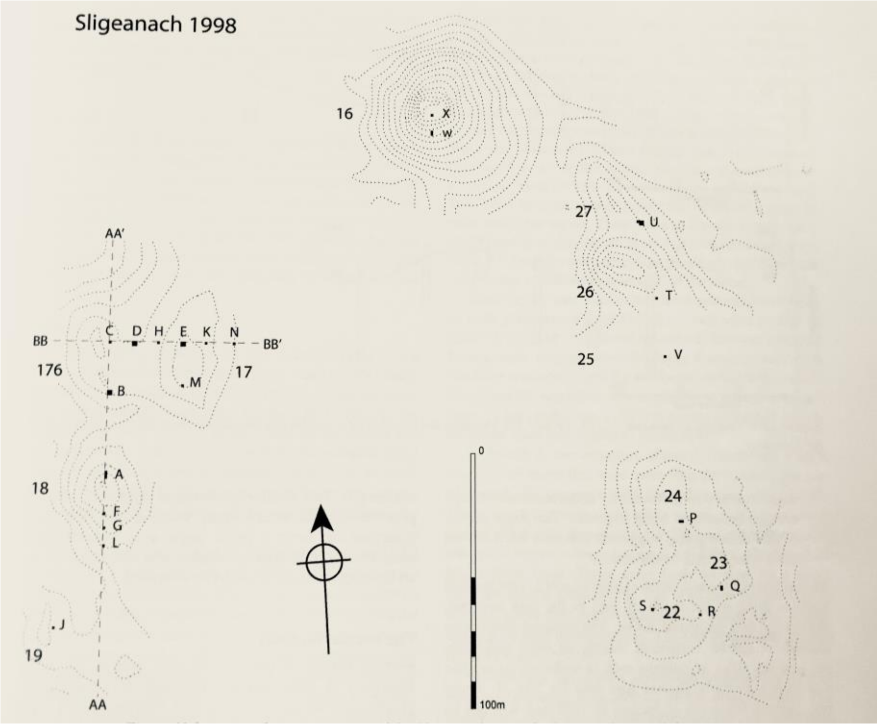


Figure 6.10: Trench locations at Sligeanach. Courtesy of Professor Niall Sharples.

6.3.2 Column 9076: Trench G

The lowest sampled deposit, the grey-orange sands, context **107**, Faunal Zone 1, had a very low number of individual snails and of species. This combination is typical of rapidly accumulating dry wind-blown sand with poor vegetation cover. The succeeding layer, pale grey sands (context **106**), has a slightly more abundant fauna, indicating slower sand accumulation and greater stability, associated with a somewhat denser but still patchy cover of grassland (Faunal Zone 2).

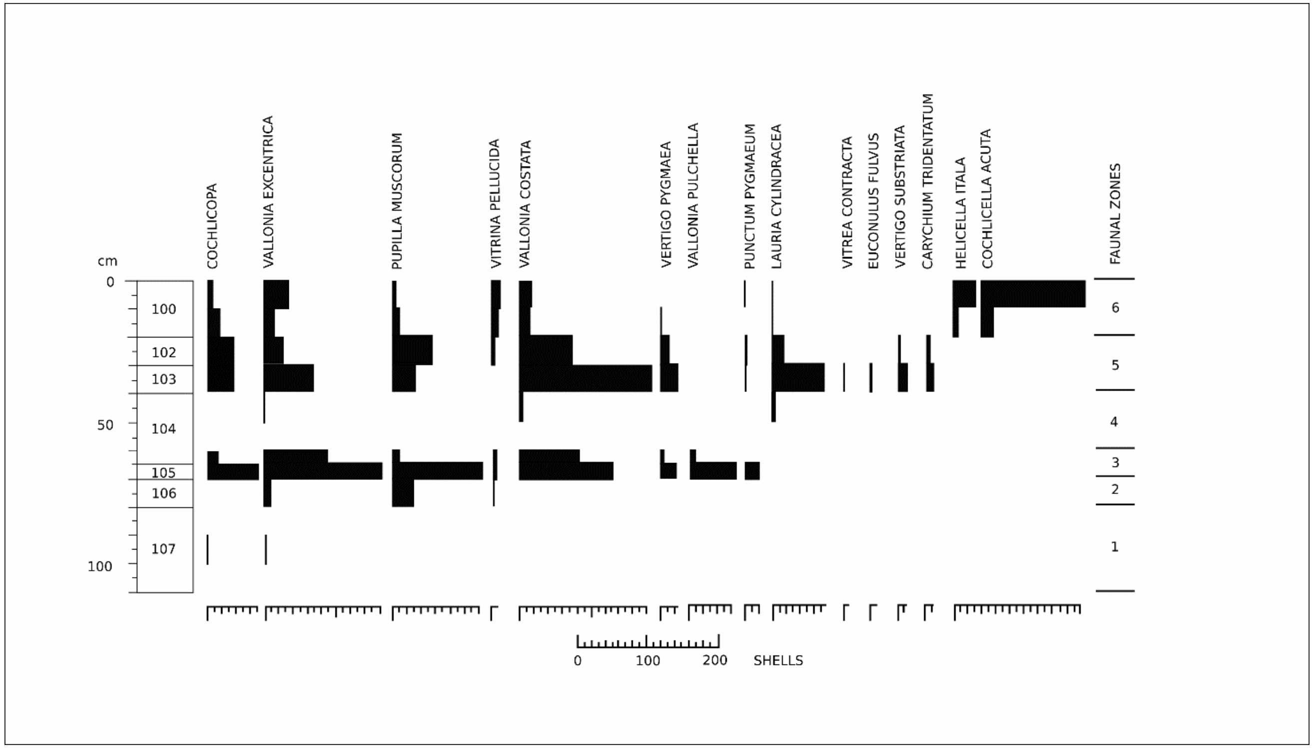


Figure 6.11: Molluscan diagram for sample column 9076 at Sligeanach. Redrawn from Evans et al. (2012).

The orange yellow sands of context **105** have a much more abundant snail fauna, with peaks in *Pupilla muscorum*, *Vallonia excentrica*, *V. costata, V. pulchella* and *Cochlicopa* spp., accompanied by less common *Punctum pygmaeum* and *Vertigo pygmaea*, pointing to still greater stability and a covering of fairly dry, short-turf, probably sheep grazed grassland (Faunal Zone 3). The fact that there was no organic horizon recorded here suggests that it was removed by subsequent erosion, consistent with the succeeding layer of clean, yellow wind-blown sand (context **104**), which includes shells redeposited from the previous soil horizon in its basal part (Faunal Zone 3), but which then has virtually no shells, suggesting an absence of vegetation and rapid deposition in dry conditions (Faunal Zone 4). The abrupt change to the more organic sands of context **103** indicates a return to more stable conditions, although this layer is associated with ard marks and therefore represents a ploughsoil. Nevertheless, the 11 species in this layer represent a peak in molluscan diversity for the sequence. Although dominated by grassland taxa, the numerous *Vallonia costata*, fairly abundant *Lauria cylindracea*, along with the presence of more shade-demanding species like *Carychium tridentatum* and *Vitrea contracta*, suggest that the ploughing regime was non-intensive, with significant fallow periods between episodes of ploughing when taller herbs were allowed to grow (Faunal Zone 5).

Context **102**, brown organic sands, has a similar fauna (also Faunal Zone 5), but the decreases in *V. costata* and *L. cylindracea*, together with a rise in *Pupilla muscorum*, might suggest that ploughing had given way to short-turf grazed grassland, though some patches with tall herbs remained. Given the extremely organic nature of contexts **102** and **103**, it seems likely that some organic material was added to the surface, which might explain the presence of *Vertigo substriata*, which prefers fairly damp conditions. This organic material was probably of vegetable origin, as few animal bones and none of the omnivorous snail species *Oxychilus alliarius* were found in the assemblages. The absence of small marine gastropods indicative of the spreading of seaweed, and of marsh plus freshwater aquatic molluscs that would have been introduced with reeds or rushes cut from the edges of nearby freshwater lakes and marshes, means that the plant material may have been either straw or tall herbs gathered from nearby. This could have been used for matting, roofing, or bedding for animals, which would explain the presence of small sherds of pottery. Alternatively, this organic material might have been animal excrement, or more likely a mixture of these elements.

Columns 9071 and 9072: Trench A

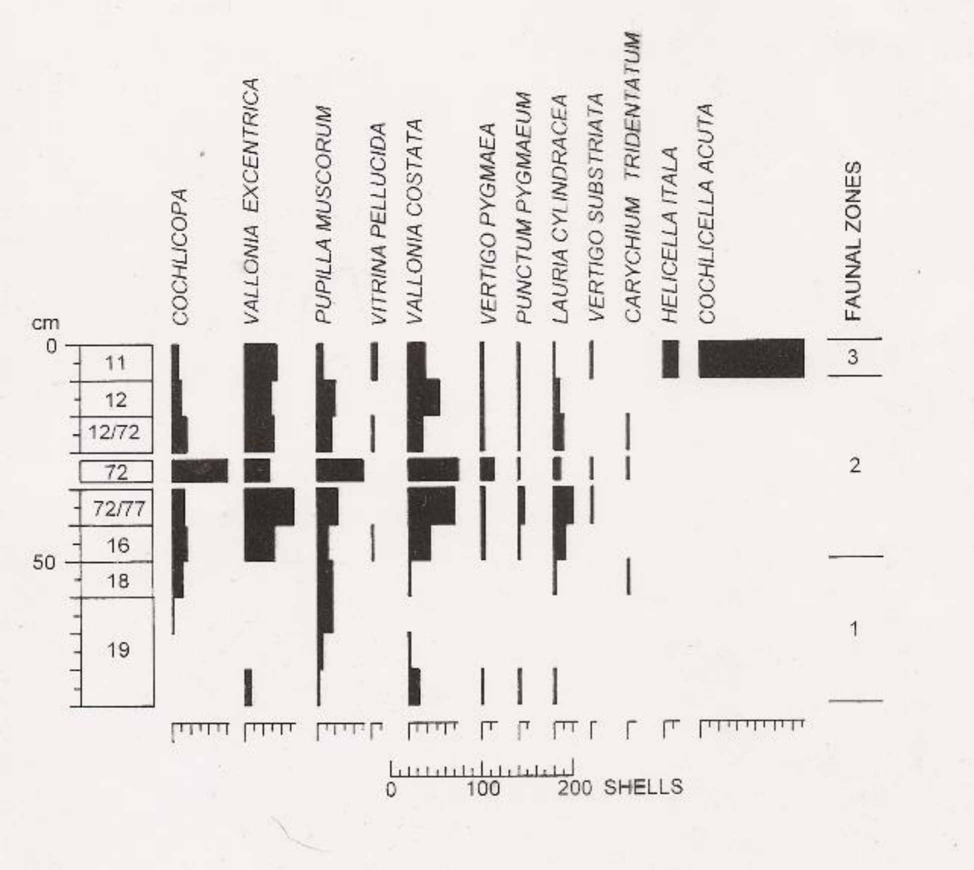


Figure 6.12: Snail diagram for sample column 9071/2, Sligeanach. Reprinted from Evans et al. (2012).

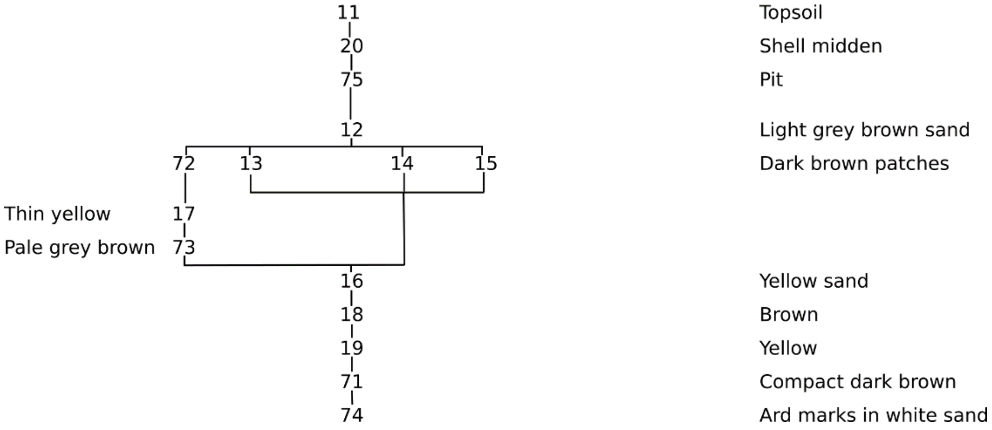


Figure 6.13: Stratigraphic matrix for Trench A, Sligeanach. Redrawn from a hand drawing by Niall Sharples.

Context **71**, a compact dark brown sand at the base of Column **9071** (not sampled), which in turn overlies a whitish sand with ard marks, is equivalent to contexts **102** and **103** of Column **9076** and is therefore a plough-soil. The succeeding layer, context **19** (Faunal Zone 1 of Column **9071**), is a clean, yellow, wind-blown sand with very few snails. In its basal part, this sand includes a variety of snail species probably redeposited from the eroded surface of the underlying plough-soil, whereas the middle and upper parts have just three species, typical of poor, tall grass vegetation growing on dry, accumulating, dune sands. The succeeding context, **18**, is a compact, dark brown organic soil, again associated with ard marks. The origin of this layer is probably similar to that of contexts **102** to **103**, with the presence of *Carychium tridentatum* indicative of taller herbs, though the fauna is numerically much poorer, suggesting more intensive ploughing activity. Moreover, there is little archaeological material possibly advocating a different origin for the plant material spread over the cultivated surface, though marine, marsh and freshwater molluscs were again absent. The yellow sand that follows (context **16**) indicates a brief period of blown sand accumulation, although the snail assemblage is very similar to those from the overlying deposits and can thus be considered with them. Context **77** is a dark organic layer, context **72** a grey sand and context **12** another dark organic soil. These three contexts are inter-layered in a complex series of deposits associated with Early Bronze Age settlement activity.

An additional sample, from context **72** in Column **9072**, has been inserted in the mollusc diagram. Important increases in both snail abundances and species diversity are linked with notable rises in *Pupilla muscorum*, *Vallonia excentrica*, *Vallonia costata*, *Cochlicopa* spp. and to a lesser extent *Lauria cylindracea*, accompanied by smaller numbers of *Punctum pygmaeum*, *Vertigo pygmaea*, *V substriata* and *Carychium tridentatum* (Faunal Zone 2). The picture that emerges is of both increased stability, associated with short-turf grassland, and some disturbance linked with the accumulation of organic material and patches of tall herbs, together with damper surface conditions. Again, the absence of *Oxychilus*, marine shells, marsh taxa and freshwater molluscs, shows that the organic material was probably of vegetable origin and/or animal excrement, but did not include seaweed, or reeds and rushes cut from nearby freshwater lakes and marshes.

The top of the sequence in Columns 9071 and 9076

In both columns, there is a very important hiatus that coincides with an erosion surface at the base of the subsequent layer. This layer includes the modern turf horizon. In column **9076** this layer is 20 cm thick (context **100**), while in **9071** it is just 10 cm thick (context **11**), suggesting that in the former column the lower 10 cm represents an earlier part of the same layer not represented in **9071**. Indeed, the assemblage from the base of context **100**, although it closely resembles those from the summit of **100** and from context **11**, with which it belongs, has far fewer shells, suggesting that much of the sample was made up of wind-blown sand. These three assemblages (Column **9076** Faunal Zone 6, Column **9071** Faunal Zone 3) are rather diverse, with 11 species represented. These include very abundant *Cochlicella acuta*, frequent *Vallonia excentrica*, and significant numbers of *Helicella itala*, *Vallonia costata*, *Pupilla muscorum* and *Cochlicopa* spp. The relative abundance of *Vallonia excentrica* suggests that the relatively deep turf horizon (10 cm) was probably formed over a fairly considerable period, with intervals of more stable short-turf, relatively damp (*Vertigo substriata*), grazed grassland (with *Vertigo pygmaea* and *Punctum pygmaeum*), alternating with phases of less stable, taller grassland associated with wind-blown sand, as *Cochlicella* is particularly well adapted to such a biotope, being able to climb the stems of marram grass to avoid the accumulating sand particles.

Overall, the majority of the sampled sequences at Sligeanach are without *Cochlicella acuta* and *Helicella itala*, with these two species appearing in abundance after the hiatus at the base of contexts **100** and **11**. The faunal sequences at the sites of Baleshare, North Uist, Hornish Point, South Uist (Thew 2003, 167), and Northton, South Harris (Evans 1971; Evans 1979, 20), suggest that these species arrived in the Western Isles towards the end of the Late Bronze Age or early in the Iron Age, and then became widespread at stage some time during the Iron Age. Their abundance at the top of the sequence at Sligeanach, above the Early Bronze Age occupation level, fits with this chronology.

When compared with contemporary snail assemblages from Northton, South Harris (Evans 1971) and from the small island of Ensay (Spencer 1974), which lies between South Harris and North Uist, the molluscan assemblages from Sligeanach are seen to be rather poor in terms of species diversity, with a maximum of just 11 non-marsh terrestrial taxa in the Beaker period to Early Bronze Age deposits. At Northton species diversities for the same time interval reach 18 non-marsh taxa, while Ensay has similarly diverse faunas.

It is worth noting that there is no evidence in the snail assemblages from Sligeanach for the use of seaweed to fertilise and stabilise the machair surface. There is also an absence of marsh and aquatic snails at Sligeanach, which suggests that the site was not prone to flooding, and so a good choice of location for year-round occupation in the Early Bronze Age. There is evidence of increased dampness in the Beaker period levels, however, which may be due to a change to a wetter climate regime. Increased use of midden material on agricultural land would also have the effect of encouraging the favoured species, however.

6.4 CLADH HALLAN

6.4.1 Introduction

The site of Cladh Hallan was excavated between 1994 and 2001 by a team from Sheffield, Cardiff and Bournemouth Universities led by Mike Parker Pearson, Jacqui Mulville and Helen Smith. The excavation focused on three terraced Late Bronze Age roundhouses. Flots of samples were examined from midden deposits containing Late Bronze Age to Early Iron Age pot sherds, as well as from the floors of two roundhouses, **1370** and **401**. Roundhouse 1370 lay to the north of the settlement, and roundhouse 401 was the central house. House 401 was occupied for the longest period of time, however all the samples examined relate to Phase 9, dated from 1200-1000 BC (Mike Parker Pearson, pers. comm.). 30 samples were analysed from across the midden deposits, as well as 28 from the floors of House 1370, and 35 from House 401. The distribution of samples across the house floors is shown below in Figures 6.10 and 6.11. Results are presented in Appendix 2.

Diversity indices were calculated for samples containing more than 50 shells in the midden deposits, and Detrended Correspondence Analysis carried out. No statistical analyses were carried out on the housefloor deposits as too few samples contained more than 50 shells.

6.4.2 Middens

Mollusc shell preservation was good in the midden deposits, although most of the samples have rather low numbers of individuals, and low numbers of taxa present. This tends to indicate rapid accumulation and sealing of deposits (see discussion of Northton NT 11, Chapter 6.22). Classically (for example at Evans's (1971) sequence from Northton), this would be taken as symptomatic of increased storminess leading to increased sand accumulation. In this case, however, as the deposits are anthropogenic, it seems likely that the rapid deposition of contexts and their subsequent sealing is due to human agency. It is probable that there is some degree of reworking of shells in these contexts.

Peak numbers of individuals, with reasonably high numbers of taxa, are reached in samples **4674** (Context **742**), **4676** (Context **736**), **4076** (Context **313**) and especially **4077** (Context **921**). This implies a stable environment, with slow accumulation of sediment.

Taken as a whole, the midden deposits are dominated by Group 4 taxa, indicative of dry, open conditions, and Group 3 taxa, which are usually grouped as catholic, tolerant of a wide range of habitats. In particular, *Vallonia excentrica*, *Pupilla muscorum* and *Cochlicopa lubrica* dominate many of the samples. The first and last of these are present in machair grassland at Cladh Hallan to the present day (see Chapter 6.1, above). *Pupilla* has declined in the Western Isles, however, perhaps as a result of competition with *Cochlicella acuta* and/ or *Helicella itala*. In mainland Britain, it is indicative of short-sward, dry grassland, although it is also present in floodplain environments (Davies 2008, 175), which are perhaps more closely analogous to the damp grassland of the Western Isles.

Group 1 taxa, indicative of shaded conditions, are present intermittently throughout the assemblage. *Oxychilus alliarius*, which is present in low numbers in machair grassland, is an omnivorous species and may be drawn to midden material (Thew 2003; see Chapter 5.6). Of the Group 1 taxa, *Lauria cylindracea* dominates. This is often a rupestral species, found on stones, and may well have been exploiting the habitat offered by the presence of the houses at Cladh Hallan.

Vitrina pellucida, which is not commonly preserved due to its fragile shell, occurs in a relatively high number (10) in sample **4071**. Its preservation is likely to be indicative of an undisturbed context that was quickly sealed, while its presence probably indicates dampness.

Helicella itala and *Cochlicella acuta* occur only in low numbers, and are probably intrusive throughout this assemblage. The dominance instead of other open country Group 4 taxa such as *Pupilla* and the *Vallonia spp*. replicates the situation found at Sligeanach (Chapter 6.3), and adds evidence to the argument for their arrival in the Iron Age in South Uist.

The presence in low numbers of *Galba truncatula* and *Zonitoides nitidus* in various contexts may be indicative of winter flooding, however apart from *G. truncatula* in sample **4073**, context **904**, they occur in samples with both a low number of taxa and of individuals. There is therefore a chance that they have been introduced into these contexts by human activity, perhaps the dumping of herbaceous or otherwise organic material from wetter areas toward Loch Hallan.

Three of the *Galba truncatula* in sample **4073**, and the *Lauria cylindracea* in sample **3296** (Context **1975**) are burnt. Their burning and subsequent incorporation into these contexts may be due to the cutting and burning of turves or peat from the back of the machair plain, and the subsequent incorporation of fire ash and sweepings into the middens.

Marine gastropods were present in 11 of the 30 samples. In many cases, these may be a natural component of the wind-blown sand, however they may also be indicative of the use of seaweed as a fertiliser or consolidant, especially when they are intact, relatively unworn shells, and not found in association with large numbers of fragmented shells or foraminifera.

Overall, the picture is one of rapid deposition and probable reworking of older deposits with allochthonous inputs, perhaps sweepings. Some stable, relatively short grassland develops around the midden areas, however.

6.4.3: House 1370 floor

Figure 6.14: Location of samples for snail analysis from house floor context 2211. Shaded polygons represent stones, unshaded polygons are voids in the floor deposit. Redrawn from the original field plan, which was provided by Professor Mike Parker Pearson.

Twenty-eight samples from floor deposits in **House 1370** (context **2211**), the northernmost of the Cladh Hallan houses, were analysed (for distribution of samples, see Figure 6.14). Generally, these contained low numbers of snails from low numbers of taxa. A small number of snails are likely to have been a natural component of the house floor fauna, others may have been introduced on materials brought into the house. The group 4 taxa, especially *Pupilla muscorum*, dominate. These open ground taxa, which prefer drier environments, are particularly likely to have established small populations within the house. Due to the small size of these snails, these populations would have been almost completely imperceptible to the inhabitants. *Clausilia bidentata*, represented by a single shell in sample **4082**, a sample taken beside the internal wall of the house, is a rupestral species likely to have been living on the wall.

6.4.4: House 401 floor

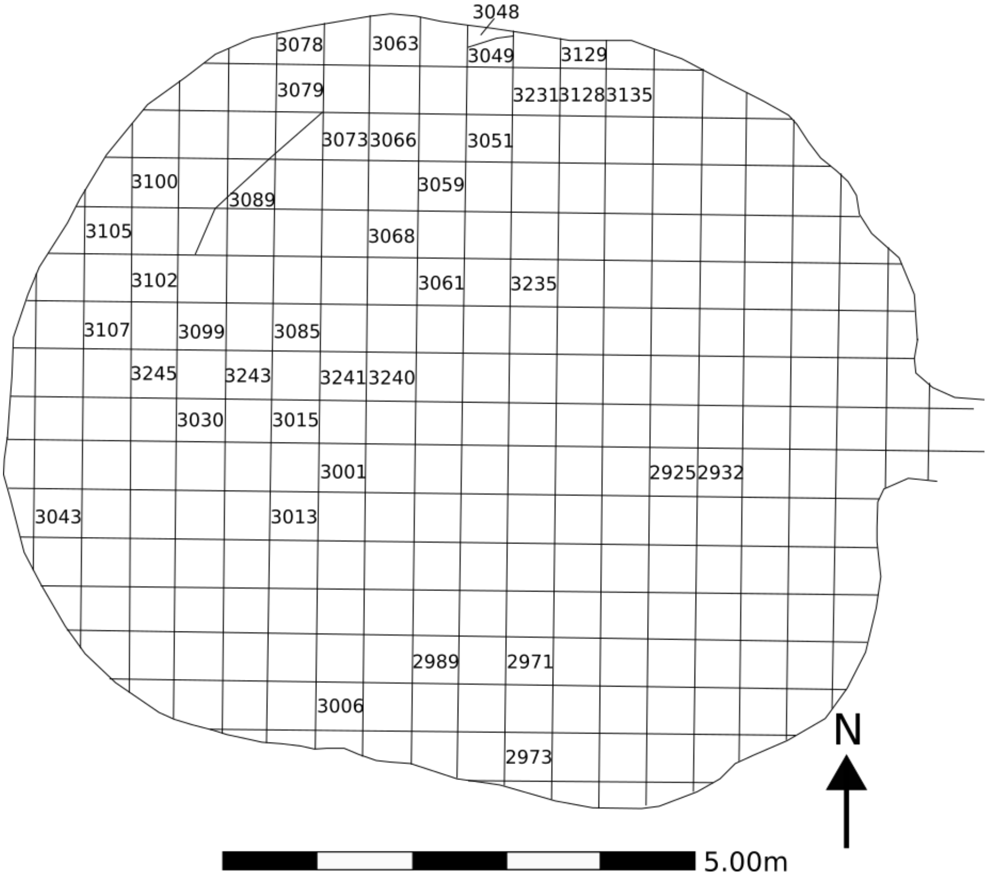


*Figure 6.15: Plan of **House 401** floor showing samples selected for molluscan analysis. Redrawn from an original field drawing provided by Professor Mike Parker Pearson.*

Thirty-five samples from floor deposits in **House 401** (contexts **1311**, **1624**, **1690**, **1698**, and **1705**), a LBA/EIA double-roomed roundhouse, were analysed (for distribution, see Figure 6.15). Once again, these generally contained a low number of snails, with Group 4 taxa, especially *Pupilla muscorum*, dominating the assemblage. Three samples, **3063**, **3079**, and **3135** (all context **1311**), contained over 100 shells, however. All three samples are dominated by *Pupilla muscorum*, but also show reasonable diversity. Sample **3063** seems to derive from a more complex habitat, with reasonably high numbers of *Oxychilus alliarius* (17) and *Lauria cylindracea* (9) suggesting taller herbage and increased humidity at ground level. The presence of 4 shells of *Littorina saxatalis* and 2 *Rissoa parva*, both marine species, suggests that there might have been some seaweed introduced to the house. It is possible that this area of the house was associated with the stabling of animals, the snails deriving in part from the favourable environment that would have existed here, and in part from plant material introduced as fodder or bedding. A similar scenario can be envisaged for sample **3135**. Here there are also two shells, a *Galba truncatula* and a *Vertigo antivertigo* (two species that are present in the modern sample from the margin of Loch Hallan discussed in Chapter 6.1) that have been introduced from a flooded, marshy context, perhaps in more fodder or stabling material, or perhaps roofing material. Both of these samples sit against the northern wall of the house (Figure 6.14) Sample **3079** predominantly contains shells of Group 4 taxa, although the presence of *Oxychilus alliarius* may once again indicate the presence of manure.

Sample **3015** (context **1690**) has strong suggestions of shade, perhaps taller vegetation, with four shells of *Discus rotundatus* present, as well as individual specimens of *Aegopinella pura* and *Vitrea contracta.* This may be stabling material again, as the presence of *Galba truncatula* suggests material from a wet context. The three examples of *Clausilia bidentata* and perhaps also the solitary *Lauria cylindracea* could be living amongst taller vegetation, or on the roundhouse wall.

6.4.5 Diversity indices

Diversity indices were calculated for 6 samples containing more than 50 snails from the midden deposits (Table 6.5). The difference between the Shannon and Brillouin indices, seen as an indicator of the 'completeness' of the sample, is low in samples **4676**, **4674**, **4077**, and **4076**, which would suggest a relatively complete assemblage with minimal taphonomic mixing. The value is especially high in sample **4078**, which has a relatively low number of individuals compared to the number of taxa present, which is likely to be a sign that individuals are missing from the assemblage or that the assemblage is conflated from more than one deposit.

The value of Fisher's Alpha is also much higher in sample **4078**, while it is low in **4077**, a sample in which all the other indices reach their peak values. It seems to be the most strongly influenced by the relative number of taxa and individuals. Points on the graph where Fisher's Alpha varies independently of other indices may thus be strong indicators of taphonomic mixing (high Fisher's Alpha value), or compositional fidelity (low Fisher's Alpha value).

Sample	**4676**	**4674**	**4078**	**4077**	**4071**	**4076**
Context	**738**	**742**	**922**	**921**	**902**	**913**
Taxa s	5	7	10	11	8	5
Individuals	81	106	54	572	75	101
Shannon	1.209	1.118	1.535	1.713	1.444	0.6372
Brillouin	1.123	1.031	1.334	1.675	1.309	0.5765
Shannon-Brillouin	0.086	0.087	0.201	0.038	0.135	0.0607
Simpson	0.6478	0.4621	0.7147	0.7674	0.7004	0.2843
Fisher's Alpha	1.178	1.683	3.61	1.932	2.267	1.105

Table 6.5: Diversity indices calculated for the midden deposits at Cladh Hallan.

6.4.6 Detrended Correspondence Analysis

Detrended Correspondence Analysis of the samples with more than 50 shells (Figure 6.16) shows a gradient along Axis 1 from relatively open conditions to more shaded conditions to the right, where *Discus rotundatus* and *Punctum pygmaeum* are to be found. Some of the ordinations appear to be artefacts of the highly variable number of individuals, however, as *Pupilla muscorum* would be expected to occur on the left of such a group, and certainly not to the right of *Nesovitrea hammonis*, *Vitrina pellucida*, *Euconulus alderi* and *Oxychilus alliarius*.

Coding the results following the example of Rousseau (1987) removes much of the extreme numerical variation (Figure 6.17). Axis 1 now accounts for much less of the variation, however, and Axis 2 accounts for almost as much. In this case, the ordination does not seem to have divided the snails into meaningful groups. It is likely that the taphonomic mixing identified during analysis of diversity indices makes this an unsuitable assemblage for ordination analysis.

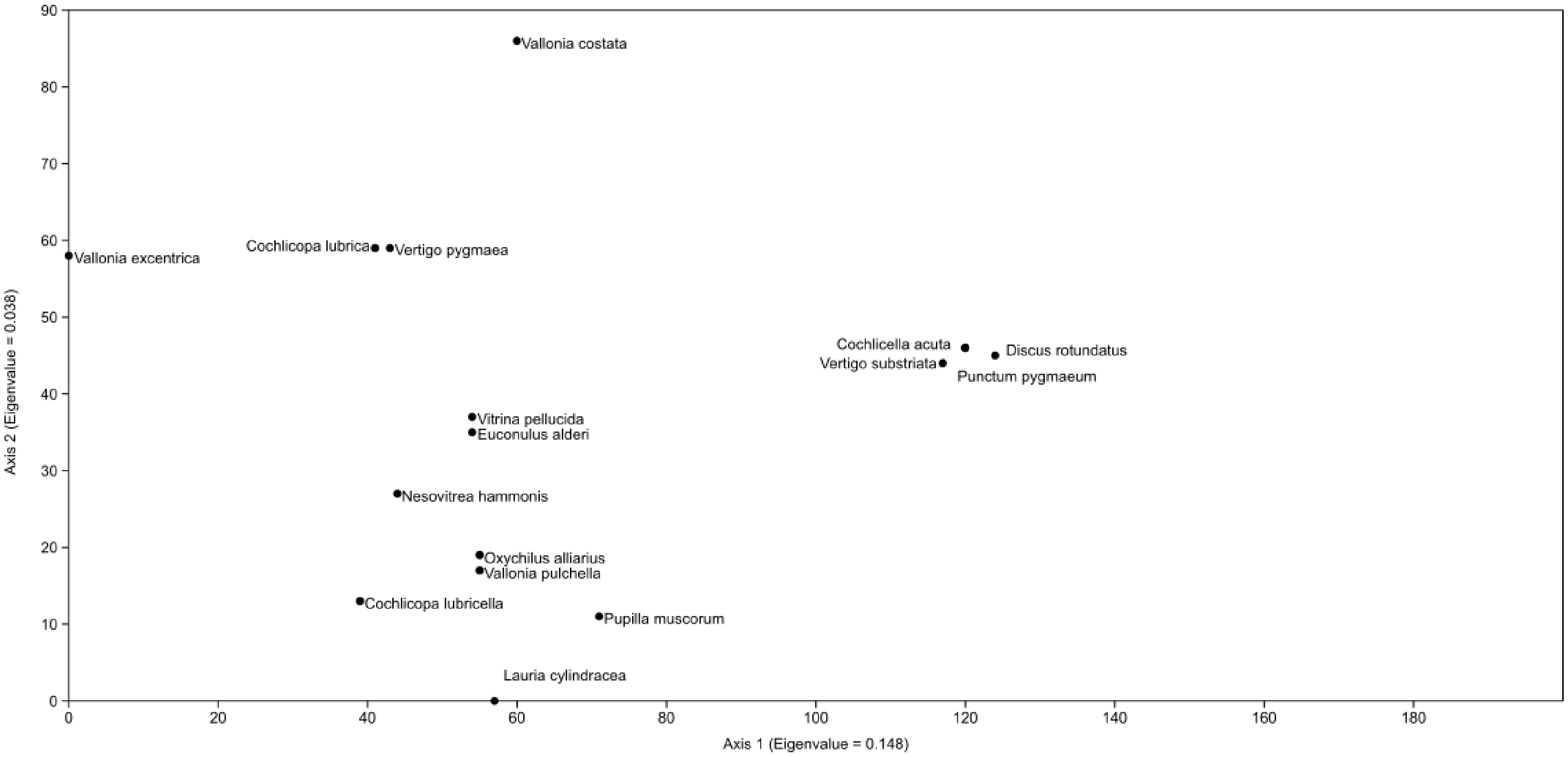


Figure 6.16: Detrended Correspondence Analysis of samples from the middens at Cladh Hallan.

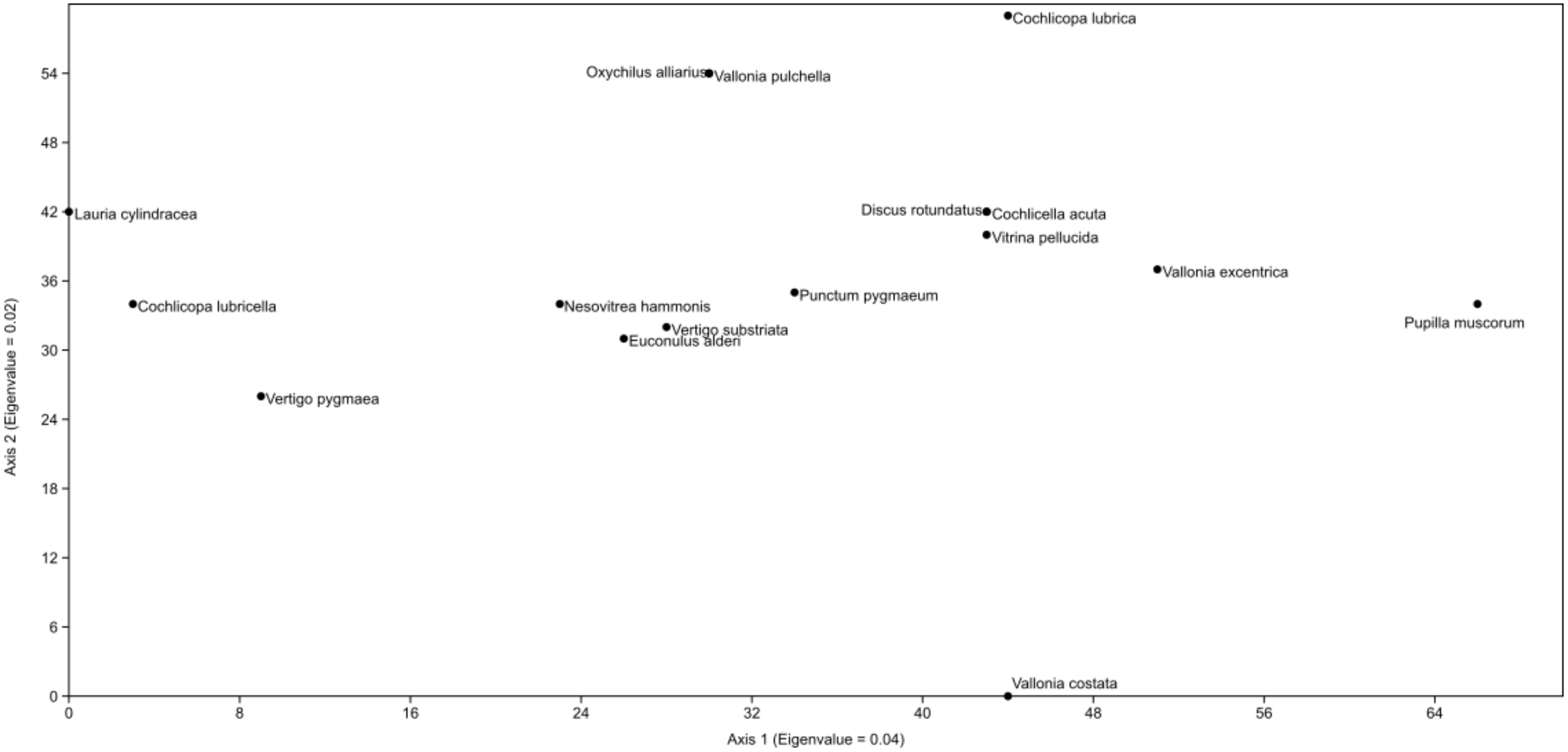


Figure 6.17: Detrended Correspondence Analysis of samples from the middens at Cladh Hallan, coded following Rousseau (1987).

6.4.7 General observations

The Cladh Hallan assemblages present a hitherto unique opportunity to look for spatial variation among snail assemblages from prehistoric house floors in the Western Isles. Unfortunately, samples from House 1370 yielded rather low numbers of snails. In general, the samples seemed to reflect a broader environment of grazed grassland. *Clausilia bidentata*, a rupestral species often associated with walls was likely to be exploiting the topography of the house. House 410 was occupied for a longer amount of time, and has a more complex fauna, perhaps suggesting the incorporation of material from areas of longer vegetation and potentially the use of the house for stabling. It is worth remembering, however, that LaMotta and Schiffer (1999, 22) cautioned that house floor deposits generally can only be expected to reflect abandonment rather than the full period of occupation (see Chapter 2.2, above). In the case of Hebridean roundhouses, where sandy floors are likely to have kept accumulating sediment through the occupation period (indeed, fresh sand may have been deliberately added) this may not be such a problem.

Various inputs appear to have contributed to the midden deposits, and this is reflected by the diversity indices and lack of clarity in the ordination obtained through detrended correspondence analysis. There is a constant presence of species indicative of short grassland across all the samples, which is likely to reflect the wider environment. The assemblage predates the establishment of *Helicella itala* and *Cochlicella acuta*.

6.5 ALLASDALE

6.5.1 Introduction and Methods

The site at Allasdale on Barra was excavated by Time Team in 2007 to investigate a number of Early Bronze Age cist burials as well as stone structures that included a possible Neolithic house and two Iron Age roundhouses eroding out of sand dunes (Wessex Archaeology 2008). A radiocarbon date was available for context **302**, a cist grave (Table 4.2). Molluscs from the excavation of the Bronze Age cists and Iron Age roundhouse and midden were discussed in brief by Dr Chris Stevens (Wessex Archaeology 2008, 24-25). Fuller examination of the flots of 7 samples was possible during the present study. The relative position of the four evaluation areas is presented in Figure 6.18.

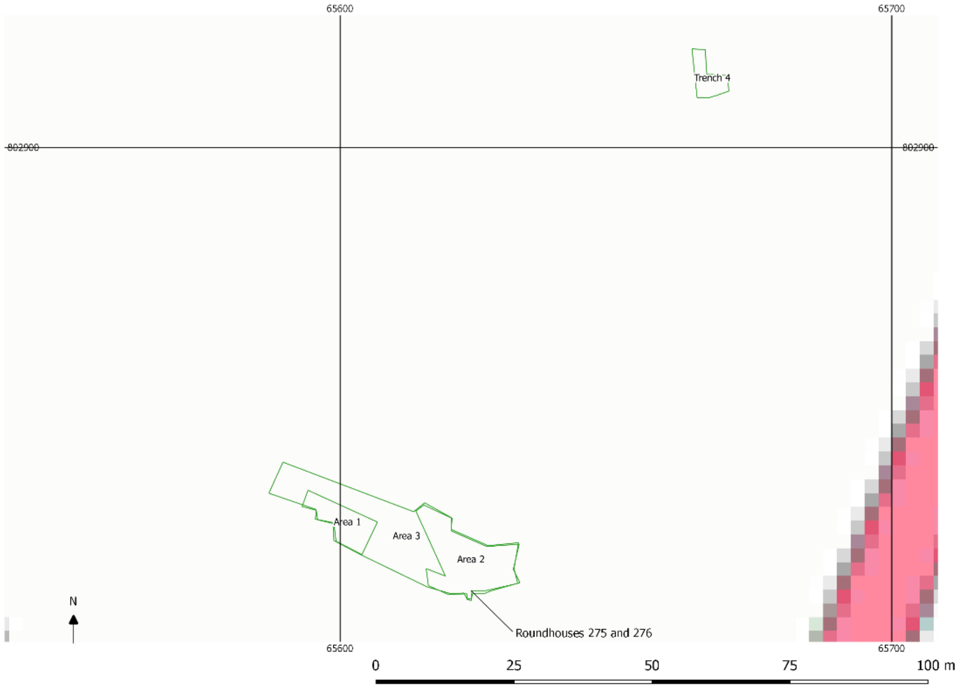


Figure 6.18: Plan showing the relative location of the evaluation areas at Allasdale.

6.5.2 Results

Results are presented in Table 6.6. Preservation was good throughout all the samples. Details of the radiocarbon date are presented in Table 6.7, taken from Wessex Archaeology (2008, Table 1).

		Context	**124**	**212**	**124**	**301**	**216**	**228**	**408**
		Sample	**2**	**4**	**10**	**31**	**7**	**no number**	**14**
		Period	**Early Bronze Age**	**Early Bronze Age**	**Early Bronze Age**	**Early Bronze Age (1730-1520 cal BC)**	**Early Iron Age**	**Early Iron Age**	**Late Iron Age**
		Description	**Cremation deposit**	**Cremation deposit**	**Cremation deposit**	**Cremation deposit**	**Possible early floor**	**Infilling of roundhouse**	**Midden**
Ecological Group	**Taxon**								
1a	*Nesovitrea hammonis*						1		4
	Oxychilus alliarius		1					2	8
1d	*Lauria cylindracea*			1					11
	Euconulus fulvus			1					
	Punctum pygmaeum			1					
3	*Cochlicopa lubrica*		3	1	3		4	2	16
4	*Cochlicella acuta*			4					
	Helicella itala			1				3	5

		Context	**124**	**212**	**124**	**301**	**216**	**228**	**408**
		Sample	**2**	**4**	**10**	**31**	**7**	**no number**	**14**
		Period	**Early Bronze Age**	**Early Bronze Age**	**Early Bronze Age**	**Early Bronze Age (1730-1520 cal BC)**	**Early Iron Age**	**Early Iron Age**	**Late Iron Age**
		Description	**Cremation deposit**	**Cremation deposit**	**Cremation deposit**	**Cremation deposit**	**Possible early floor**	**Infilling of roundhouse**	**Midden**
Ecological Group	**Taxon**								
	Pupilla muscorum			9					
	Vallonia excentrica		14	14		1	4		
	Vertigo pygmaea		3		1				7
5a	*Galba truncatula*			3					2
5b	*Oxyloma elegans*								1
	Vertigo antivertigo						1		
	Vertigo angustior			1					
5c	*Carychium minimum*		1						
	Total		22	36	4	1	10	7	54
	Taxa s		5	10	2	1	4	3	8

		Context	**124**	**212**	**124**	**301**	**216**	**228**	**408**
		Sample	**2**	**4**	**10**	**31**	**7**	**no number**	**14**
		Period	**Early Bronze Age**	**Early Bronze Age**	**Early Bronze Age**	**Early Bronze Age (1730-1520 cal BC)**	**Early Iron Age**	**Early Iron Age**	**Late Iron Age**
		Description	**Cremation deposit**	**Cremation deposit**	**Cremation deposit**	**Cremation deposit**	**Possible early floor**	**Infilling of roundhouse**	**Midden**
Ecological Group	**Taxon**								
	MARINE SNAILS								
	Rissoa parva			11		1	1		
	Tricolia pullus			1					1
	(Rissoa - ribbed)		3	*					1
	Littorina saxatalis								1
	Littorina obtusata								1

Table 6.6: Results of snail analysis from Allasdale, Barra. Shaded cells represent shells judged to be intrusive.

Laboratory Number	Sample Reference	Material	Radiocarbon age	δ^{13}C (‰)	Reported calibrated age range (95% confidence) (Recalibrated date in grey)
NZA 28254	302	Human bone	3342±30	-19.5	1730-1520 cal BC (1731-1532 cal BC)

Table 6.7: Radiocarbon results from Allasdale, reproduced from Wessex Archaeology (2008, Table 1).

6.5.3 Bronze Age Cremation Deposits

The deposits containing Bronze Age cremations (contexts **124**, **212** and **301**) contain a relatively low number of snails, dominated by Group 4 taxa, especially *Vallonia excentrica*. Context **212** has a rather more diverse fauna, albeit with a low number of individuals (n = 36). Tall, damp vegetation is implied by the presence of *Punctum pygmaeum* and *Euconulus fulvus*, and flooding may be implied by *Galba truncatula* and *Vertigo angustior*. There are shells of *Cochlicella acuta* and *Helicella itala*, the two late prehistoric arrivals in the Western Isles fauna, present in this context, however, which are likely to be intrusive judging by the preservation of their periostraca (Figure 6.19). It seems probable that there has been some overlying sand eroded from above this cremation, creating a conflation deposit. There are also a few small marine gastropods in this context. These are all below 1.5mm in their largest dimension, and are likely to be part of the windblown shell sand. The low numbers of taxa and individuals in cremation deposits **124** and **301** are much more suggestive of rapidly sealed deposits and less likely to be significantly mixed by subsequent erosion or deposition.

Figure 6.19: Shells of Cochlicella acuta *(left) and* Helicella itala *from Context* ***212****, Allasdale (there is a* Vallonia excentrica *shell visible within the* Cochlicella *shell.*

6.5.4 The Middle Iron Age House and Midden

A possible early floor deposit, context **216**, has four specimens of *Cochlicopa lubrica*, four *Vallonia excentrica* and one *Nesovitrea hammonis*. This low-number, low-diversity assemblage suggestive of reasonably short vegetation may well be part of the household fauna, as they would be able to live among domestic detritus on a sandy floor. The shell of *Vertigo antivertigo*, a marsh species, is likely to be allochthonous, however, and is probably indicative of herbaceous material being brought into the house from a loch margin or dune slack, a similar situation to that at Cladh Hallan.

The deposit infilling the roundhouse, context **228**, contains three *Helicella itala*, two *Oxychilus alliarius* and two *Cochlicopa lubrica*, an assemblage of snails that are typical of machair grassland. The low numbers suggest a history of active erosion and deposition, and it may be that the assemblage is considerably mixed, or much later than Middle Iron Age.

The midden deposit, **408**, contains the highest number of snails, and is dominated by *Cochlicopa lubrica* and *Lauria cylindracea* with reasonably high numbers of *Oxychilus alliarius* and *Vertigo pygmaea*. *O. alliarius* is an omnivorous species particularly attracted to midden material, while *C. lubrica* and *V. pygmaea* are often found in dry, open environments. *L. cylindracea* which prefers damper more shaded habitats, may be favoured by the relatively higher humidity at ground level created by the midden. *Galba truncatula* and *Oxyloma elegans* are associated with wet conditions, such as flooded areas, however it is more likely that plant material from a marshy environment was being introduced to the midden rather than the middens directly flooding.

6.5.5 Diversity indices

The sample from context **408**, the Middle Iron Age midden, contained enough individuals to permit analysis of diversity indices. Results for these are presented in Table 6.8. The difference between the Shannon and Brillouin indices is quite high, suggesting that there has been some mixing of fauna in this sample. This is to be expected from a midden deposit, especially when there is a suggestion of snails being carried into the midden deposit from marshy environments away from the site.

Taxa *s*	8
Individuals	54
Shannon	1.841
Brillouin	1.636
Shannon - Brillouin	0.205
Simpson	0.8162
Fisher's Alpha	2.596

Table 6.8: Diversity indices calculated for context 408, Allasdale.

6.5.6 General Observations

The samples from Allasdale represent the only archaeological snail assemblage analysed from Barra at present. The composition of the fauna nonetheless resembles that of samples from Harris and the Uists. Across the different sites a largely open, but damp, environment predominated, with some flooding. The Middle Iron Age house floor contained some elements that may have been favoured by the locally shaded environment of the house, and a potential indicator of imported material from a marshy context, whilst the midden deposits contain the omnivore *Oxychilus alliarius*, which Thew (2003) noted would be attracted to midden material. Inputs are relatively mixed in this deposit, as suggested by the diversity indices.

6.6 HORGABOST

6.6.1 Introduction and Methods

The first century AD settlement site at Horgabost, Harris, Western Isles, was excavated by a team led by Kevin Colls and Professor John Hunter, then of the University of Birmingham. Flots from two samples, one from the single fill of a large posthole or pit, and one from a red black burnt clay deposit associated with a hearth, were found to contain snails and were submitted for analysis.

6.6.2 Results

Absolute counts for all species from the two samples are presented within ecological groups in Table 6.9. In general, the molluscs were well-preserved, with the usual loss of the proteinaceous periostracum seen in sub-fossil shells. None of the shells appeared to be modern intrusions.

	Context	**1061**	**1020**
	Sample number	**5**	**9**
	Sample size (litres)		
Ecological group	**Taxon**		
1a	*Nesovitrea hammonis*	1	1
	Oxychilus alliarius	1	
	Vitrina pellucida		7
1b	*Carychium tridentatum*	4	6
1d	*Acanthinula aculeata*		8
	Lauria cylindracea	1	4
	Vertigo substriata		1
3	*Cochlicopa lubrica*	2	15
	Cochlicopa lubricella		8
4	*Cochlicella acuta*	1	
	Pupilla muscorum		1
	Vallonia costata	5	10

	Context	**1061**	**1020**
	Sample number	**5**	**9**
	Sample size (litres)		
Ecological group	**Taxon**		
	Vallonia cf excentrica	16	45
	Vertigo pygmaea		3
	Total	**31**	**109**
	Taxa s	8	12
	Seaweed snails		
	Cingula semistriata	2	3
	Rissoa parva	5	28
	Tricolia pullus		1
	Skeneopsis planorbis		1

Table 6.9: Snails from Horgabost

6.6.3 Sample 5, Context 1061

Sample **5** was taken from within a red-black burnt-clay deposit associated with hearth **1066**, dating to the first century AD. Despite being recovered from a deposit of burnt clay, none of the shells appeared to be charred, which suggests that they probably accumulated soon after the kiln was abandoned. The assemblage is dominated by *Vallonia excentrica*, with lesser numbers of *Vallonia costata*, *Carychium tridentatum* and *Cochlicopa lubrica*. This points to a stable grassland environment with some taller herbs, suggesting that this part of the site had become abandoned. The presence of the omnivorous snail *Oxychilus alliarius* as well as specimens of the small marine gastropods *Rissoa parva* and *Cingula semistriata* may indicate that middening was taking place, with seaweed and domestic refuse being spread over the surface of the machair. The recovery of a single shell of *Cochlicella acuta* suggests that this species had not yet come to dominate the machair (cf. Thew 2003).

6.6.4 Sample 9, Context 1020

Sample 9 was taken from the single fill (**1020**) of a large posthole or small pit. It contains a fairly rich fauna (109 shells) from a relatively large number of terrestrial species (12). In general, larger frequencies of snails and higher numbers of snail species reflect slower sedimentary deposition in more stable conditions that encourage greater molluscan diversity. Most of the shells in this assemblage will either have been reworked from the deposit(s) that the post-hole/pit was cut through or have accumulated while the feature was open, which probably includes some time after the post-hole/pit had ceased to function. Therefore, they reflect conditions over a longer period of time than the feature was in use. The assemblage as a whole suggests stable grassland (frequent *Vallonia excentrica*, presence of *Vertigo pygmaea*) with significant frequencies of tall herbs (*Carychium tridentatum*, *Cochlicopa lubrica*, *Nesovitrea hammonis*) and perhaps even scattered bushes (*Acanthinula aculeata*). There are species typical of both damp (*Vertigo substriata* and *Vitrina pellucida*) and dry (*Cochlicopa lubricella*) habitats. The former may well have taken advantage of damper conditions within the depression left by the infilling post-hole/pit. The presence of several specimens of *Lauria cylindracea* may suggest that there was a walled structure or broken ground nearby, as this deposit predates the period when *Lauria* expanded its ecological range into open grassland habitats (cf. Evans 2004, 371). Significant numbers of small marine snails are also present, suggesting that seaweed was being spread onto the land surface or being used in some other way near this feature, although *Tricolia pullus* is represented only by a fragment of shell, suggesting it is more likely to be a component of the wind-blown shell sand.

6.6.5 Diversity indices

The assemblage from context **1020** was large enough to permit the calculation of diversity indices, with the marine gastropods excluded. These are presented in Table 6.10. The difference between the Shannon and Brillouin indices is indicative of an incomplete sample, which suggests a mixed input into the sample. This is to be expected from the pit fauna, which is likely to represent a mixture of snails reworked from the sediment the pit was cut through, and those exploiting the pit environment while it is open or filling.

	1020
Taxa s	12
Individuals	109
Shannon	1.926
Brillouin	1.763
Shannon-Brillouin	0.163
Simpson 1-D	0.7819
Fisher's Alpha	3.442

Table 6.10: Diversity indices calculated for snails from context 109, Horgabost.

6.6.6 General Observations

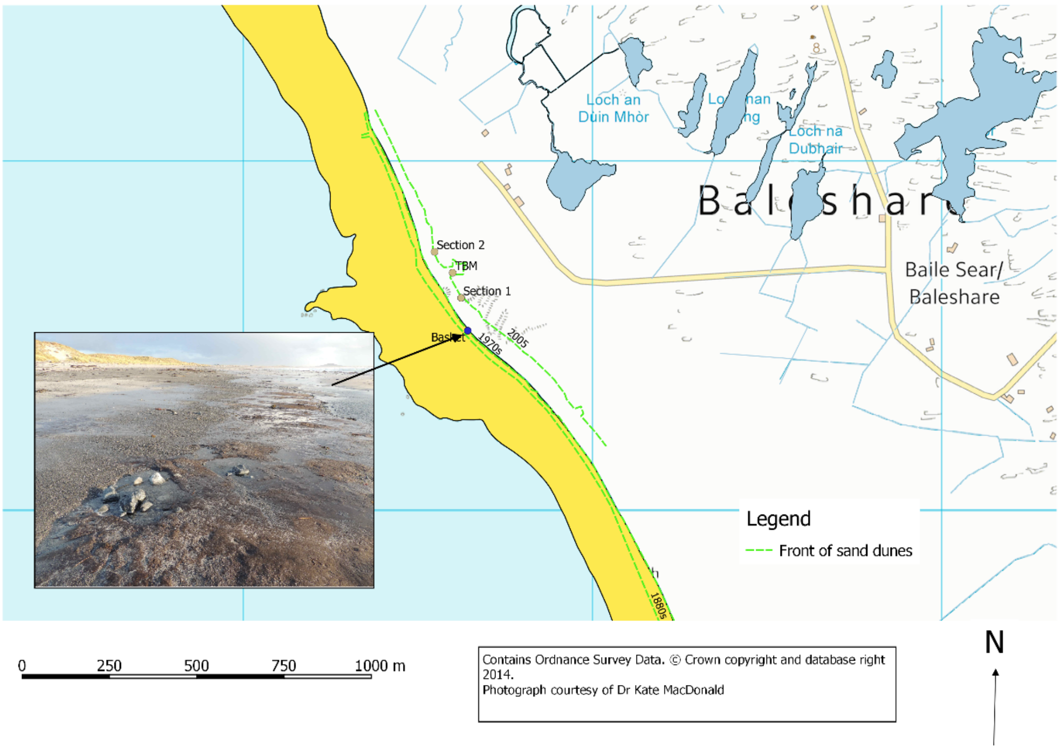
The snails from the two contexts at Horgabost suggest that at times a stable grassland environment with tall herbs was allowed to colonise parts of the site.

Only one shell of *Cochlicella acuta* is present in these samples. As noted above, it is a late prehistoric addition to the Hebridean snail fauna, and went on to dominate mollusc populations on the machair grassland. At Northton, further south on Harris, *Cochlicella acuta* appeared within the Iron Age II horizon (Evans 1971, 59). Its virtual absence from the Horgabost samples suggests that they colonised this part of Harris no earlier than the first century AD.

6.7 CEARDACH RUADH, BAILE SEAR

In September 2014, an eroding wheelhouse and midden deposit were sampled at the coast on Baile Sear at a location known as Ceardach Ruadh, the Red Smithy (James & Duffy 2003, 43). The site lay immediately to the north of the Baleshare site excavated in the 1980s by the Central Excavation Unit (James & Duffy 2003), whose snails were analysed by Thew (2003). That site is now lost to the sea. Marine erosion has been extensive along the Baile Sear coast – indeed the name Baile Sear translates to ‘the east village’ (James & Duffy 2003, 43). Figure 6.20 shows the extent of coastal erosion at Ceardach Ruadh between the first edition Ordnance Survey of 1881 and 2005 Google Earth satellite imagery. At the point of Section 1, the land had retreated some 60 metres since

1881, and at Section 2 it had retreated 51 metres. These figures may not be wholly accurate, as errors may have arisen from georeferencing the Google Earth imagery, as well as from the positional accuracy of the original 1881 and 1970s Ordnance Survey maps (Heywood *et al*. 2006, 140).



Contains Ordnance Survey Data. © Crown copyright and database right 2014.
Photograph courtesy of Dr Kate MacDonald

Figure 6.20: Erosion of the coastline at Ceardach Ruadh since 1881.

Two sections were recorded and sampled (Figure 6.20). The first, at 077624E/ 861608N, comprised a long vertical sequence spanning from clean sand underlying a midden deposit with abundant shells, context **112** (see also Chapter 7.3), up to the modern dune sand, context **100**. The second, at 077548E/861740N, was a shorter sequence opportunistically sampled adjacent to what appeared to be a collapsed wall, and comprised a red sandy clay floor deposit, overlain by clean sand, which in turn was overlain by a midden deposit. A subsequent gale in November 2014 removed the sand from the beach in front of these sections, revealing a peat deposit and a waterlogged wooden basket containing animal bones and quartz pebbles, suspected to be of Iron Age date (Kate MacDonald, pers. comm.).

Dr Becky Rennell (University of the Highlands and Islands and Uist Archaeology) provided the level, tripod and staff. The height of the temporary bench mark above Ordnance Datum was obtained using a differential GPS system by staff from AOC Archaeology in November 2014 by arrangement with Dr Kate MacDonald (Uist Archaeology). The animal bone recovered from the site was subsequently identified by Dr Jennifer Jones (University of Cantabria) and Dr Richard Madgwick (Cardiff University). A table of animal bone identifications with number of fragments by context is included as Appendix 5. Dr Alan Lane (Cardiff University) commented on the ceramics. Description of the contexts recorded, and their inclusions, follows.

6.7.1 Section 1

6.7.1.1 The Stratigraphic Sequence

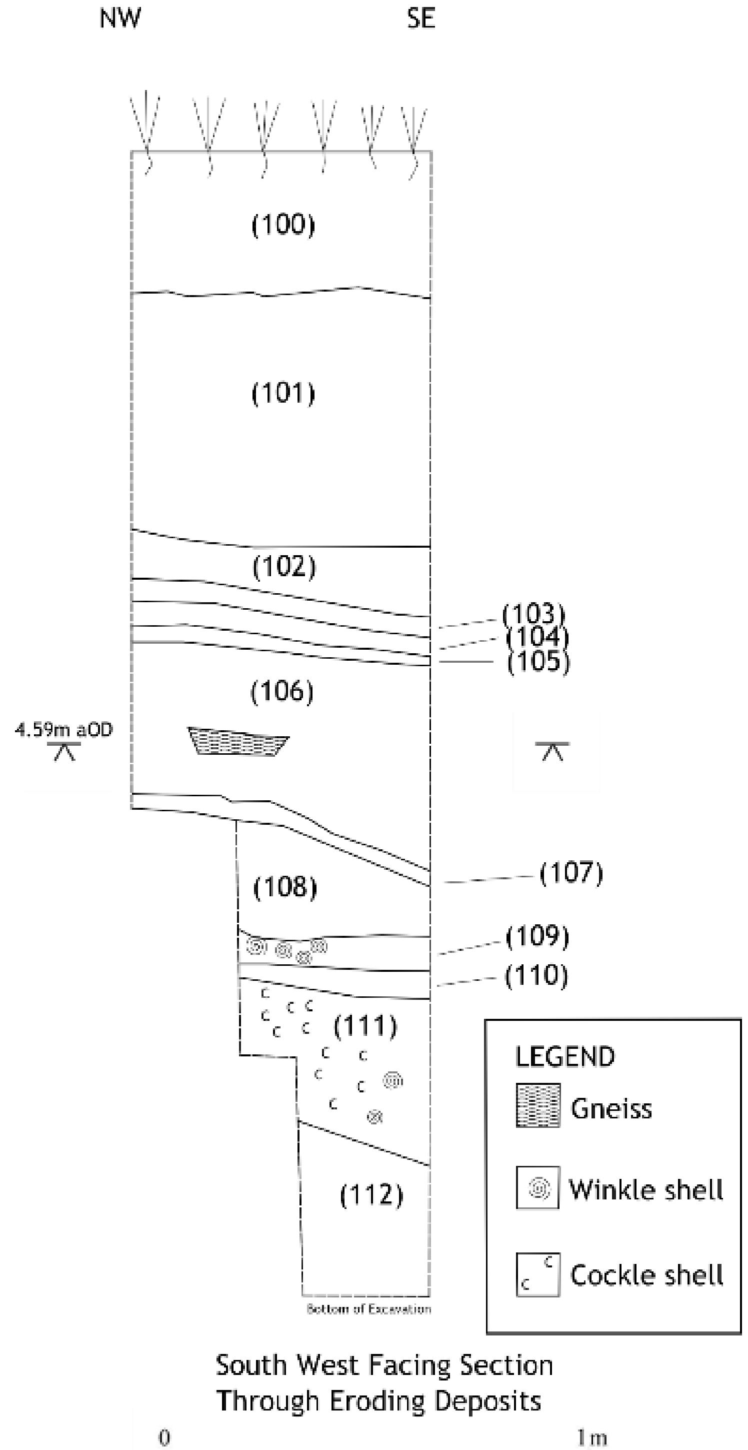


Figure 6.21: Section drawing showing the eroding deposits at Section 1, Ceardach Ruadh

Figure 6.22: Looking north east at Section 1, Ceardach Ruadh. The area featured in Figure 6.20 is at the bottom centre of the picture. The top two scale bars are 1 metre.

At the bottom of the excavated sequence at Section 1 was a clean yellow windblown sand, context **112**. This was excavated to a thickness of 0.40 metres, although it appeared to continue below that depth, in a small shovel pit 0.30 metres wide that was excavated at the base of the sequence. Sample **17** from this deposit contained part of the tibia, pelvis and the incisor of a sheep or goat; a fragment of a cattle scapula was also hand collected from this context. This was overlain by the main midden deposit, **111**, a dark yellow sand up to 0.40 metres thick, with abundant cockle shells (Figure 6.23). Sample **16** from this deposit contained a fragment of the mandible or maxilla of a large mammal, and sample **15**, also from this deposit, contained the radius of a rat. The deposit also contained two fragments of the ribs of a medium mammal, part of the radius of a large mammal and the lower first or second molar of a cow, at a medium stage of wear.

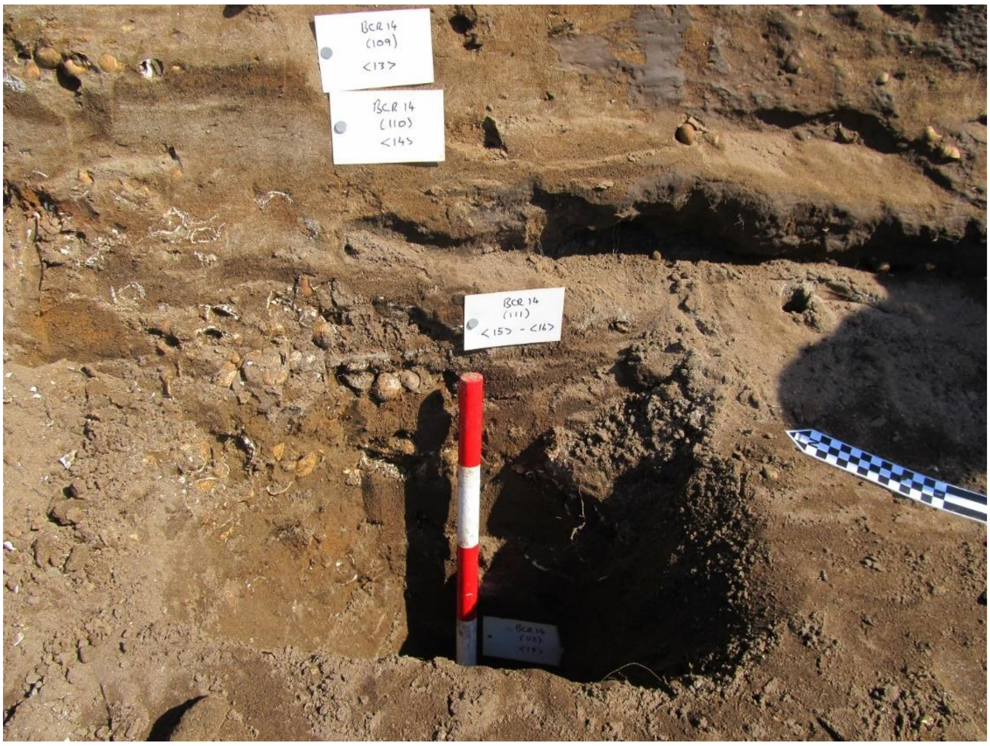


*Figure 6.23: Detail of the main midden deposit, context **111** at Section 1, Ceardach Ruadh, looking NE.*

Overlying this was relatively clean pale yellow windblown sand, context **110**, which was 0.06 metres thick. Sample **14** from this sample contained unidentified bone fragments. This sand underlay the upper midden deposit, context **109**, a dark blackish brown sand with moderately frequent winkle shells. This was up to 0.08 metres thick.

This was sealed by a thick pale yellow sand, context **108,** which was up to 0.28 metres thick. Sample **12,** from the bottom half of this deposit, contained part of a cattle metapodial and tibia, as well as a calcareous tube of *Spirorbis spirobis* (Linnaeus, 1758), a marine polychaete worm found on *Fucus spp.* seaweeds (Knight-Jones *et al*. 1995, 266). The unworn condition of this tube may suggest that it became incorporated into the sediment on a frond of seaweed which has since decomposed, rather than being a stray component of windblown sand. Sample **11**, from the top half of the deposit, contained part of the femur or humerus of a large mammal.

Overlying this deposit was a red, probably burnt, sand, context **107,** which was up to 0.04 metres thick. Sample **10** from this sand contained part of the tibia of a sheep and a tibiotarsus of an unidentified bird. This sample also contained an undecorated pot sherd showing a grass impression and another with a false rim, actually a construction join (Figure 6.24). This might date to the 6th to 9th century A.D. (Dr Alan Lane, pers. comm.). The lower first or second molar of a sheep at a mid-wear stage was hand collected from this context.

*Figure 6.24: False rim on a pot sherd from Context **107** at Ceardach Ruadh, Baile Sear*

Overlying this was a thick dark yellow windblown sand, context **106**, which was up to 0.50 metres thick. Sample **9**, from the bottom half of this deposit contained the patella of a sheep or goat and an unidentified fish vertebra, and sample **8** from the top half of this deposit contained two fish vertebrae. This context also contained a sherd of pot showing a construction join at more of an angle than that of the sherd from **107**, possibly suggesting a Norse date (Dr Alan Lane, pers. comm.).

This was overlain by a sequence of three very thin deposits that appeared burnt. The lowest of these was a red sand, context **105**, which was 0.20 metres thick. A sample of this context, **7,** contained a murid (mouse) lower incisor, small fish vertebrae and a small bird phalanx (Figure 6.25). Above this, context **104** was a dark greyish brown sand that was 0.06 metres thick. Sample **6** from this context contained a charred grain and a caprine (sheep or goat) incisor, as well as sheep or goat rib fragments. This in turn was overlain by another red sand, context **103**, which was 0.05 metres thick. Sample **5** from **103** contained parts of the ribs of a sheep or goat.

*Figure 6.25: Bird phalanx from context **105**. Small squares are 1mm.*

This sequence was overlain by a thicker burnt deposit, a blackish sand up to 0.16 metres thick, context **102** (Figure 6.26). This contained part of the pelvis of a juvenile sheep or goat, part of the rib of a sheep or goat, and the radius of a sheep or goat which had been gnawed, perhaps suggesting slow incorporation into the deposit.

Figure 6.26: Middle section of Section 1, Ceardach Ruadh, looking NE. Scale bar = 0.50 metres

At the top of the sequence was a thick yellow sand deposit with some shell and bone, context **101.** This was up to 0.41 metres thick. Sample **3** from the bottom half of this deposit contained part of the tibia of a sheep or goat that had possibly been gnawed, and sample **2** from the top half of this deposit contained part of the humerus of a juvenile sheep or goat. The uppermost deposit at Section 1 was a modern whitish yellow sand, context **100**, which was uncomformable with **101** and appeared to derive from downslope mass movement of the dunes. This deposit was up to 0.32 metres thick, and stabilised at the top by growth of marram grass (Figure 6.27).

Figure 6.27: Upper part of the Section 1 sequence at Ceardach Ruadh. Scale is 0.50 metres

6.7.1.2 The Snails

Samples of 1.5kg were taken through the sequence from each identified context from top to bottom, taking care to avoid contamination. These were washed through a 500μm mesh sieve and extracted and identified under a low-power binocular microscope. A small number of marine shells were hand-collected during cleaning of the section as well, one of these contained sand with a terrestrial snail shell inside. Results are presented in Table 6.11, below.

		Context	100	103	104	106	111	111
		Sample	1	5	6	9	16	Hand collected
		Description	Windblown sand	Burnt red sand layer	Burnt greyish-brown sand	Wind-blown sand	Midden deposit	Midden deposit
Ecological Group	**Taxon**							
1a	*Oxychilus alliarius*				1		3	
1d	*Lauria cylindracea*		1					
2	*Cepaea hortensis*		4				4	1
4	*Pupilla muscorum*			2		1	3	
	Vallonia costata			1	1			
	Cochlicella acuta		63					
5a	*Galba truncatula*				1			
	Total number of individuals		68	3	3	1	10	1
	Taxa s		3	2	3	1	3	1
	MARINE SNAILS							
	Cingula semistriata						1	
	Rissoa parva							1

Table 6.11 The snails from Section 1, Ceardach Ruadh, Baile Sear.

The lower midden deposit, **111**, was rich in marine shell (see Chapter 7.3, below), but contained just 11 shells from three terrestrial species, including one juvenile *Cepaea hortensis* (listed in Table 6.11 above as hand-collected but actually contained within a sand matrix within a hand-collected cockle shell). This rather small fauna suggests that the midden deposit was rather rapidly sealed, in contrast to those at Cladh Hallan (Chapter 6.4), Allasdale (Chapter 6.5), or at Freswick in Caithness (O'Connor 1987). *Oxychilus alliarius* is an omnivore that would have been attracted to midden material, while *Pupilla muscorum* and *Cepaea hortensis* are elements of machair grassland, although both much scarcer in the Western Isles in modern times.

Snails are absent from the rapidly deposited and sealed deposits samples of the layers overlying Context **111** - clean windblown sand **110**, upper midden deposit **109**, clean windblown sand **108**, and burnt sand deposit **107**.

There is a lone *Pupilla muscorum* shell in sand deposit **106** (a pot sherd recovered from this layer suggests that it is likely to be of Norse date), and no snails in burnt sand **105**. Burnt sand **104** contains three shells (*Oxychilus alliarius*, *Vallonia costata* and *Galba truncatula*) that may indicate a mixed input, perhaps through human agency. The frequent occurrence of marsh taxa like *Galba truncatula* in samples from the 1980s Baleshare excavation lead Thew (2003) to conclude that the site was prone to flooding.

The overlying burnt deposit **103** contains two *Pupilla* and one *Vallonia costata*, suggestive of an open environment, although the very low numbers suggest instability and rapid sealing of the deposit. Burnt sand **102** is devoid of snails as is wind-blown sand **101**.

The modern dune sand **100** at the top of the sequence contains 1 *Lauria cylindracea*, 3 juvenile *Cepaea hortensis* and 63 *Cochlicella acuta*, a fauna fairly typical of modern dune system grasses (see Chapter 6.1), and further evidencing the shift in ecological preferences undertaken by *Lauria cylindracea* over the past few centuries (Evans 2004).

As a whole, the sequence suggests a very active regime of erosion and deposition, at different points aeolian or anthropogenic in origin, which has not been conducive to the establishment of rich mollusc populations.

6.7.2 Section 2

6.7.2.1 The Stratigraphic Sequence

Figure 6.28: Section 2 after cleaning, looking north east. The collapsed wall can be seen in the foreground. The scale bar is 0.50 metres.

Section 2 was 152 metres north west of Section 1. The section was opportunistically sampled after a pot sherd was seen in the section. Stone protruding from the section showed that it was inside a building, and cleaning revealed this to be a wall which was initially thought to be one of the radiating stone piers of a wheelhouse (Figure 6.28). Due to height differences, a second

TBM, with a height of 3.27m above Ordnance Datum, was established shoreward of the section on a large flat piece of pink gneiss.

At the bottom of the section, with a surface at 4.35m aOD, was a floor deposit, context **203**. This was a pinkish red sandy clay with frequent charcoal. This was cleaned over an area that extended 0.60 metres north-south and 0.54 metres east-west. Sample **20** from this deposit contained two charred grains. Overlying this was a sterile yellow blown sand, context **202**. This was up to 0.28 metres thick, and presumably represented a post-abandonment phase. This was overlain by a dark brown sand with occasional shell, context **201**. This was up to 0.11 metres thick, and its base was at 4.79 m aOD. At the top of the sequence was a thick yellow sand, context **200**.

6.7.2.1 The Snails

Results of snail analysis are presented in Table 6.12. The sample from the possible floor deposit, **203**, did not contain any snails. The windblown sand sealing the structure, context **202**, contained an open country fauna, dominated by *Pupilla muscorum*, with single specimens of *Cepaea hortensis*, *Cochlicopa lubrica* and *Vallonia excentrica*. This suggests that there are likely to have been times when the sand was accumulating quite slowly, allowing a relatively stable and relatively short turf cover to develop.

The overlying darker sand, context **201**, contained a more diverse fauna, with 2 *Cochlicopa lubrica*, 1 *Oxychilus alliarius*, 1 *Pupilla muscorum*, 1 *Vertigo pygmaea* and 1 *Helicella itala*. These are representative of machair grassland, perhaps with taller vegetation than the *Pupilla*-dominated fauna of **202**.

One point of note is the complete absence of from this sequence of *Cochlicella acuta*, which is dominant in the modern turf sample from Section 1, and the presence of only one *Helicella itala*. In Thew's (2003, 167) work at Baleshare, immediately west of the present site *C. acuta* is largely absent, arriving in Phase 2 or 3 and only ever being present in low numbers. *H. itala* arrives at a similar point, but goes on to be the dominant snail of the pair by Phase 4. It may be the case, then, that this sequence of samples predates Phase 4 at Baleshare (although *Cochlicella* is also largely absent in Section1, including in contexts which do not appear to predate Phase 4). Small marine snails are present in both of these samples, and may suggest that seaweed was being introduced to the site.

		Sample	201	202
		Context	18	19
		Description	Wind-blown sand	Wind-blown sand sealing structure
Ecological Group	**Taxon**			
1a	*Oxychilus alliarius*		1	
2	*Cepaea hortensis*			1
	Cochlicopa lubrica		2	1
4	*Pupilla muscorum*		1	28
	Vertigo pygmaea		1	
	Vallonia excentrica			1
	Helicella itala		1	
	Total number of individuals		6	31
	Taxa s		5	4
	MARINE SNAILS			
	Cingula trifasciata		3	
	Rissoa parva		1	2

Table 6.12: The snails from Section 2, Ceardach Ruadh, Baile Sear.

6.7.3 General observations

The sections stand at the back of the area investigated by the Central Excavation Unit in the 1980s and represent a continuation of that site, although the lack of firm dating evidence makes comparisons difficult. The building is locally described as an eroding wheelhouse (Rebecca Rennell, pers. comm.).

The midden deposit at the bottom of Section 1 contains only a small number of snails, but *Oxychilus alliarius*, known to be favoured by middening, is among them. Deposition seems to have been relatively rapid. This was also the case in the 1980s sequences at Baleshare, where sand deposits 2-3m thick formed rapidly (Barber 2011, 50; Chapter 4.4.1). There appears to have been a hiatus, most likely due to aeolian erosion, beneath the modern top of the sequence. *Cochlicella acuta* is absent from all but the top of the sequence, but this is not necessarily a Bronze Age/ Iron Age sequence. The possible Norse potsherd was found in context **106**. *Cochlicella*'s absence may therefore be the result of rapid accumulation or an environment without long marram grass. Section 2 yielded a small fauna largely indicative of an open machair environment.

6.8 CILL DONNAIN

6.8.1 Introduction and Methods

The site of Cill Donnain was excavated between 1989 and 1991, and was the first major excavation of the SEARCH project. The excavations revealed an Iron Age wheelhouse and the remains of a Middle Bronze Age occupation layer (Parker Pearson & Smith 2014, 1). A plan of the distribution of numbered metre squares is shown in Figure 6.29, and a long SW facing section from the 1989 excavation is shown in Figure 6.30. Samples were taken based on judgment from sealed contexts that appeared to contain charred material (Grinter & Valamoti 2014, 174). Snails were extracted from flots under a low power microscope and identified to species level where possible with a reference collection. The flots had been caught on 1mm and 300μm mesh sieves, these two fractions were combined for analysis.

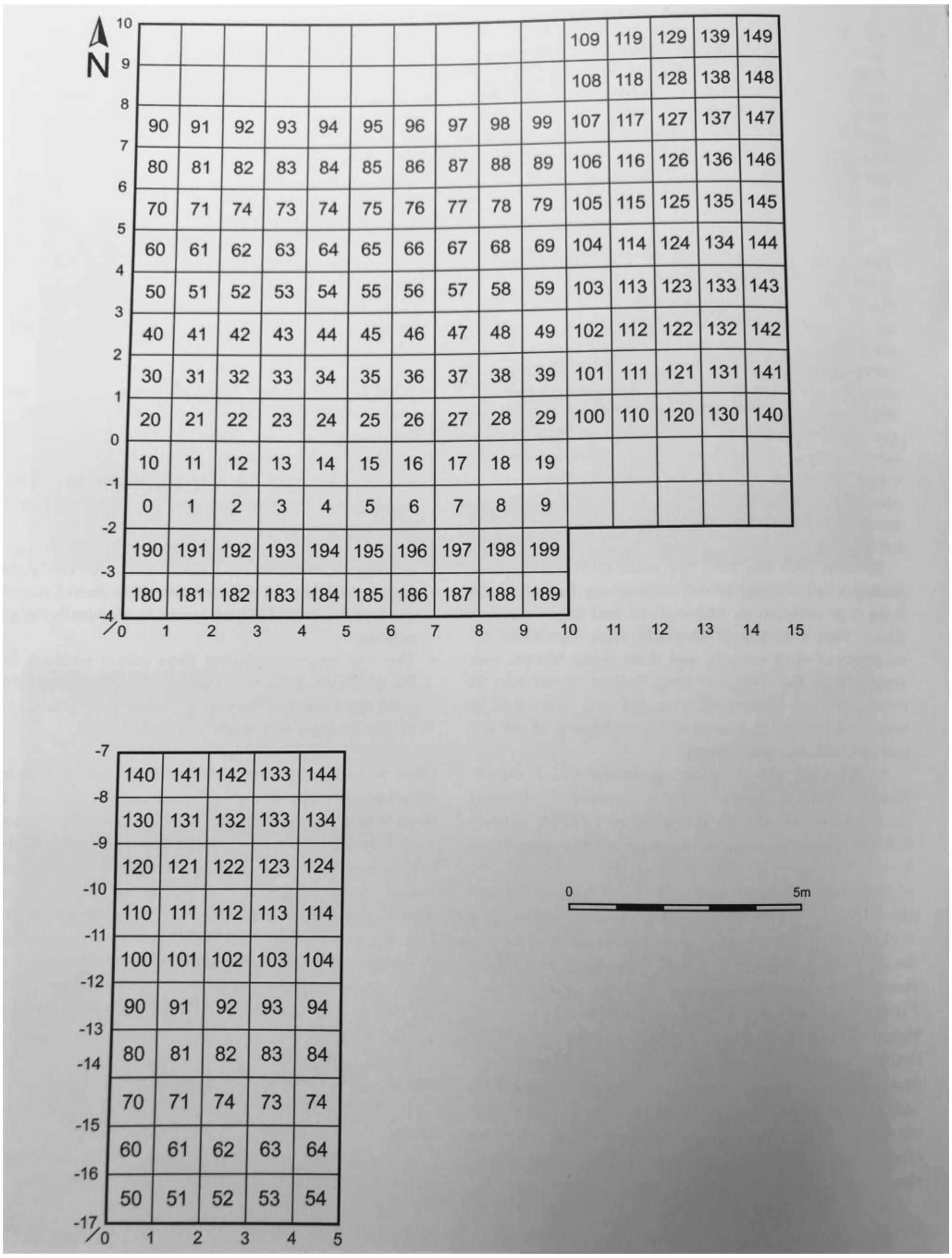


Figure 6.29. Distribution of the numbered squares at Cill Donnain III. Reproduced from Zvelebil and Parker Pearson 2014.

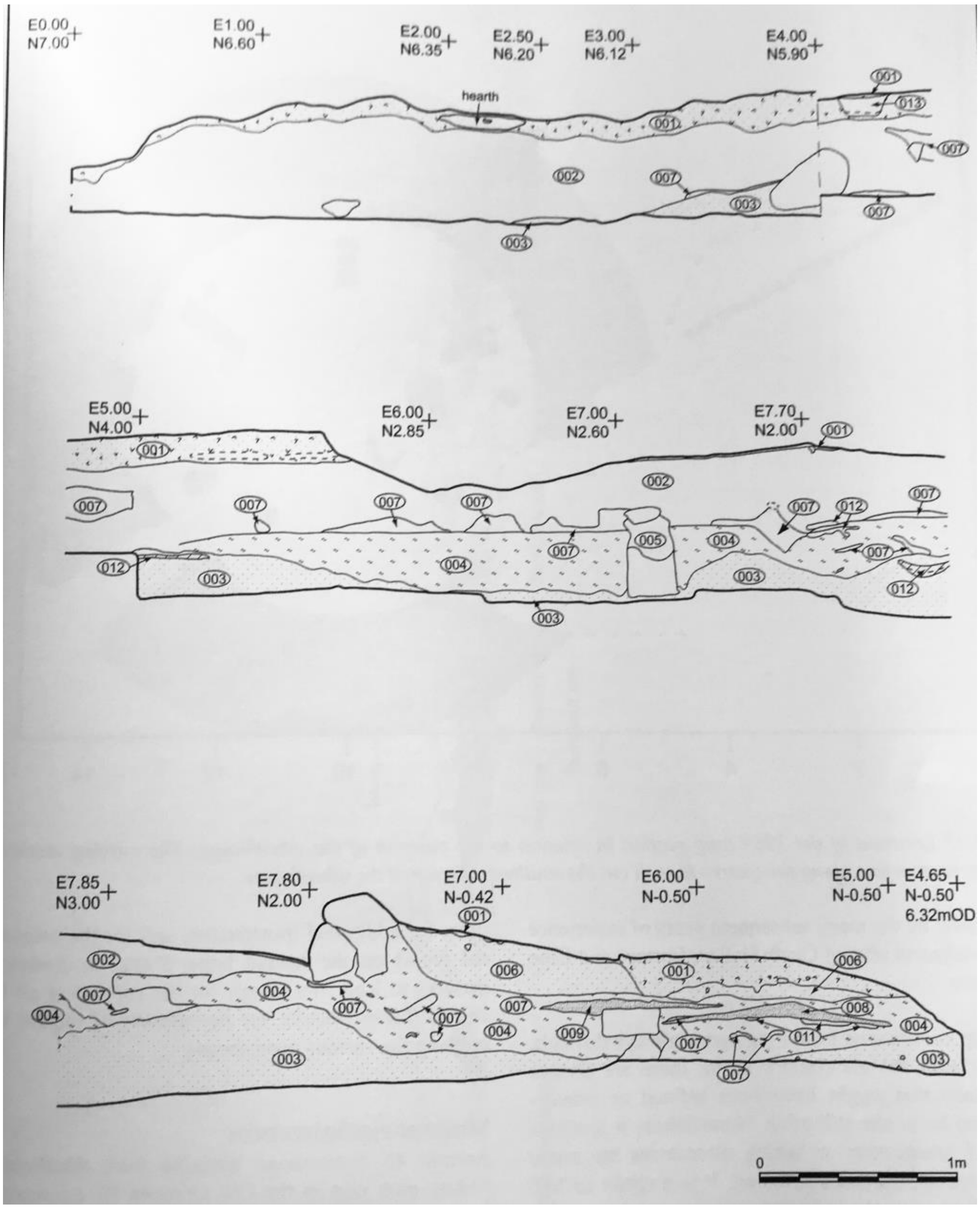


Figure 6.30: South-west facing section of excavations in 1989. Reproduced from Zvelebil and Parker Pearson 2014.

Ten samples were examined from Middle –Late Iron Age deposits excavated in 1989. Three radiocarbon dates were available, from two of the contexts. These are presented in table 6.13 below.

Laboratory Number	**Sample reference**	**Material**	**Radiocarbon Age (BP)**	**δ^{13}C (‰)**	**Reported calibrated age range (95% confidence) (Recalibrated dates in grey)**
SUERC-37606	Layer 1 - 1	Carbonised grain, *Hordeum vulgare*	1735±30	-24.3	cal AD 230-400 (cal AD 240-385)
SUERC-37607	Layer 1 - 2	Carbonised grain, *Hordeum vulgare*	1755±30	-23.6	cal AD 210-390 (cal AD 180-385)
SUERC-38628	Layer 15 - 3	Carbonised grain, barley	1430±30	-25	cal AD 570-660 (cal AD 575-657)

Table 6.13: Radiocarbon results for Cill Donnain III, after Marshall and Cook 2014, Table 16.

6.8.2 Results

Snails were well-preserved and abundant in all samples. The table of results is presented in Appendix 2.

6.8.2.1 Late Middle Iron Age – Early Late Iron Age

Most the samples were taken from deposits related to the wheelhouse and dated to the late Middle Iron Age to early Late Iron Age. The windblown sand, context **2**, contained a rich and diverse fauna suggestive of relatively stable machair grassland, with high numbers of *Vallonia excentrica*, *Cochlicopa lubrica* and *Helicella itala*; and lesser amounts of *Vallonia costata*, *Vertigo pygmaea* and *Pupilla muscorum*. The fourteen shells of *Cochlicella acuta* all appear to be intrusive. Individual shells of *Vitrina pellucida* and *Oxychilus alliarius* suggest that taller vegetation existed at times while the sediment was accumulating.

Context **4**, wheelhouse fills, contained a diverse fauna dominated by open country Group 4 taxa, but also with high numbers of *Lauria cylindracea* and *Oxychilus alliarius*, as well as significant numbers of *Vitrea contracta*. These species are likely to have been attracted to relatively damp or humid conditions, and may be indicative of midden material or animal manure. Alternatively, *L. cylindracea* may have been living on the wall, along with the rupestral *Clausilia bidentata*. The lone *Anisus leucostoma* may be suggestive of herbaceous material from a marshy location being imported into the site. Similarly, the small number of the marine snail *Rissoa parva* may reflect seaweed being imported.

The wheelhouse wall core, Context **6**, the windblown sand, context **7**, and the fill outside the wheelhouse, context **8**, are also dominated by Group 4 taxa which suggest an open environment with relatively short vegetation, once again with an appreciable contribution from Group 1 taxa suggesting more shaded or humid areas were available.

There is a significant change in the faunal composition of Context **12**, the peat ash lens, which suggests that it is later than the other late MIA-early LIA contexts. This context is dominated by *Cochlicella acuta*, previously only present in low numbers, suggesting that at this point *C. acuta* is well established at Cill Donnain as the dominant snail.

6.8.2.2 Late Iron Age Middens

Two midden contexts were examined. Context **1** was dated to the late 4th or early 5th century AD, and context **15** was dated to the late 7th century AD. Context 1 was overwhelmingly dominated by *Cochlicella acuta*, with lesser numbers of other Group 4 taxa, all suggesting a rather open machair grassland environment. Aside from a single specimen of *Oxychilus alliarius*, there is no specific suggestion in the snail assemblage of midden material, nor any snails introduced on seaweed.

Context **15** has a rather different assemblage, dominated by *Helicella itala* with significant numbers of *Cochlicella acuta* and other Group 4 taxa. In many ways, it is more reminiscent of the earlier Late MIA-Early LIA deposits, and the chance that there has been some conflation of two or more deposits here cannot be ruled out. Nonetheless, it does make some ecological sense, suggesting rather short grassland, with a small number of Group 1 taxa implying taller vegetation. The presence of *Galba truncatula* might suggest material from marshy contexts being introduced onto the site, and *Rissoa parva* may have been imported on seaweed.

6.8.2.3 Diversity indices

Diversity indices for all ten samples analysed from Cill Donnain are presented in Table 6.14, below. Peaks in Fisher's Alpha coincide with high differences between the Shannon and Brillouin indices in sample **15** (context **4**), and sample **13** (context **7**), suggesting a mixed input or incomplete sample. The difference between the Shannon and Brillouin indices is higher than 0.1 in most samples, although the assemblages are ecologically coherent. This may suggest that a slightly higher 'break point' than 0.1 is tolerable in Western Isles assemblages.

Context	**1**	**2**	**4**	**4**	**6**	**6**	**7**	**8**	**12**	**15**
Sample	**19**	**6**	**7**	**15**	**5**	**9**	**13**	**8**	**19**	**16**
Taxa s	7	8	10	12	8	8	9	9	10	11
Individuals	198	311	157	187	94	96	57	122	136	130
Shannon	0.5913	1.608	2.094	2.102	1.875	1.885	2.017	1.9	1.843	2.008
Brillouin	0.5448	1.561	1.978	1.992	1.738	1.745	1.79	1.779	1.726	1.872
Shannon-Brillouin	0.0465	0.047	0.116	0.11	0.137	0.14	0.227	0.1211	0.117	0.136
Simpson	0.241	0.7694	0.86	0.8577	0.8298	0.8129	0.847	0.8332	0.7962	0.8361
Fisher's alpha	1.415	1.498	2.378	2.86	2.09	2.075	3.006	2.242	2.488	2.868

Table 6.14: Diversity indices for samples from Cill Donnain (CD89).

6.8.2.4 Detrended Correspondence Analysis

Detrended Correspondence Analysis for absolute values of snails from Cill Donnain III is presented in Figure 6.31, and for values coded following Rousseau (1987) in Figure 6.32. The results are somewhat difficult to interpret. The more dominant species throughout the assemblage are towards the left-hand side, while *Cochlicella acuta*, which comes to dominate two of the samples, is furthest to the right. It seems likely that uniformity of dominance across the samples is affecting the ordination.

Coding the counts following the example of Rousseau (1987) should remove much of this variation. It also further reduces the amount of variation accounted for by the two axes (indicated by their respective eigenvalues). The close pairing of *Vallonia excentrica* and *Pupilla muscorum* makes sense, as does their closeness to *Helicella itala*, indeed these three occupied similar positions along Axis 1 in Figure 6.31, albeit widely separated along Axis 2. It may be, however, that there is either insufficient ecological variation between samples, or too much mixing of deposits, to allow particularly meaningful ordination.

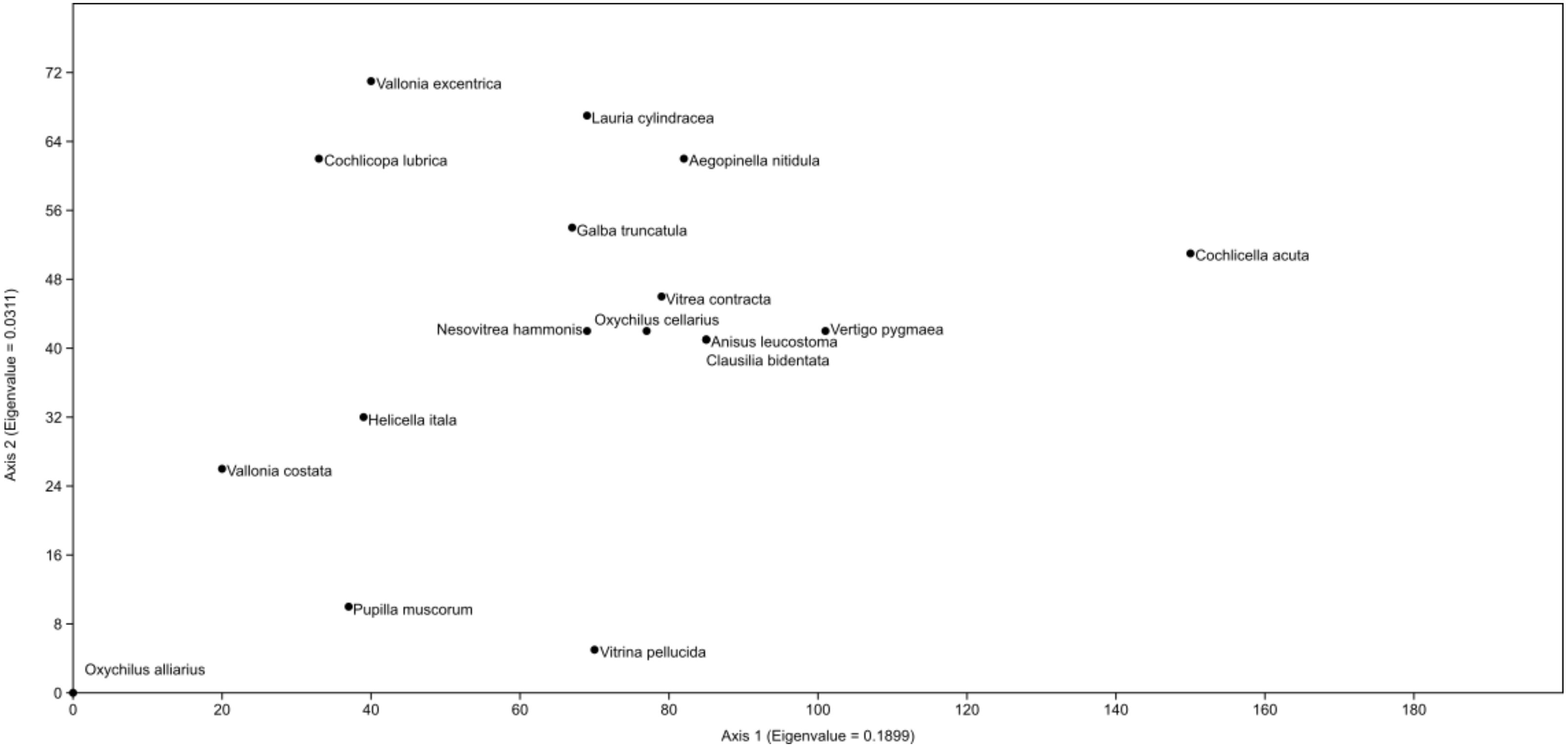


Figure 6.31: Detrended correspondence analysis of snails from samples at Cill Donnain III.

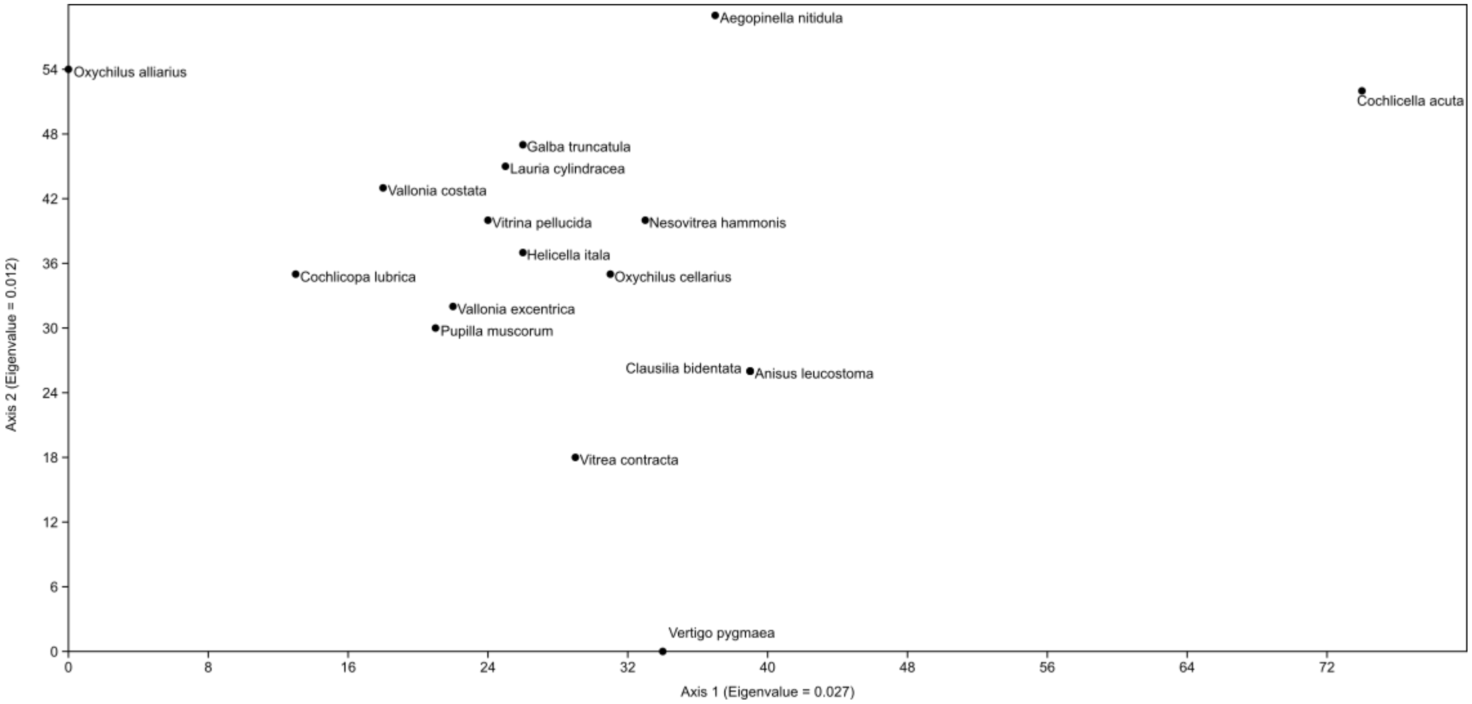


Figure 6.32: Detrended correspondence analysis of snails at Cill Donnain III using totals coded following Rousseau (1987).

6.8.3 General Observations

The overall fauna at the site reflects open grassland, dominated by Group 4 taxa, although snails indicative of damper, more shaded environments are present throughout the assemblage. Context 4, filling the wheelhouse, may contain evidence of imported material in the form of *Anisus leucostoma* (from a marshy environment) and *Rissoa parva* (from seaweed). *Cochlicella acuta* appears to become established at Cill Donnain during the period covered by these samples.

6.9 MOUND 2A, BORNAIS

6.9.1 Introduction and Methods

Three large settlement mounds were excavated at Bornais on South Uist in the late 1990s and early 2000s. The mollusc samples examined for this study were taken from Mound 2A, which lies to the south east of the main Mound 2 (Figure 6.33). It comprises Norse domestic structures with associated midden deposits and cultivation layers (Sharples 2005, 11). The contexts from the site have been assigned to stratigraphic blocks, for Mound 2A these begin with the letter G. They are:

GA The Early Norse phase
  GAA are the primary cultivation soils
  GAB is a hearth and associated ash layers found within that soil
  GAC is another hearth and associated ash layers found sitting on top of the ploughsoil
  GAD is the grey sand layers that cover these features

GB The Middle Norse phase
  GBA is the primary structure above the grey sand
  GBB is the construction of the south kiln
  GBC is the use of the south kiln
  GBD is the construction of the north kiln
  GBE is the use of the north kiln
  GBF is deposition associated with kiln use in the centre of the excavated area
  GBG are ash layers spread around the periphery of the mound when the kiln was in use

GC Late Norse ancillary structures
  GCA is the construction of ancillary building 2
  GCB is the use of ancillary building 2
  GCC is the construction of ancillary building 3
  GCD is the use of ancillary building 3
  GCE is the construction of building 4
  GCF is the use of building 4

GD Late Norse peripheral middens
  GDA is the middens deposited on the west side of the mound
  GDB is the middens deposited on the north side of the mound
  GDC is the middens deposited on the east side of the mound

GE Late Norse houses

GEA is the construction of south house 1
GEB is the occupation of south house 1
GEC is the infilling of south house 1
GED is the construction of south house 2
GEE is the use of south house 2
GEF is the infilling of south house 2
GEG is the construction of south house 3
GEH is the occupation of south house 3
GEI is the construction of south house 4

GG An isolated Late Norse building
GGA is a structure dug into the deposits in the north east corner of the mound
GGB is the occupation of the structure in the north east corner
GGC is the abandonment of the structure in the north east corner

GF The final occupation on mound 2A
GFA are isolated features representing the final occupation of the mound
GFB are layers representing post occupation erosion and sand accumulation

(Niall Sharples, pers. com.)

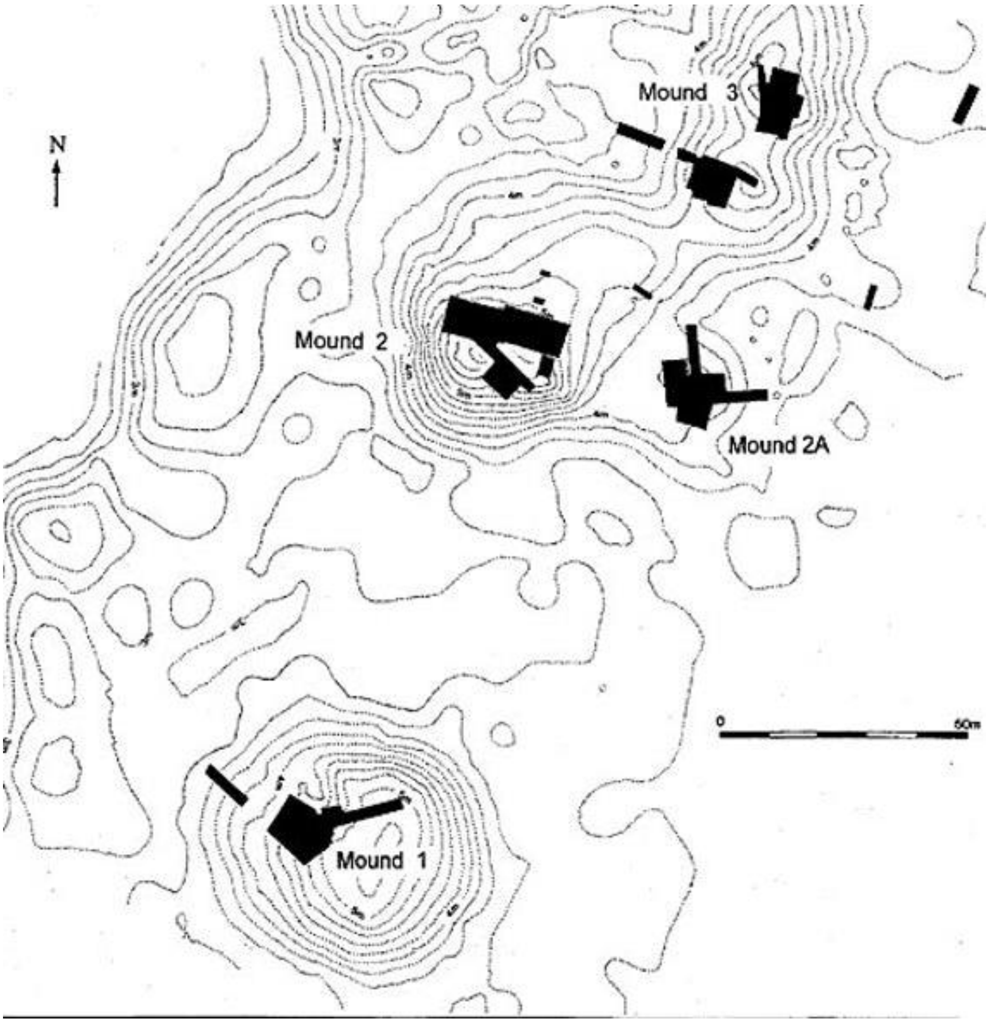


Figure 6.33: The relative position of the excavated mounds at Bornais. Image courtesy of Professor Niall Sharples.

Fifteen samples were taken from Unit GAA, the first phase of activity in Mound 2A during the 10th Century AD. This consists of a thick sequence of ploughsoil layers, rich in animal bone and marine shell and with a strong ash component, interpreted as being primary cultivation soils (Sharples, unpublished). These ploughsoils are covered by grey sand layers that make up Unit GAD, from which 15 samples were examined. Unit GDC consists of midden layers located on the east side of the mound, which date from the 13th to 14th Centuries AD. Thirteen samples were taken here. Two samples from the earliest and latest house-floors from Mound 2 (Units BBC and BED) were also examined.

The molluscs were extracted from the flots of sediment samples originally collected and processed for the analysis of carbonised plant remains. Sorting shells from flots derived from the processing of large (6-51 litre) bulk sediment samples taken for archaeobotanical analysis, as opposed to much smaller (1-2 kg) column and spot samples taken specifically for molluscan analysis, enabled very substantial volumes of cultural deposits to be examined. Both the coarse (>1mm) and fine (300µm to 1mm) fractions were sorted using a binocular microscope, and the totals combined.

Species identifications for the Rissoidae were checked by Jennifer Gallichan at Amgueddfa Cymru – National Museum of Wales and the Littorinidae by Dr David Reid at the Natural History Museum, London.

6.9.2 Results

Detailed results are presented in Appendix 2.

Preservation was moderate to good throughout the samples. Some samples have particularly well-preserved shells where the proteinaceous periostracum is preserved and the shell is partially transparent, showing them to be fairly recent and therefore probably intrusive.

6.9.3 The ploughsoils (Block GAA)

There are relatively high numbers of *Pupilla muscorum* and the other Group 4 taxa (*Vallonia excentrica*, *Vallonia costata* and *Vertigo pygmaea*) in 6 of the 15 samples (**7028**, **7030**, **7038**, **7044**, **7094**, **9032**), which is likely to indicate open grassland and a relatively stable surface. This stability suggests hiatus periods in the ploughing regime. By contrast, the low total frequencies and relatively few species present in the majority of the samples suggest relative instability and rapid sedimentation. Assemblages in which Group 4 species are scarce, like the basal plough soils of samples **7157** and **9275**, point to intensive ploughing activity. Two samples (**7020** and **10704**) have much higher total frequencies, but still have low species diversity and are dominated by *Cochlicella acuta*, suggesting an unstable environment with a significant degree of aeolian sand movement. The presence of Group 1 taxa, especially *Aegopinella nitidula*, *Punctum pygmaeum* and *Vertigo substriata*, suggests fallow periods where longer vegetation was able to grow.

There are small peaks in the occurrence of the marine snails *Rissoa parva* and/or *Peringia ulvae* which often coincide with the presence of shells of *Oxychilus alliarius*, which Thew (2003, 170) concluded was often associated with middening. The marine shells may have been introduced with collected seaweed (see Chapter 5.7), so this suggests that midden material and seaweed were being spread across the land surface as a fertiliser and to consolidate the soils and reduce the risk of erosion.

6.9.4 Grey Sand Accumulation (Block GAD)

Lauria cylindracea, a species that Evans (2004) considered to have expanded its ecological range in northern Britain to include grazed grassland, is at its most common in the grey sand accumulation, Block GAD, where it is present in four samples. The overall scarcity of *Lauria* at Bornais suggests that this ecological expansion had not yet occurred when these sediments were accumulating, or perhaps was just beginning when Block GAD was accumulating.

Relatively high numbers of *Pupilla muscorum*, *Vallonia excentrica*, *Vallonia costata* and *Vertigo pygmaea* are found in several of the samples. When combined with a higher species diversity, elevated total frequencies and a significant presence of Group 1 taxa (like *Carychium tridentatum*, *Punctum pygmaeum*, *Vitrina pellucida*, *Nesovitrea hammonis*, *Euconulus fulvus* and *Vitrea contracta*), this indicates several intervals with significant surface stability associated with a mix of stable grassland and taller, denser vegetation. *Vitrina pellucida* can also often be found in dune slacks (Davies 2008, 176), and as seen in the modern mollusc samples from Cladh Hallan, *Punctum pygmaeum* may be found in grazed grassland in the Western Isles (Chapter 6.1). The presence of *Oxychilus alliarius* and small marine gastropods in the majority of samples suggests that midden material and seaweed continued to be spread across the land surface around the settlement. Some samples (**9228**, **9238**, **11005**, **11046**) have faunas with fewer species that are dominated by *Cochlicella acuta*, suggesting greater instability and the accumulation of wind-blown sand.

6.9.5 The middens (Unit GDC)

The variation both in kinds and number of taxa present, and in relative abundance of snails, in different deposits within the midden accumulation (Unit GDC) reveals details of the formation of this area of the site. All the samples have low numbers of Group 4 taxa, except for *Cochlicella acuta*. The highest number of snails in Unit GDC came from a patchy deposit of red clayey sand **899** (sample **9214**). This is not an artefact of different sample sizes, as it is not one of the largest samples in the group, instead, it is probably indicative of a long period of surface stability and slow accumulation. Interestingly, sample **7153**, from context **1624** which is the same as **899**, contains far fewer snails despite being a larger sample. This may suggest faster burial or a less suitable (perhaps more exposed) environment for snails in this area of the site, and sheds light on spatial variability across deposits. The two species represented here, *Cochlicopa lubrica* and *Vallonia costata*, are certainly consistent with an open environment.

A silty layer **779** from which sample **9221** was taken was exceptionally humic. It only contained two land snails, an *Oxychilus alliarius* and a *Vallonia costata*, suggesting that it was deposited quickly and subsequently rapidly buried.

Both *Oxychilus* and *Nesovitrea*, species likely to be favoured by middens (see Chapter 5.6) are present in low numbers within unit GDC. The strongest occurrence of this group is in unit GAD, the grey sand accumulation, however. That said, it is telling that the ‘midden’ species occur in unit GDC in contexts **1691** and **1637** (samples **7907** and **7196**), which are both rich in marine shell and bone, and likely to be primary midden deposits.

6.9.6 House Floors (BBC and BED)

Of the two small (6 litre) samples taken in the floors of Houses 1 and 3 from Mound 2, one (**7602**) included a specimen of *Lauria cylindracea*. Both sample faunas have few species and may well represent clean blown sand brought in from the machair.

6.9.7 Marsh and freshwater taxa

Although no true freshwater species were present in the samples, specimens of the Group 5 marsh species, in particular *Galba truncatula* and *Zonitoides nitidus,* are present in Block GAD, Block GDC and one of the house floors. The fact that wet and damp ground taxa are present throughout the samples is perhaps no surprise. Blocks GAA and GAD are not far above the water table (Niall Sharples, pers.com.), and the Western Isles have a very wet climate, so areas of longer vegetation might be expected to retain moisture, and low-lying areas be subject to seasonal flooding. At Bornais, wet-ground species are low in number, and completely absent from Block GAA. They occur in the highest frequencies in Block GAD, where they are often present with high numbers of short dry vegetation species such as *Vallonia excentrica* and *Pupilla muscorum*, and so may represent episodes of seasonal flooding. At other sites, this co-occurrence of species indicative of dry grassland with wet-ground and freshwater taxa has been attributed to seasonal flooding, with important implications for the availability of the site for human use year-round (Thew 2003, 168). Equally, however, they may have been incorporated into the contexts by human agency, for example on reeds, especially in the case of the 10 *Galba truncatula* in context **1378**, sample **7735**, from House 3.

6.9.8 Marine gastropods

Specimens of the marine gastropods *Rissoa parva*, *Littorina saxatalis* and *Lacuna vincta*, as well as the brackish water snail *Peringia ulvae*, were found in several samples from Units GAA, GAD and GDC. These shells probably brought onto the site attached to seaweed. As detailed in Chapter 5.7, evidence for seaweed collection is usually indirect in the form of invertebrate remains that may have been attached to it.

Small marine gastropods occur in 7 samples from Unit GAA, in 11 samples from Unit GAD; and in 8 samples from Unit GDC. The spread of seaweed in association with midden material is especially interesting as it may suggest that seaweed was being mixed with the rich, organic midden material to enrich it prior to it being used as a fertiliser on the cultivation soils of Unit GAA. Alternatively, the co-occurrence of marine shells and of taxa indicative of middening throughout the grey sands of Unit GAD may simply suggest that seaweed was being used in conjunction with midden material to spread over the surface around the settlement to improve and stabilise the land, and to consolidate the machair soils, as it can take more than four months to decompose (Bell 1981, 119).

6.9.9 ‘*Rupestral’ taxa*

Within Units GAA and GAD few of the snails belong to rupestral species (*Clausilia bidentata* and *Lauria cylindracea*). These may have been associated with the presence of buildings, although it should be noted that they do occur in damp grassland. For example, an unpublished survey of modern mollusc populations on the dunes at Braunton Burrows, Devon, revealed *Clausilia bidentata* at the base of grassy tussocks in an otherwise open landscape (Davies 2008, 140), while Thew (2003, 170) also noted that this species may sometimes be found in damp grassland in parts of Scotland. Nevertheless, the presence of *C. bidentata* in the samples from Bornais seems most likely to have been linked with walled structures, as there are no peaks in Group 1 species (snails typically associated with taller vegetation and shaded conditions) in the samples where it is present, as would have been the case if it were living among damp tussocky grassland. Similarly, the notable peak in *Lauria cylindracea* in context **1747** (samples **10223** and **11022**) of Unit GAD may reflect the proximity of a north-south stone wall (context **2428**). Finally, *Vertigo substriata* is present in sample **7030** of Unit GAA. Evans (1972, 295) described *V. substriata*, a taxon that commonly lives in damp, shaded places under logs and stones, as often being “largely rupestral”, although in the sequence from Northton, this taxon seems to have been most frequent in layers associated with stable conditions and a rather dense and fairly damp vegetation cover.

6.9.10 Diversity Indices

Diversity indices were calculated for all samples containing more than 50 shells from Blocks GAA, GAD and GDC (Tables 6.15, 6.16, 6.17). Intrusive shells were removed from the counts beforehand.

The difference between the Shannon and Brillouin indices for samples **7020** and **10704** from Block GAA are low, suggesting reasonably complete samples, whereas the particularly high value from sample **7044**, which coincides with a relatively high number of taxa compared to the number of individuals, suggests that there are components of this sample missing or that more than one deposit has been conflated. The low scores for Simpson's 1-D in samples **7020** and **10704** reflect the dominance of *Cochlicella acuta*.

Context	**1192**	**1195**	**1605**	**1617**	**1789**
Sample	**7020**	**7028**	**7044**	**7094**	**10704**
Taxa s	6	8	8	10	8
Individuals	358	100	54	98	369
Shannon	0.2849	1.469	1.911	1.758	0.5368
Brillouin	0.2637	1.352	1.7	1.609	0.5077
Shannon-Brillouin	0.0212	0.117	0.211	0.149	0.0291
Simpson	0.1026	0.6708	0.834	0.7584	0.2314
Fisher's Alpha	1.024	2.046	2.596	2.787	1.442

Table 6. 15: Diversity indices calculated for Block GAA, Bornais Mound 2A.

In Block GAD, there is a low difference between the Shannon and Brillouin indices overall, likely suggesting relatively complete assemblages. The highest difference occurs in sample **7760**, where it coincides with a peak in Fisher's Alpha and there is a relatively high number of taxa. This would again appear to suggest some faunal mixing.

Context	**954**	**1625**	**896**	**1611**	**2305**	**1747**	**1714**	**1707**	**979**	**2328**	**1729**	**2353**
Sample	**9228**	**7155**	**9221**	**7072**	**11005**	**10223**	**7760**	**7752**	**9238**	**11024**	**7926**	**11046**
Taxa s	7	9	14	9	7	12	13	10	5	7	7	5
Individuals	529	862	170	243	190	156	145	157	373	80	60	314
Shannon	0.2772	0.5912	2.067	0.9862	0.4262	1.914	1.953	0.8217	0.1487	0.7197	1.278	0.3809
Brillouin	0.2591	0.5748	1.939	0.9305	0.3834	1.794	1.819	0.7449	0.1356	0.6233	1.129	0.3603
Shannon-Brillouin	0.0181	0.0164	0.128	0.0557	0.0428	0.12	0.134	0.0768	0.0131	0.0964	0.149	0.0206
Simpson	0.095	0.2609	0.8451	0.4249	0.1598	0.8143	0.8166	0.3441	0.05253	0.2934	0.5728	0.1663
Fisher's Alpha	1.14	1.401	3.616	1.84	1.429	3.03	3.458	2.378	0.816	1.846	2.054	0.8444

Table 6. 16: Diversity indices for Block GAD, Mound 2A, Bornai.s

The two samples analysed from Block GDC have low differences between their Shannon and Brillouin score, and relatively comparable numbers of taxa and species. These are likely to be fairly complete samples.

Context	**899**	**1608**
Sample	**9214**	**7070**
Taxa s	5	5
Individuals	102	90
Shannon	0.4462	0.6311
Brillouin	0.3934	0.5684
Shannon-Brillouin	0.0528	0.0627
Simpson	0.1836	0.2948
Fisher's Alpha	1.102	1.142

Table 6.17: Diversity indices calculated for two samples from the middens, Block GDC, at Mound 2A, Bornais.

6.9.11 Ordination techniques

Detrended Correspondence Analysis of the snails in Block GAA was carried out to explore patterns in the data. The results of this are presented in Figure 6.34, below. The ordination is difficult to interpret on ecological grounds, predominantly the taxa are Group 4 or 3 species favoured by open environments. Coding the samples following Rousseau (1987) to reduce the numerical variation brings little clarity (Figure 6.35), although it does lessen the amount of variation described by each axis. It is likely that the ploughsoil assemblages are too mixed for successful ordination.

Figure 6.36 presents the results of Detrended Correspondence Analysis of samples containing more than 50 shells from Block GAD using absolute counts, and Figure 6.37 presents Detrended Correspondence Analysis of the same results coded following Rousseau (1987). Axis 1 accounts for most of the variation, and may be inversely related to humidity at ground level. *Cochlicella acuta* is likely to be affected by its very prominent occurrence in the samples. It was possible to recognise distinct groups in this dataset – these have been circled on the graph. After coding following Rousseau, the picture becomes more clear. The distribution of species along Axis 1 is reasonably similar to that in Figure 6.36, although the distance along the axis is smaller and it now accounts for less of the variation.

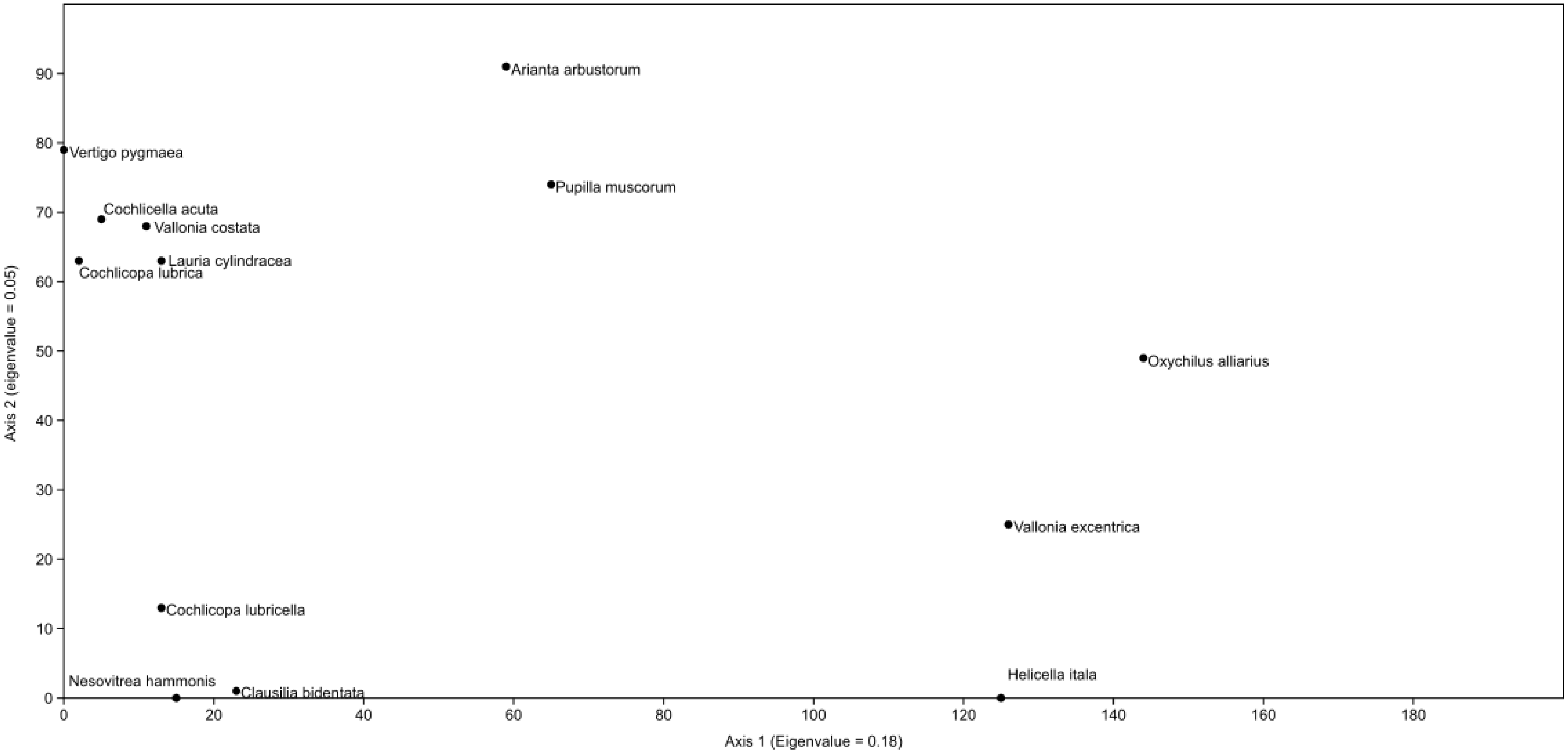


Figure 6.34: Detrended Correspondence Analysis of snails in samples from Block GAA, Mound 2A, Bornais.

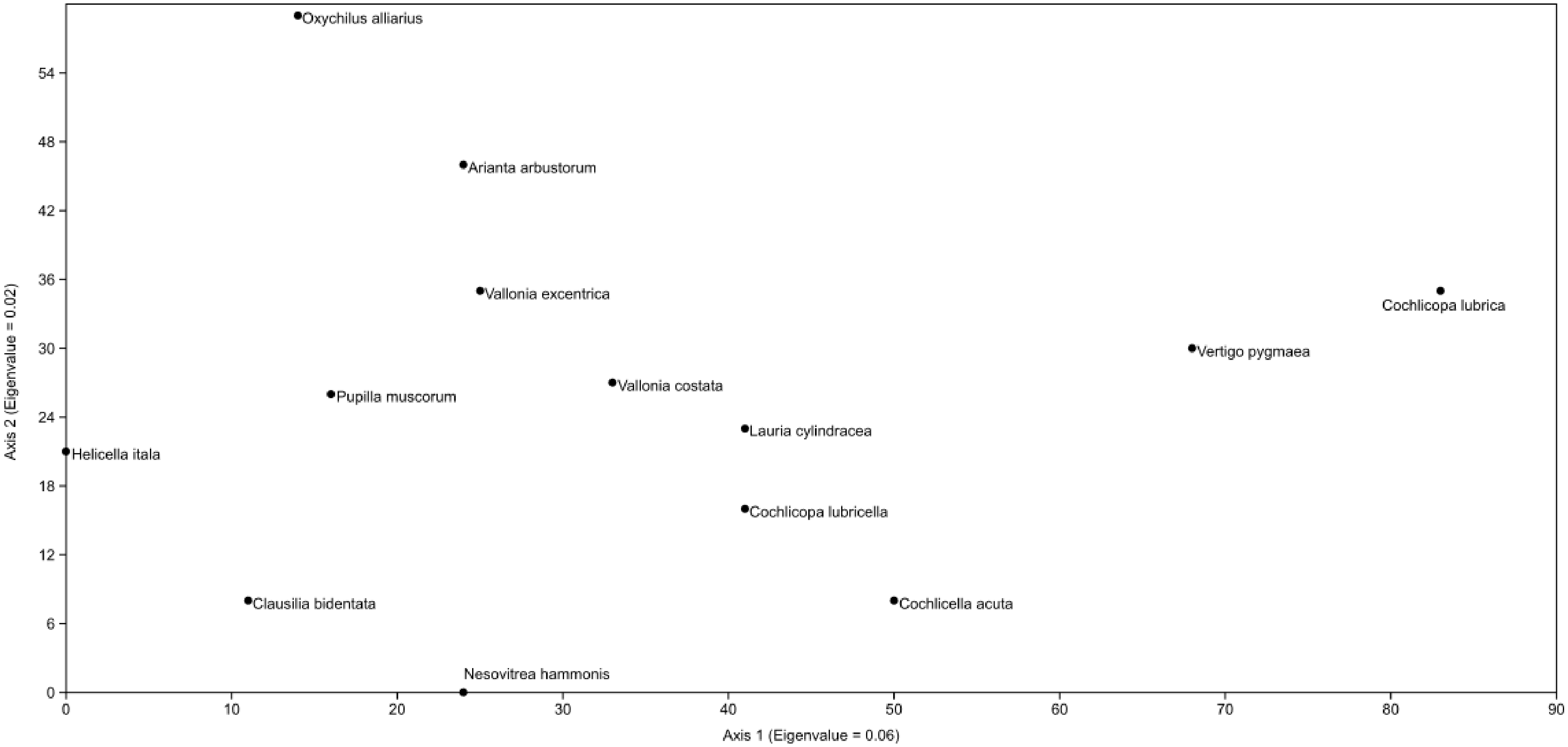


Figure 6.35: Detrended Correspondence Analysis of snails in samples from Block GAA, Mound 2A, Bornais, coded following Rousseau (1987).

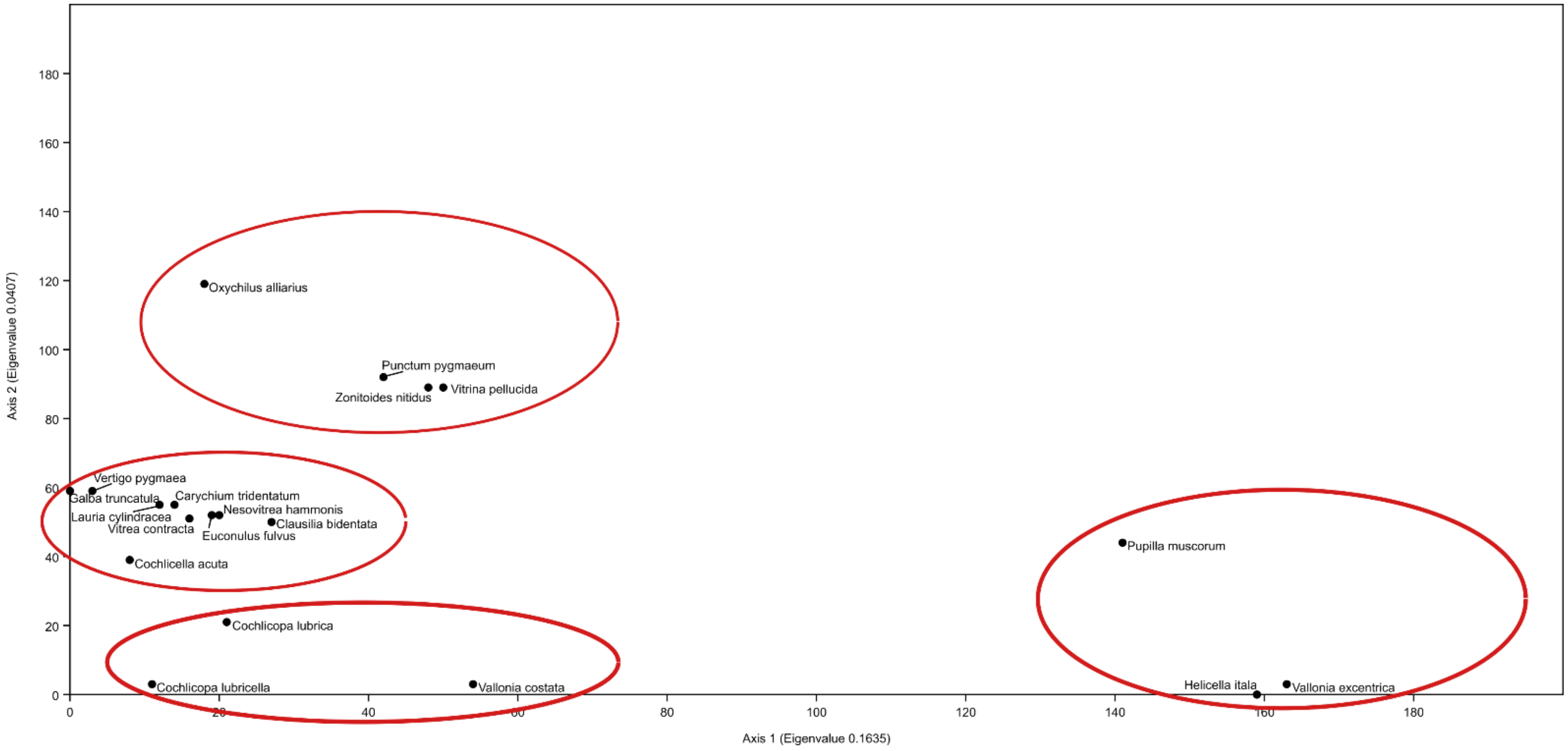


Figure 6.36: Detrended Correspondence Analysis of snails from stratigraphic block GAD at Mound 2A, Bornais.

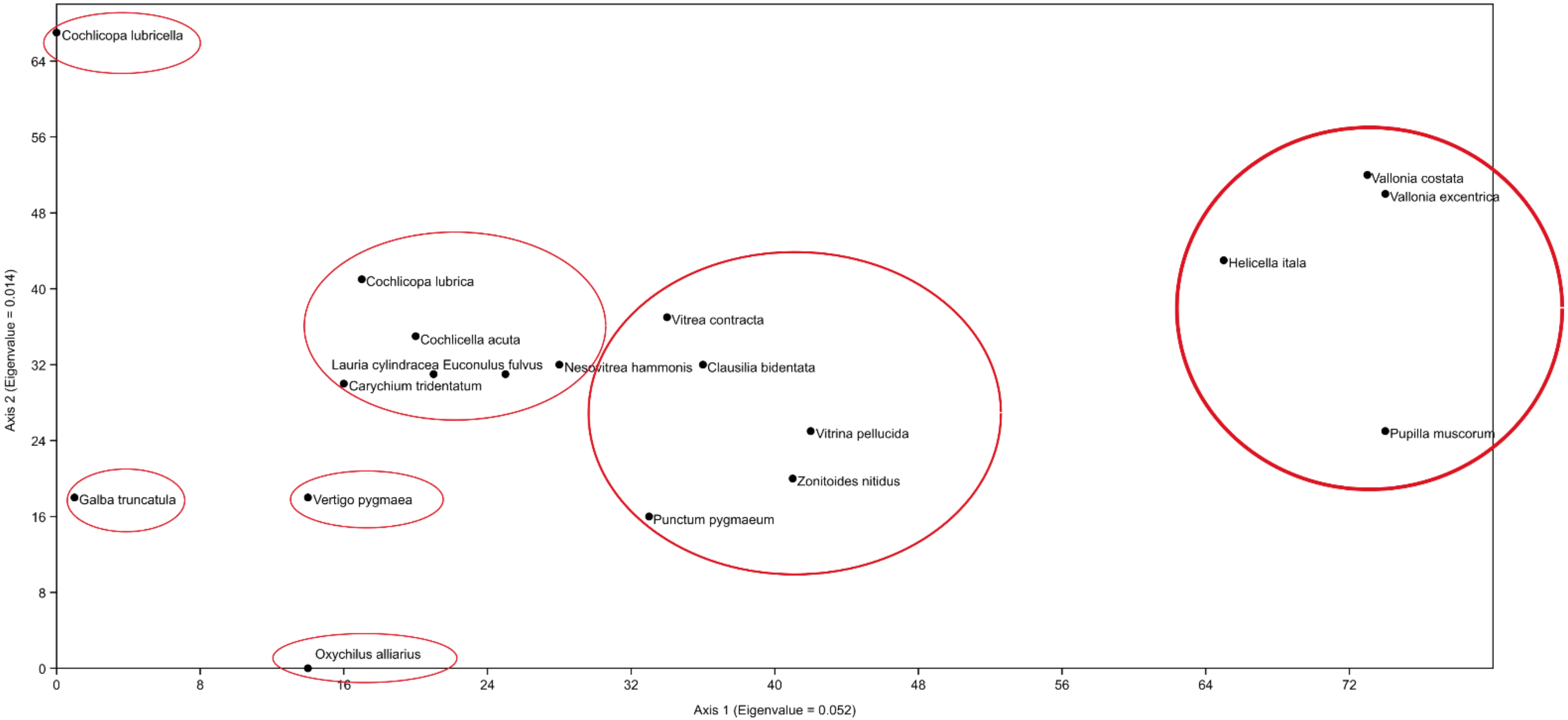


Figure 6.37: Detrended Correspondence Analysis of the same dataset, after coding following Rousseau (1987).

Figure 6.38 shows Detrended Correspondence Analysis of samples in the GAD dataset. This was carried out as the Detrended Correspondence Analysis of the snails appeared to show a coherent ecological pattern. In this case, Axis 1 is inversely related to the dominance of *Cochlicella acuta*, with samples to the right containing higher numbers of *Pupilla muscorum*, *Vallonia costata* and *Vallonia excentrica*, and those to the left containing high numbers of *C. acuta*, to the detriment of the former three species. Figure 6.39 shows Detrended Correspondence Analysis of the same samples after coding following Rousseau (1987). Again, the relationship between *Cochlicella* and the *Pupilla-Vallonia* group is emphasised.

Figure 6.40. shows Non-Metric Multidimensional Scaling of samples from Mound 2A, Bornais, South Uist, calculated in two dimensions using a Bray-Curtis similarity matrix, with stress = 0.04. The closest samples, **10223** and **7760**, have similar numbers of snails and taxa and *Pupilla*-*Vallonia* and *Cochlicella* groups. **7752** has one more snail than **10223**, and two fewer species, but a far greater dominance of *Cochlicella* over the *Pupilla-Vallonia* group.

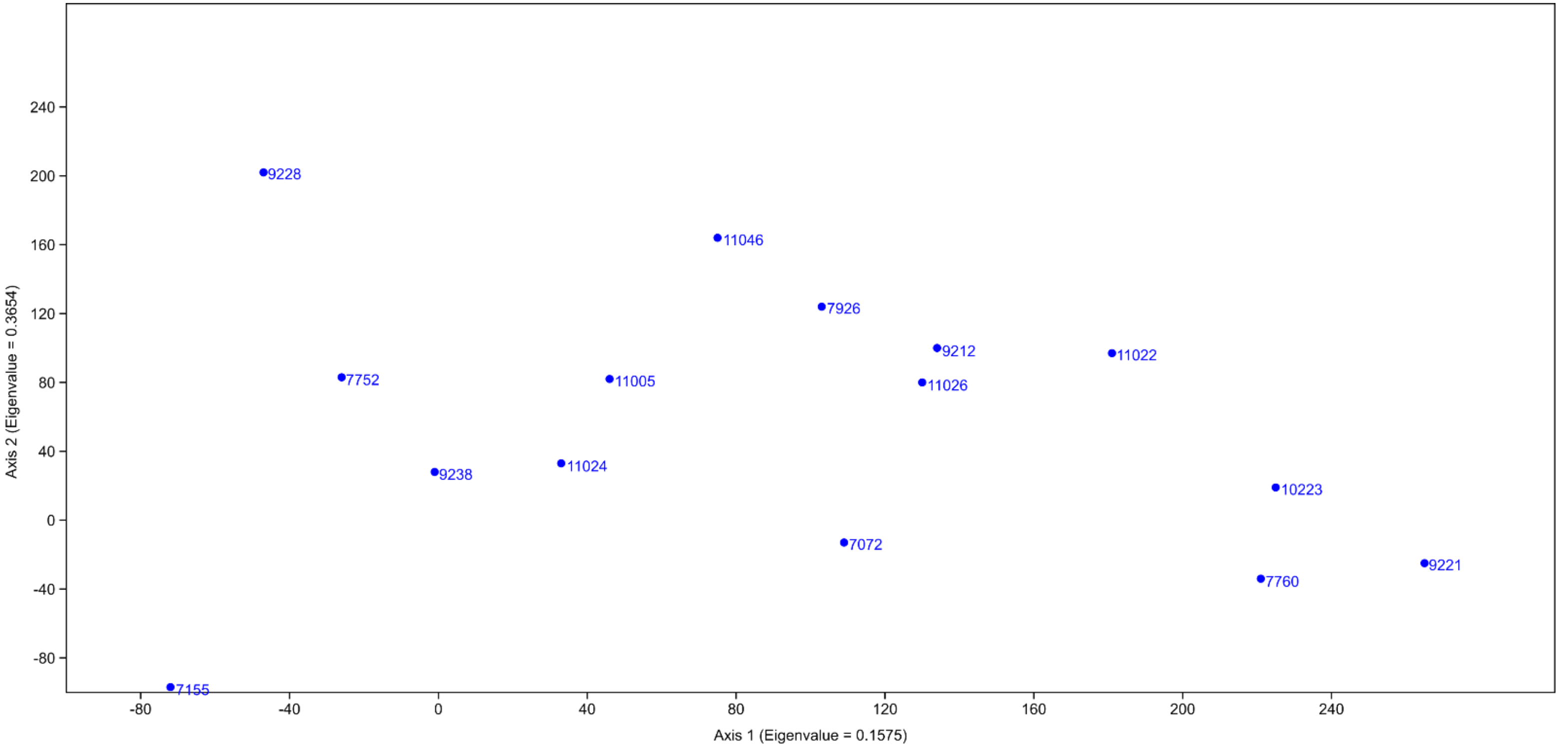


Figure 6.38: Detrended Correspondence Analysis of samples from Mound 2A, Bornais, South Uist.

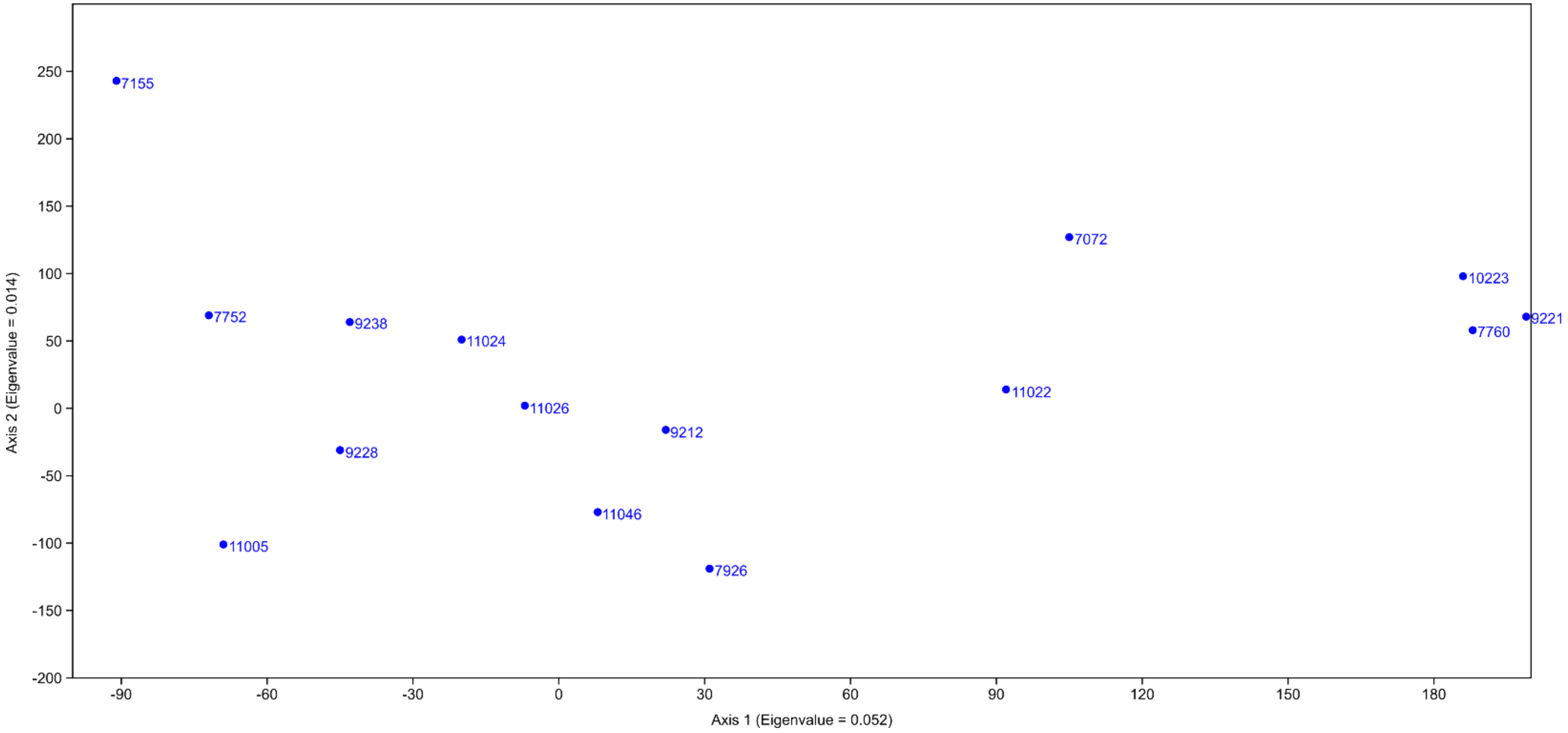


Figure 6.39: Detrended Correspondence Analysis of the same dataset after coding following Rousseau (1987).

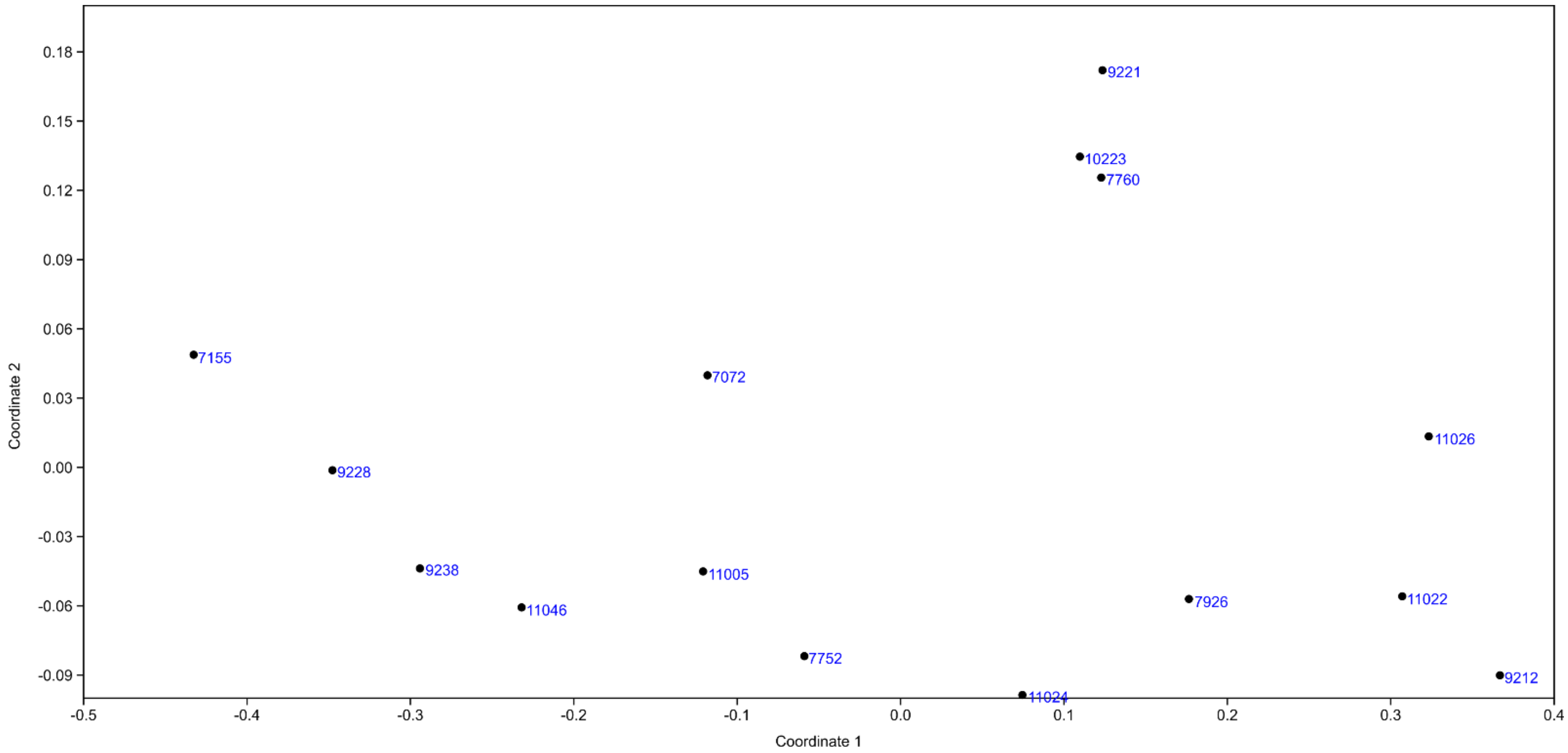


Figure 6.40: Non-Metric Multidimensional Scaling of samples from Mound 2A, Bornais, South Uist, calculated in two dimensions using a Bray-Curtis similarity matrix. Stress = 0.04.

6.9.12 General Observations

Most of the recorded species in the Bornais samples may be found today in sand dune environments. *Arianta arbustorum* is confined to blown sand environments in northern Britain (Davies 2008, 35), despite being common in a wide range of damp habitats farther south.

Many of the samples from Bornais are overwhelmingly dominated by *Cochlicella acuta*, a late prehistoric arrival in the British fauna. One reason for the success of *C. acuta* is its ability to climb the stems of marram grass during times of instability when sand is being blown by the wind. *C. acuta* is known to be polymorphic, with shell banding and colour reflecting the degree of vegetation cover (Lewis 1965), a potentially useful trait for archaeologists interested in reconstructing microenvironments and their associated site formation processes. Unfortunately, in most of the samples the periostracum of the shells has not been preserved. The disappearance of the periostracum is caused by bacterial action after burial, although larger snails may have their periostracum denuded in life by the abrasive action of wind-blown sand (Kerney & Cameron 1979, 13).

Overall, the samples demonstrated variations in the degree of instability and mixing across the ploughsoils, with rather more stability in the overlying grey sands. This is supported by both the diversity indices and detrended correspondence analysis, where more coherent groupings have been obtained for Unit GAD. Evidence for the use of seaweed is present in GAA, GAD and GDC, as well as evidence for seasonal flooding. The house floors reflect open, dry conditions.

6.9.13 Larger Helicelids at Mound 2, Bornais

During the course of analysis of marine shell from Mound 2, Bornais (see Chapter 7.4, below), fifteen shells of *Cepaea hortensis* were encountered. Although a common species, the survival of intact shells within archaeological deposits in the Western Isles is uncommon. As the snails are known to vary both in shell dimensions and colouring or degree of banding according to environmental factors, the opportunity was taken to record the shells in detail. Each specimen was measured following Thomas (1978, figure 5): the shell height, shell diameter and apertural height. The number of bands was also counted. *Cepaea* shells are large relative to most other British land snails, and although reasonably robust, they appear to be under-represented in archaeological assemblages (the shells recorded in the sites above are generally juveniles or broken fragments). This is likely to be an issue of preservation, the large shell being likely to be damaged. This limits the usefulness of the methods proposed by Thomas (1978), however good ecological information is available for the polymorphism of *Cepaea spp*., so where they are preserved some tentative conclusions may be drawn.

The results are presented in Table 6.18 below.

As published records of size variation in *C. hortensis* are not available, a small sample of intact adult shells from recent excavations at Cherhill, Wiltshire, England (Law, unpublished data) were also measured for comparison. These are presented in Table 6.19.

Context	Sample	Stratigraphic Block	Context Description	Shell height (mm)	Diameter (mm)	Aperture height (mm)	Number of bands
573	7791	BEA	Dark brown sand	13.8	16.2	8.8	5
1336	7388	BEF	House 3 abandonment - brown sand	15	17.2	7.5	5
1395	10029	BEE	House 3 secondary occupation - primary floor deposit	15	17.5	8	5
1514	7577	BBC	House 1 occupation - floor deposit at south of house	15.5	17.5	7.5	5
1514	7588	BBC	House 1 occupation - floor deposit at south of house	15.2	17.8	7.5	5
2258	11285	BCC	House 2 occupation. Mid red hearth	15	17.5	7.5	5
2289	11305	BCC	House 2 occupation. Hearth	14	17.8	6.8	5

Context	**Sample**	**Stratigraphic Block**	**Context Description**	**Shell height (mm)**	**Diameter (mm)**	**Aperture height (mm)**	**Number of bands**
573	7791	BEA	Dark brown sand	13.8	16.2	8.8	5
1336	7388	BEF	House 3 abandonment - brown sand	15	17.2	7.5	5
1395	10029	BEE	House 3 secondary occupation - primary floor deposit	15	17.5	8	5
2627	11384	BCC	House 2 mid to dark brown compact floor	14.2	18	7	5
2637	11396	BCC	House 2 dark brown floor	13	16	6.5	5
2653	11495	BCC	House 2 mottled brown compact floor	16	19.2	7.5	5
2658	11458	BCC	House 2 brown with orange clay flecks	13.8	17.2	7.8	5
2669	11478	BCC	House 2 brown red hearth trample	13.5	16.2	7.2	5
2669	11478	BCC	House 2 brown red hearth trample	13.8	16.2	8.2	5
2724	12101	BCA	House 2 mid brown fill of cut [2723]	13	16.2	4.5	5
2755	12119	BCA	House 2 foundation pits. Fill of cut 2754	15	18.2	6.8	5
MEAN				14.4	17.2	7.3	

Table 6.18: Measurement of 15 Cepaea hortensis *shells from Mound 2, Bornais.*

Context	Shell height (mm)	Diameter (mm)	Aperture height (mm)	Number of bands
Unstratified	13.5	16	7.5	5
Unstratified	16	19.5	8	0
1008	13.5	18	7.8	5
1023	14.2	17.5	7.5	5
1023	14.5	18.5	9.5	0
1031	13.5	15.5	9.5	1
1085	16	19.5	8.2	5
MEAN	14.5	17.8	8.3	

Table 6.19: Measurement of Cepaea hortensis *shells from Cherhill, Wiltshire.*

The Bornais shells are roughly in the middle of the size range reported by Kerney and Cameron for the UK as a whole (1979, 204), and (although the sample size in both cases is tiny) the mean values are smaller for Bornais than for Cherhill. *Cepaea hortensis* is naturally a smaller species than *Cepaea nemoralis*, studied by Thomas (1978) (the Western Isles lie beyond the northern limit of distribution of *Cepaea nemoralis*), however some relevant details emerge from his work. Thomas (1978, 14) found that *Cepaea nemoralis* shells from sand dune and coastal clifftop environments were smaller than those from inland sites. He suggests that the smaller body size may allow relatively freer movement among denser vegetation, whereas larger body size may be favoured in microclimates subject to greater temperature variation as it produces a relatively low surface area to volume ratio, reducing heat gain in summer and heat loss in winter (Thomas 1978, 14).

All of the shells were of the yellow 5-banded morphotype. Although this is not the only morphotype that occurs, it is the dominant one at coastal sites in northern Scotland (Cain *et al.* 1969, Fig 6), and especially dominant in more exposed areas, yellow unbanded morphs occurring in enclosed basins (Cain *et al.* 1969, 284). The Evolution Megalab project, which ran in 2009, invited records of polymorphism of modern *Cepaea nemoralis* and *Cepaea hortensis* from members of the public and schools (Worthington *et al.* 2009). One dataset is available for the Western Isles, from sand dunes at Traigh Mor on Lewis. Of 250 *C. hortensis* recorded, 2 were pink unbanded, 3 were pink many banded, 50 were yellow unbanded, 84 yellow one-banded, 74 yellow many-banded, 3 brown unbanded, 28 brown one banded, and 6 brown many banded (evolutionmegalab.org, n.d.), although more specific information about habitat is not available. This suggests that a variety of morphotypes might be expected in an environment like Bornais, but that morphotypes associated with exposed conditions may predominate, perhaps due to land use.

A shell of *Cornu aspersum* was also encountered in sample **12105** from House 2 floor deposit (**2731**). This is mentioned here as *C. aspersum*, which is a late introduction into the Hebridean fauna, has not previously been reported from archaeological assemblages in the Western Isles. Its periostracum is missing, suggesting it is not a recent intrusion into the deposit. *C. aspersum* is tolerant of a wide range of ecological conditions provided there is adequate dampness, so it does not add significantly to palaeoecological interpretation.

6.10 GUINNERSO

6.10.1 Introduction and Methods

Shells were extracted from the flots of 8 bulk sediment samples from excavations by Dr Claire Nesbitt and Dr Mike Church of Durham University and Dr Simon Gilmour of the Society of Antiquaries of Scotland of three semi-circular satellite cells and surrounding features at Guinnerso, Isle of Lewis, Western Isles. Shells were identified to species level using a binocular microscope, with help from the mollusc reference collection at Cardiff University

6.10.2 Results

The MNI values for all species from the 8 samples are presented within ecological groups in Table 6.20. All the mollusc shells are rather transparent, with well-preserved periostraca. and appear to be recent intrusions. All shells show signs of corrosion.

	Context Number	248	249	285	295	382	413	331	491
	Sample Number	163	164	180	184	252	284	331	346
	Trench	Cell G	Cell G	4	Cell G	Cell G		6B	7
	Context Description	Wall fill	Wall fill	Fill	Wall fill. Brown clay with charcoal inclusions.	Compact layer at base of wall structure of cell G	Grey gritty wall fill		Brown sandy silt
Ecological Group	**Taxon**								
1a	*Oxychilus alliarius*	1	1	1	1	1	1	2	1
	Total snails	1	1	1	1	1	1	2	1

Table 6.20: MNI values for snails from Guinnerso, Lewis

The presence of intrusive shells in these contexts may be due to biological activity within the sediment, or aeolian activity. The signs of corrosion are significant as they suggest an acid environment in which it is unlikely that subfossil shells would survive, limiting the likelihood of recovering archaeologically useful assemblages from this site. In the Western Isles today, *Oxychilus alliarius* generally favours synanthropic habitats, although it is also present in low numbers in damp grassland.

6.10.3 General Observations

The entire assemblage from Guinnerso may be judged to be intrusive. Poor preservation is to be expected as the site is not situated on the calcareous machair. *Oxychilus alliarius* may well be able to thrive on the acidic blacklands (this could reflect the situation on Hirta, St Kilda – see Chapter 5.1.14).

6.11 MULTIVARIATE ANALYSIS

Detrended Correspondence Analysis (see Chapter 2.3, above) was used to identify any discernible patterns in a meta-analysis across all the sites investigated as part of this study. Results from the different sites were combined into one spreadsheet, and then samples containing fewer than fifty individuals were eliminated from the analysis. This left 47 samples across 7 sites (including the modern transect at Cladh Hallan) available for analysis. Individuals that were judged to be intrusive due to their preservation, marine gastropods and taxa that were present in fewer than 10% of the samples were excluded from the analysis.

The first hypothesis explored was how the type of context sampled influenced patterns in the data. Figure 6.41 presents ordination of the 47 qualifying samples labelled by context type. Some clustering by context type is apparent, with house floors towards the bottom right of the graph, and plough soils in the centre left, with contexts that we might expect to be relatively more damp and shaded clustered around the centre of the plot. Axis 1, which accounts for 26% of the variation may show a transition to drier conditions as the *x* axis value increases, although there are midden deposits towards the top right, which we may expect to be relatively humid, and the modern loch margin deposit (surely the dampest!) is towards the centre. Axis 2, which accounts for 8% of the variation may reflect increasing instability (or mixed inputs) as the *y* axis value increases.

Although neither factor proposed above accounts for most of the variation, it is worth exploring whether there might be a temporal factor. To investigate this, the same plot was relabelled with the archaeological period of the sample. This is shown in Figure 6.42.

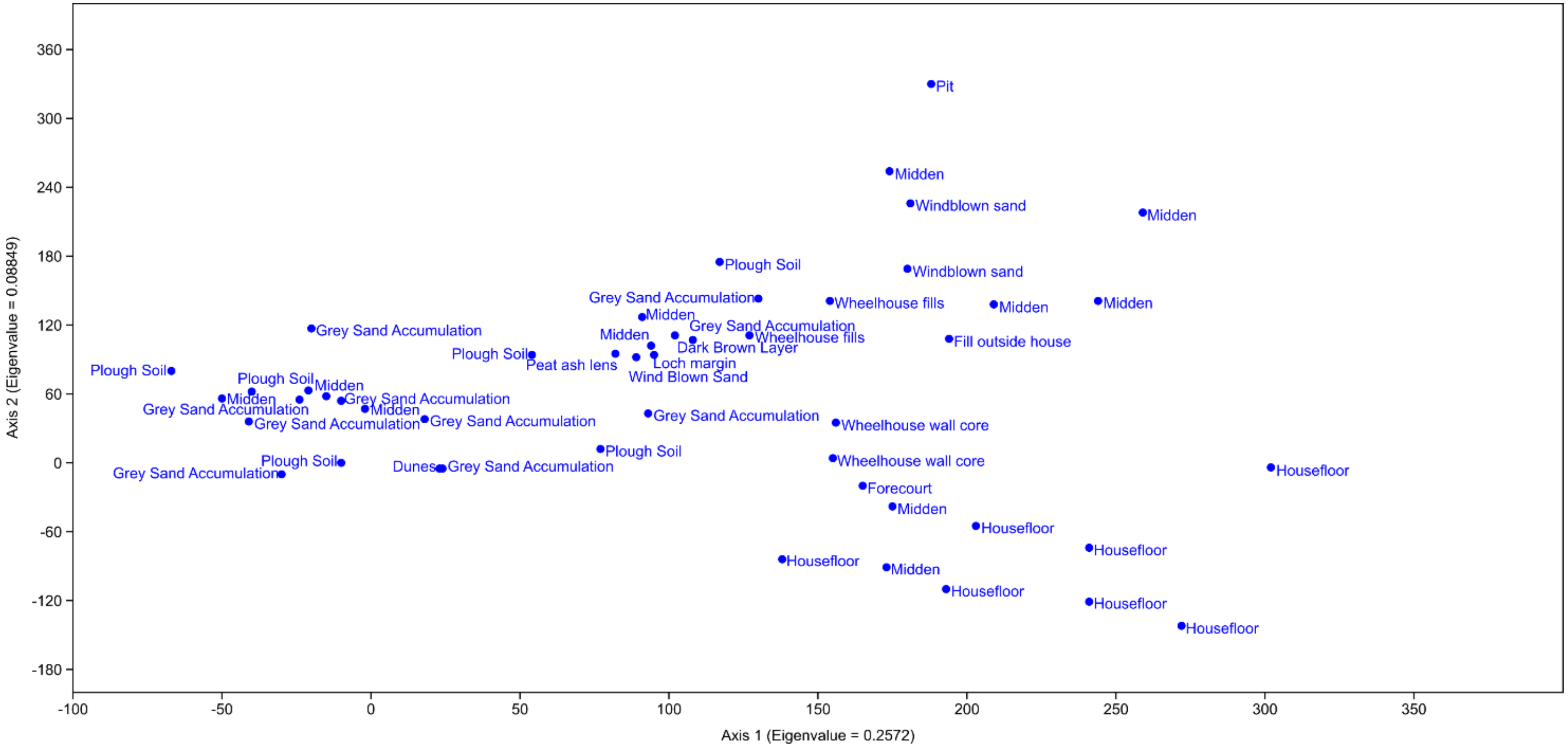


Figure 6.41: Ordination (via Detrended Correspondence Analysis) of samples from the present analysis, labelled by context type.

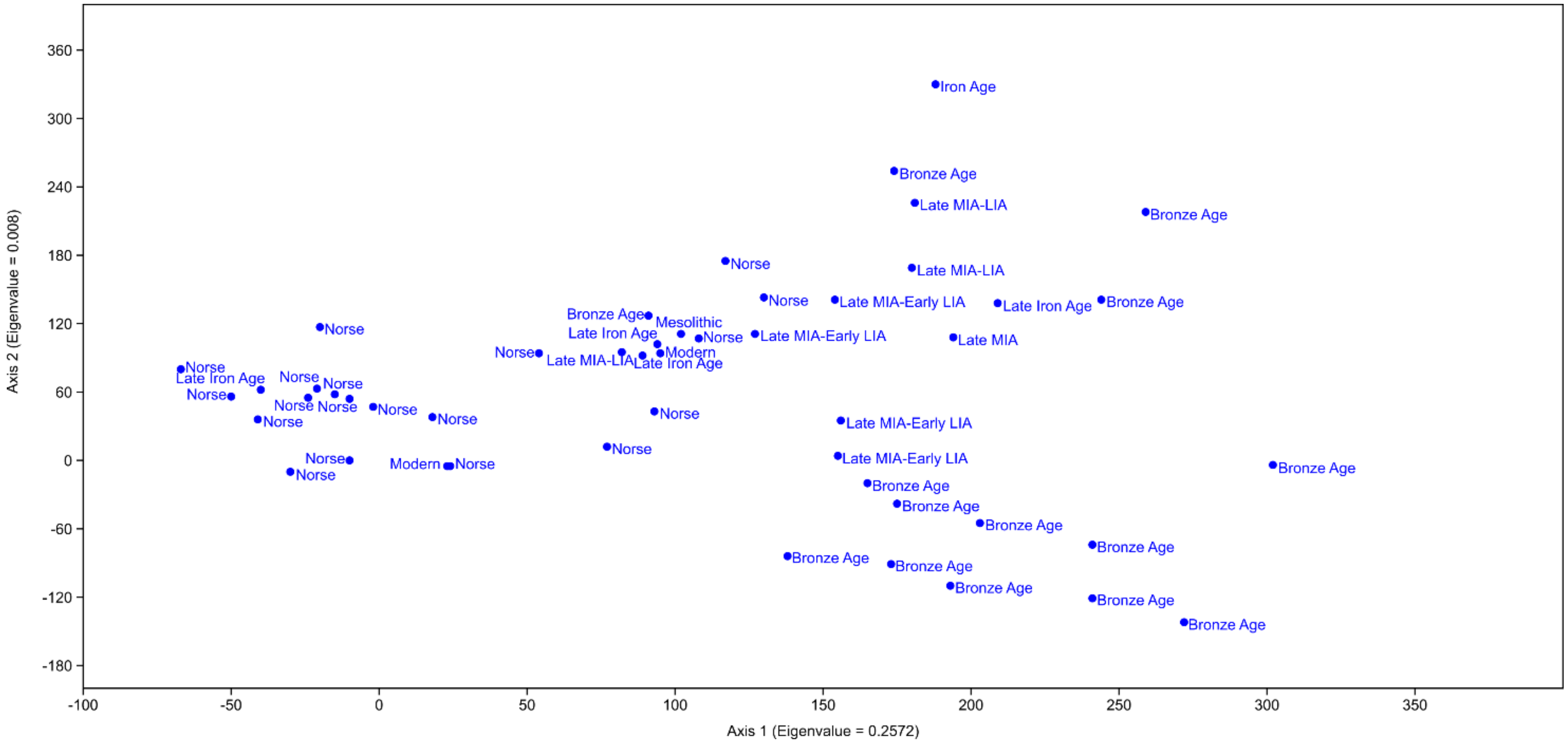


Figure 6.42: Detrended Correspondence Analysis of samples from the present analysis, labelled by archaeological period.

In this analysis, some pattern emerges, with older samples tending to be further along Axis 1 (although again there are exceptions). Two factors may account for this. The first is that there tend to be an abundance of particular context types in different periods (e.g., lots of samples from Norse Bornais came from ploughsoils, while lots of samples from Bronze Age Cladh Hallan came from house floors) so that the two sets of variables (date and context type) are not truly independent. The second is that there is also a tendency for later samples to be dominated by *Cochlicella acuta*, which is often super-abundant relative to other species.

Ordination of the same samples by species along the same axes was undertaken to reveal further patterns in the data. This is presented in Figure 6.43, below.

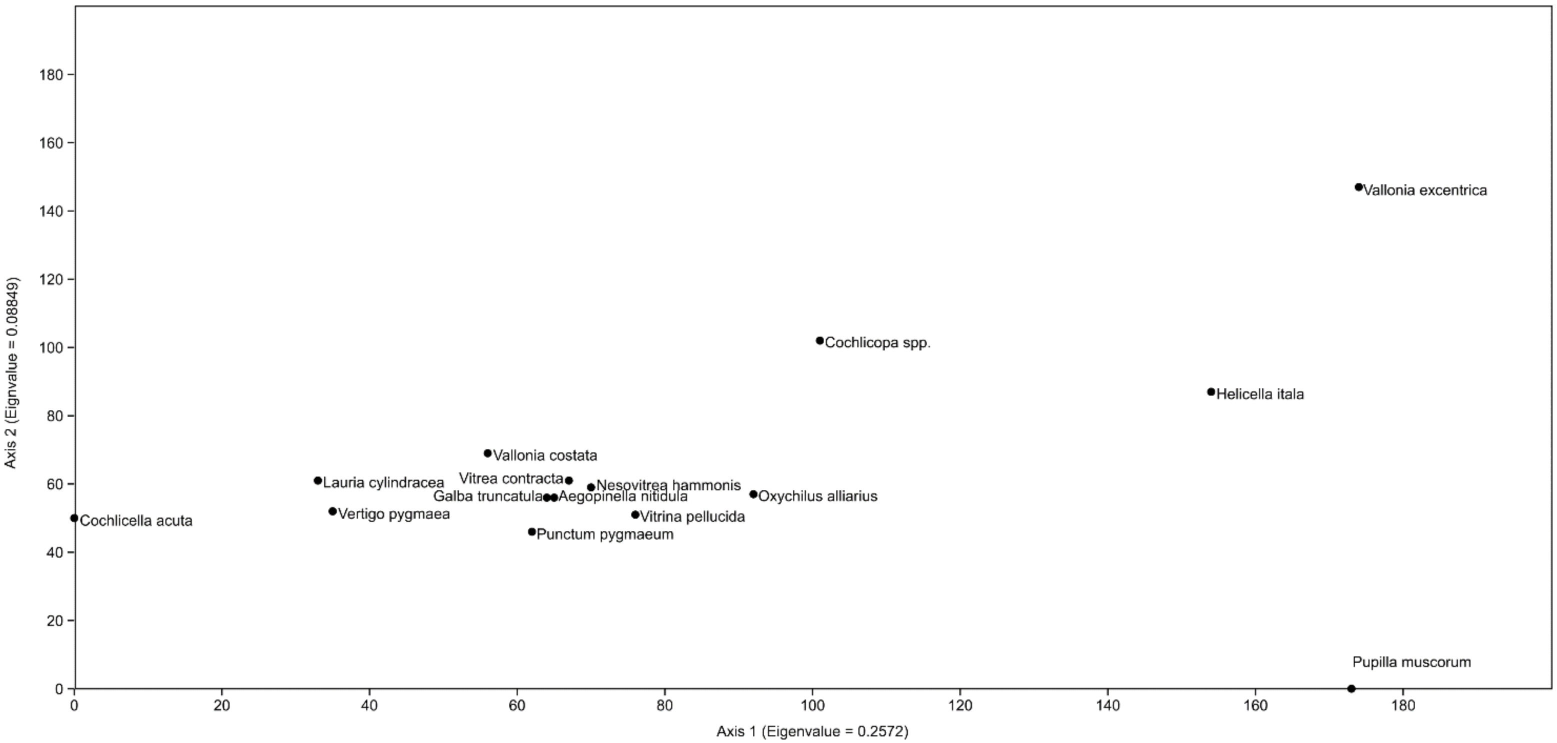


Figure 6.43: Detrended Correspondence Analysis of samples from the present analysis, by species. Note that, although the axes are the same as in Figures 6.41 and 6.42, they are presented at a larger scale.

This appears to reveal some patterns. *Cochlicella acuta* is on the far left, where it would be among the Norse ploughsoils, confirming its influence on the ordination of samples above. Snail species with a preference for drier habitats (*Helicella itala*, *Vallonia excentrica* and *Pupilla muscorum*) tend to be concentrated to the right of Axis 1, although *Vertigo pygmaea* is in the midst of a concentration of species that would be associated with relatively damper, more shaded habitats. This cluster is somewhat to the left of the clustering of damp, shaded samples seen in Figure 6.41. Looking at the ordination of taxa, it would again appear that it is Axis 1 that relates to dampness, albeit tempered by the presence of *Cochlicella acuta*. Overall, we may suspect that the initial conclusions that the axes are controlled by dampness/ humidity at ground level and stability are correct, although dampest conditions are obtained somewhere between the values of 60 and 120 on Axis 1, with samples to the left of that affected by the high numbers of *Cochlicella acuta*.

Coding the counts into Base 2 following the recommendations of Rousseau (1987) may remove some of the influence of *Cochlicella acuta* and mitigate the impact of its abundance on the ordination. Figure 6.44 shows ordination of the coded samples, labelled by context type, and Figure 6.45 shows ordination of the species following coding.

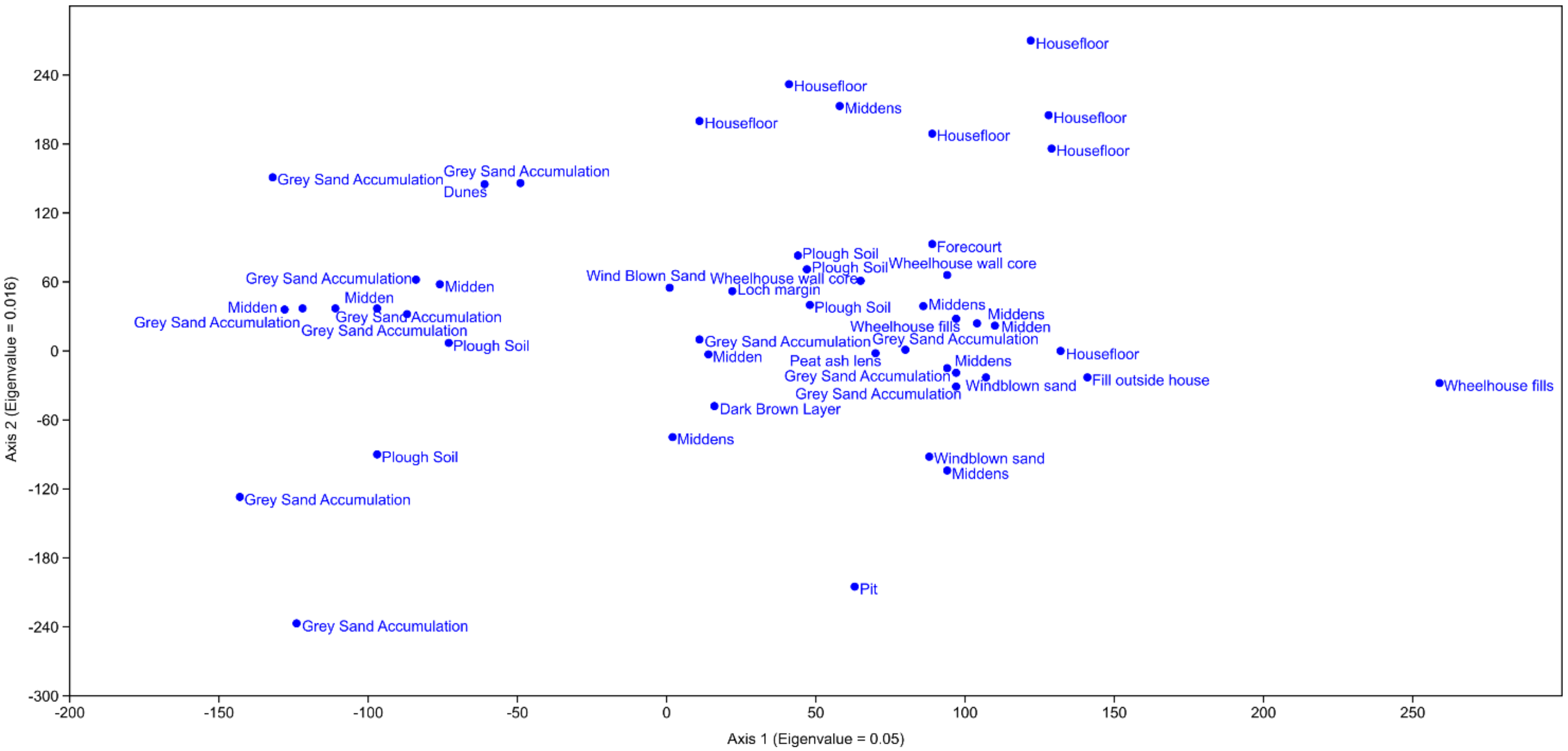


Figure 6.44: Detrended Correspondence Analysis of samples from the present analysis, after coding following Rousseau (1987).

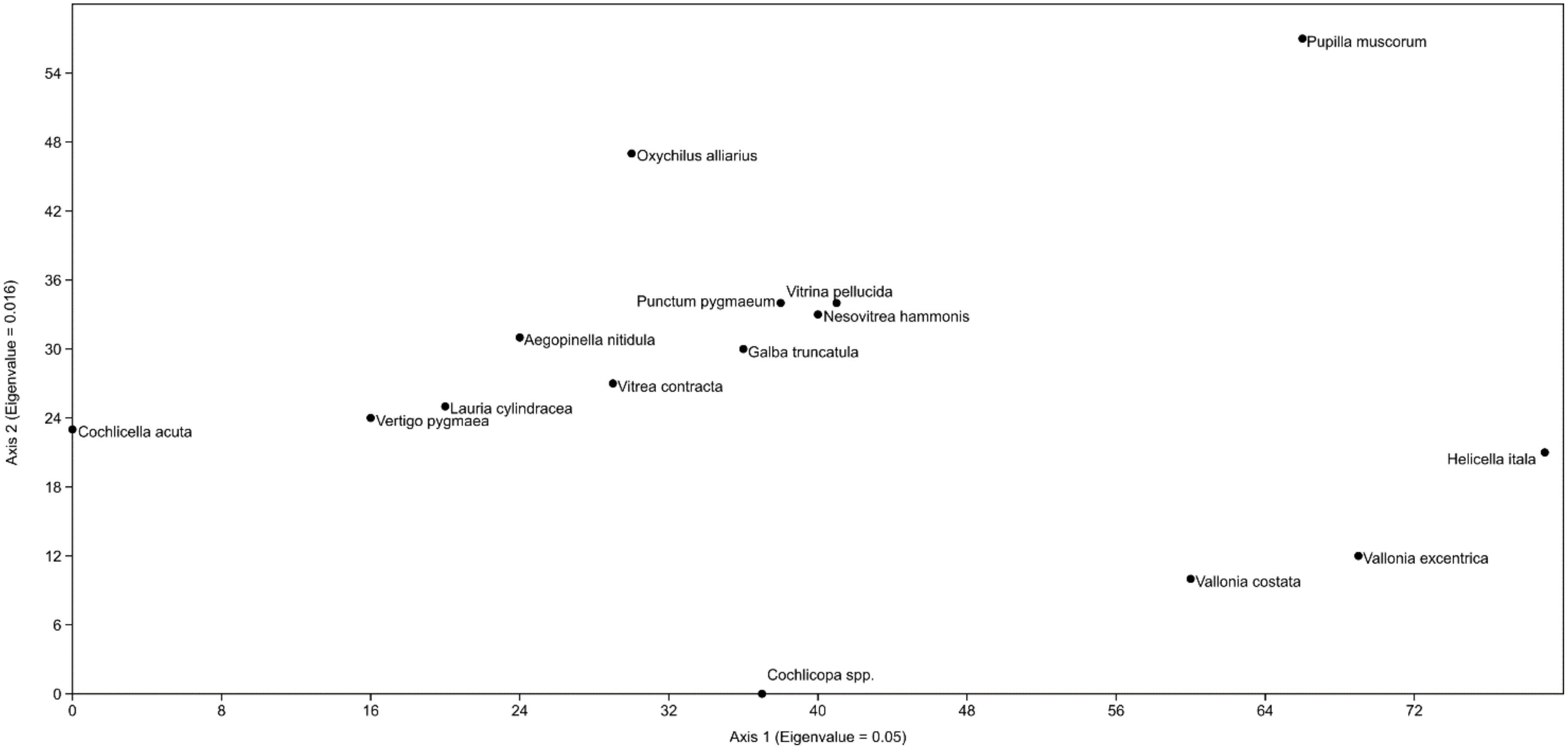


Figure 6.45: Detrended Correspondence Analysis of species in the present analysis, after coding following Rousseau (1987).

In this case, the two axes account for far less variation (5% and 2% respectively). The arrangement of samples labelled by context shows a concentration of samples in the centre which might be expected to be damper and more shaded (this coincides with the placement of taxa like *Vitrina pellucida*, *Nesovitrea hammonis*, *Punctum pygmaeum* and *Galba truncatula*).

Ordination of the spread of species reveals a core group associated with damper, more shaded contexts in the centre of the plot, with Group 4 taxa tending to be towards the right-hand side, except for *Cochlicella acuta*, which is likely to be favoured by instability. It seems in this case that Axis 1 may still be explained by humidity at ground level, with the additional influence of the dominance of *Cochlicella acuta*. Overall, ordination by detrended correspondence analysis appears to organise the samples and species into coherent groups, although these are attributable partly to environmental conditions and partly to the predominance in later samples of *Cochlicella acuta*. Coding into Base 2 does not appreciably clarify the situation.

6.12 CONCLUSIONS

The analysis above contributes 8 new sites to the archaeomalacological record of the Western Isles, which represents an 88% increase to the total corpus, with the addition of an additional set of records of the occurrence of modern taxa. Findings will be discussed in full in Chapter 8, however some brief discussion with respect to the areas of interest highlighted in Chapter 5 follows.

Cochlicella acuta and *Helicella itala* remain absent until later prehistory. *Helicella* first appears in the Middle Iron Age at Cill Donnain III, and *Cochlicella* is largely dominant at all sites from the Late Iron Age onwards. The placement of Ceardach Ruadh with respect to these two taxa is problematic, as they are seemingly absent until the modern dune surface, although the small amount of ceramic evidence would suggest much of Section 1 is later than Late Iron Age. Clearly more investigation of this eroding site will be necessary to clarify the dating. From this study, it appears that *Cochlicella* and *Helicella* arrive in South Uist in the Middle Iron Age and in the Horgabost area of Harris in the Late Iron Age.

In terms of the vegetation history of the islands, there is little in the new analyses to suggest that the wider environment is wooded during the period the sites studied were in use. A few shade-demanding taxa are present at various times, however these all reflect local environment, either taller vegetation or the presence of structures. Likely phases of flooding were identified at Allasdale and at Bornais. Marine gastropods indicative of the collection of seaweed were identified at Cladh Hallan, Allasdale, Horgabost, and Bornais.

The use of numerical analyses, and especially diversity indices, helps determine the likelihood that shell inputs into a deposit are mixed. This will be explored further in Chapter 8.2. Coding of data for Detrended Correspondence Analysis into Base 2, following the recommendations of Rousseau (1987) adds little.

Figure 7.1: Sites considered. Contains Ordnance Survey data. Crown © and database right 2017.

Marine shells are commonly found at archaeological sites in the Western Isles, indeed eroding deposits rich in marine shells at the coast, or marine shells scattered around the entrance to rabbit burrows, are often the most obvious indication that a buried archaeological site exists. Sites investigated are shown in Figure 7.1. They span the Early Bronze Age through to the Norse period. Land snails from each of these sites, apart from Mound 2 at

Bornais are discussed in Chapter 6. Once again, sites are organised in a roughly chronological order.

The aims of this part of the study can be summarised as

1. To assess the contribution that analysis of marine shells can make to wider archaeological narratives at sites in the Western Isles.

2. To investigate changes in the composition of marine shell assemblages at different sites through time.

The specific objectives were

1. To use the availability of assemblages of marine molluscs from recent excavations to contribute to broader archaeological narratives.
2. To quantify the species present at each site and comment on changes through time
3. To use analysis of variations within species from select samples to draw conclusions about shellfish harvesting.

The methodology used was largely similar for each of the sites, where differences exist these are explained below. For gastropod species, the most commonly represented non-repetitive element (usually the shell apex, umbilicus, or body whorl with mouth) was counted to determine the minimum number of individuals (MNI) present, following the advice of Giovas (2009). For bivalve taxa, the left and right umbones were separated and counted, and the higher number used as MNI. The principle source consulted for ecological information was Hayward *et al.* (1995). Nomenclature follows CLEMAM (Checklist of European Marine Molluscs, online at http://www.somali.asso.fr/clemam/).

7.1 SLIGEANACH

7.1.1 Introduction and Methods

Marine shells from eleven bulk sediment samples from Niall Sharples's excavations in 1998 at the Early Bronze Age site of Sligeanach, Cill Donnain, South Uist were analysed (Table 7.1). The shells derived from a greater than 10mm fraction following sieving of sample residues. This will have had some impact on the number and variety of shells recovered compared to use of a smaller mesh sieve. Although few edible taxa are likely to be smaller than this size, limpets (*Patella* sp.) in particular may be fragmentary in archaeological assemblages. The results of this analysis have been published (Law 2012), although reference is made here to subsequent publications. Results (minimum number of individuals) are presented in Table 7.1. A total of 3,544 shells were recovered and identified.

7.1.2 Limpets

Apart from samples **9050** and **9051**, both from context **242** in Trench X (Mound 16), limpets were the dominant shells in the samples. As stated previously (Chapter 5.9), there has been some debate about the purpose of limpets in prehistoric societies, with their use as animal fodder and fishing bait invoked as explanations for the presence of their shells in archaeological contexts. Collections of intact shells found in inland contexts are most parsimoniously interpreted as anthropogenic food waste, however (Sharples 2005, 159).

To investigate the provenance of the limpets in relation to their position on the shore, 100 intact limpet shells from two samples, **9039** and **9042**, were measured, these are plotted in Figure 7.2. The size range within the two samples is broadly similar, suggesting little difference in environmental conditions. A paired t-test revealed that neither the difference in mean shell length between the two samples nor the difference in mean shell height between the samples were statistically significant (for length $p = 0.2$, for height $p = 0.39$). All the limpets at Sligeanach were consistently small compared to the size range for adults (Hayward *et al.* 1995, 502) and quite squat, suggesting a harvesting location on the mid to low shoreline (see Chapter 2.2.6.1). The mean limpet sizes from Sligeanach are slightly smaller than those reported from the Norse period settlement at Mound 3 at Bornais, and from Iron Age and Post-Medieval contexts at Dun Vulan (Sharples 2005, 159 – 161), which are also rather small. It is clear that limpets were not being selected for maximum individual meat yield.

A small number of the limpet shells recovered bore patches of encrustation from spirorbid worms, mostly the larger, more pointed shells. Pointed shells may be associated with stress in limpets (Campbell 2008). Most species of spirorbid worms live below the mid tide mark, suggesting that the limpets whose shells bear their tunnels are unlikely to be high shore limpets. Campbell (2007) found a similar situation at Le Yaudet in Brittany, and concluded that, as spirorbids are associated with seaweed, limpets were more stressed under seaweed cover and so were growing more pointed shells.

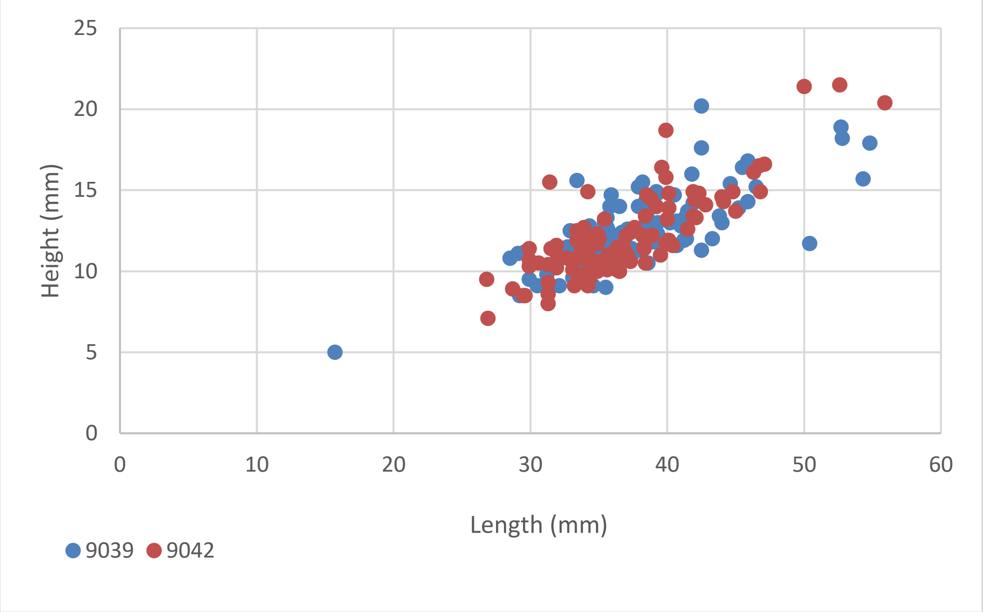


Figure 7.2: Limpet shell length against shell height in millimetres. Sample 9039 (mean shell length = 37.9 mm, mean height =12.6 mm). Sample 9042. (mean shell length = 36.1 mm, mean shell height = 11.8 mm).

7.1.3 Other marine shell

MNI (Minimum Number of Individuals) values for other marine molluscs from the samples examined are listed in Table 7.1. Apart from limpets, winkles (*Littorina littorea*) are the only other taxon to occur in any great quantity, and are the dominant species in the two samples from Trench X (Mound 16). These are most likely food waste. Unlike limpets, they continue to be a popular foodstuff in the present day. At Mound 3 at Bornais, winkles were the dominant species in most of the samples from all but one stratigraphic block (Sharples 2005, 89). At neighbouring Cill Donnain, winkles predominate in all phases (Early-Middle Bronze Age to Late Iron Age), although limpets decline in popularity through time (Bell and Godden 2014, 184-5).

Other shells occur only as incidental finds. The small number of cockle and razor shell fragments are likely to represent food waste harvested from a different source location as they are found on sandy shores rather than on rocks. Razor shells are burrowing species capable of digging at great speed, which presents a challenge when harvesting them (Chambers 2009, 165-6), The other recovered species may have been brought to the site accidentally, and are all small shells (the individual shell of *Buccinum undatum* is of a young individual). They represent intertidal species, although *Buccinum undatum* and *Gibbula cineraria* are more usually sublittoral and lower shore species (Hayward *et al.* 1995, 506, 535), perhaps lending support to the idea that the lower shore was preferred for shellfish harvesting.

7.1.4 General Observations

In common with most other previously reported (see Chapter 5.9) prehistoric assemblages from the Western Isles, limpets and winkles predominate. In particular, limpets are dominant overall, and seem to have been harvested from the lower shore.

	<9000> Context 4 Tr B	<9002> Context 18 Tr A	<9031> Context 158 Tr K	<9032> Context 172 Tr Q	<9039> Context 172 Tr Q	<9041> Context 183 Tr S	<9042> Context 191 Tr P	<9045> Context 202	<9050> Context 242 Tr X	<9051> Context 242 Tr X	<9052> Context 221 Tr T
	Mound 238	Mound 18	Mound 17	Mound 23	Mound 23	Mound 22	Mound 24		Mound 16	Mound 16	
Species											
GASTROPODA											
Littorina littorea (Linnaeus, 1758) Common periwinkle	4	3	4	6	18	1	3	4	76	120	2
Littorina obtusata (Linnaeus, 1758) Flat periwinkle	-	-	-	-	3	-	-	-	1	-	1
Patella spp. Limpets	6	8	-	972	1102	16	1051	3	60	70	2
Gibbula cineraria (Linnaeus, 1758) Grey topshell	-	1	-	-	-	-	2	-	-	1	-
Buccinum undatum (Linnaeus, 1758) Common whelk	-	-	-	-	1	-	-	-	-	-	-
BIVALVIA											
Cerastoderma sp. Cockles	-	1	-	1	-	-	-	-	-	-	-
Solenidae sp. Razor shells	-	-	-	-	-	-	-	-	1	-	-

Table 7.1: Marine shell from Sligeanach.

7.2 ALLASDALE

7.2.1. Introduction, Methods and Results

Marine shells were both hand-collected and extracted from the residues of sediment samples from the Neolithic to Iron Age site of Allasdale on Barra. The sample residues were caught on a 1mm mesh. The shell assemblage was discussed very briefly in Wessex Archaeology (2008, 22), and has been re-examined for this study. A total of 139 shells were recovered and identified. Generally, there are low numbers of shells in each context, and most of the shells were from later prehistoric levels. Results and individual sample volumes are presented in Appendix 2. Preservation was generally good throughout the assemblage, indicating relatively swift burial in calcium-rich contexts.

7.2.2 Discussion

The assemblage is dominated by limpets (*Patella spp.*), which are the most numerous type of shell in all but two of the contexts in which they occur, although common periwinkle (*Littorina littorea*) is almost as common in the Late Iron Age midden deposit, context **408**. Great scallop (*Pecten maximus*) shells are present in the cultivation layer **217** and the possibly Late Bronze Age post-abandonment topsoil **255**. These are of note because unlike the other edible taxa represented here, they are not harvested from the shore, rather they are collected by diving or dredging. There is a possibility, however, that the empty shell was collected as a curio. The two shells of Northern cowrie (*Trivia arctica*) in windblown sand context **201** may also be curios, as it is not an edible species, alternatively they may have been transported by birds.

7.3 CEARDACH RUADH, BAILE SEAR

7.3.1 Introduction and Methods

Marine shells were recovered from two vertical sequences of samples from Ceardach Ruadh, Baile Sear (for details, see Chapter 6.7). Samples were washed through a 500µm mesh sieve. Additional shells were hand collected from the lower midden deposit, context **111**. The minimum number of individuals are presented in Table 7.2, and as a biostratigraphic diagram in Figure 7.3. A total MNI was 170. Due to the low number of limpet shells, metrical analysis was not undertaken.

7.3.2 Section 1

The southernmost section investigated, Section 1, was a long vertical sequence. At the bottom of the sequence was a yellow sand deposit (**112**), which contained 4 common periwinkles (*Littorina littorea*) and 3 left valves of common cockle (*Cerastoderma edule*). This was overlain by the lower midden deposit (**111**), which contained the greatest abundance of shells: at least 67 cockles, 50 winkles and a mussel (*Mytilus edulis*). Discrete dumps of shells that are less than 2m across and 2-10cm thick, such as this context, probably represent single discard events and may even be the result of one meal (Campbell 2015, 4). This dump was sealed by a sand deposit (**110**) which contained three winkles, and then the upper midden deposit (**109**), which contained 24 winkles and 1 juvenile flat periwinkle (*Littorina obtusata*). This was most likely accidentally collected as it was too small to contain much meat.

The overlying context, **108**, did not contain any marine shell, context **107** contained just one winkle, **106** contained a fragment of mussel shell, and **105** did not contain any shell. Between **104** and **101** there was a small assemblage of winkle shells, and one limpet shell in **104**.

The relatively high number of cockles in **112** and especially **111** are worthy of note. Although present in low numbers in most archaeological shell assemblages from the Western Isles, cockles are seldom dominant. They do make significant contributions to the makeup of Bronze Age assemblages at Cill Donnain (Bell and Godden 2014) and Cladh Hallan (Parker Pearson unpublished, reported in Bell and Godden 2014), however, but decline at both sites during the Iron Age. This situation is reversed at Northton, where after a significant presence in the Neolithic, they decline in the Beaker levels and become more numerous again in the Iron Age II horizon (Evans 1971, 61-2). This suggests that the consumption of cockles is linked to local availability, which varies in response to environmental factors or degree of exploitation.

7.3.3 Section 2.

A small assemblage of marine shell was also recovered from section 2. Context **203**, a floor deposit, contained one winkle, while **201**, a somewhat organic sand deposit, contained a cockle shell and a rough periwinkle, the latter very unlikely to be food waste.

	Context Number	**101**	**102**	**103**	**104**	**106**	**107**	**108**	**109**	**110**	**111**	**111**	**111**	**112**	**201**	**203**
	Sample Number	**3**	**4**	**5**	**6**	**8**	**10**	**11**	**13**	**14**	**Hand collected**	**15**	**16**	**17**	**18**	**20**
Taxon																
GASTROPODA																
Patella vulgata Linnaeus, 1758 (Common limpet)					1											
Littorina littorea (Linnaeus, 1758) (Common periwinkle)		3	1	2	2		1	2	24	3	16	27	7	4		1
Littorina saxatalis (Rough periwinkle)															1	
Littorina obtusata (Flat periwinkle)									1							
BIVALVIA																
Cerastoderma edule (Linnaeus, 1758) (Common cockle)											14	30	23	3	1	
L. valve											*14*	*30*	*14*	*3*	*1*	
R. valve											*14*	*14*	*23*			
Mytilus edulis Linnaeus, 1758 (Common mussel)						1					1					

	Context Number	**101**	**102**	**103**	**104**	**106**	**107**	**108**	**109**	**110**	**111**	**111**	**111**	**112**	**201**	**203**
L. valve											*1*					

Table 7.2: MNI of marine shells from Ceardach Ruadh, Baile Sear (BCR14).

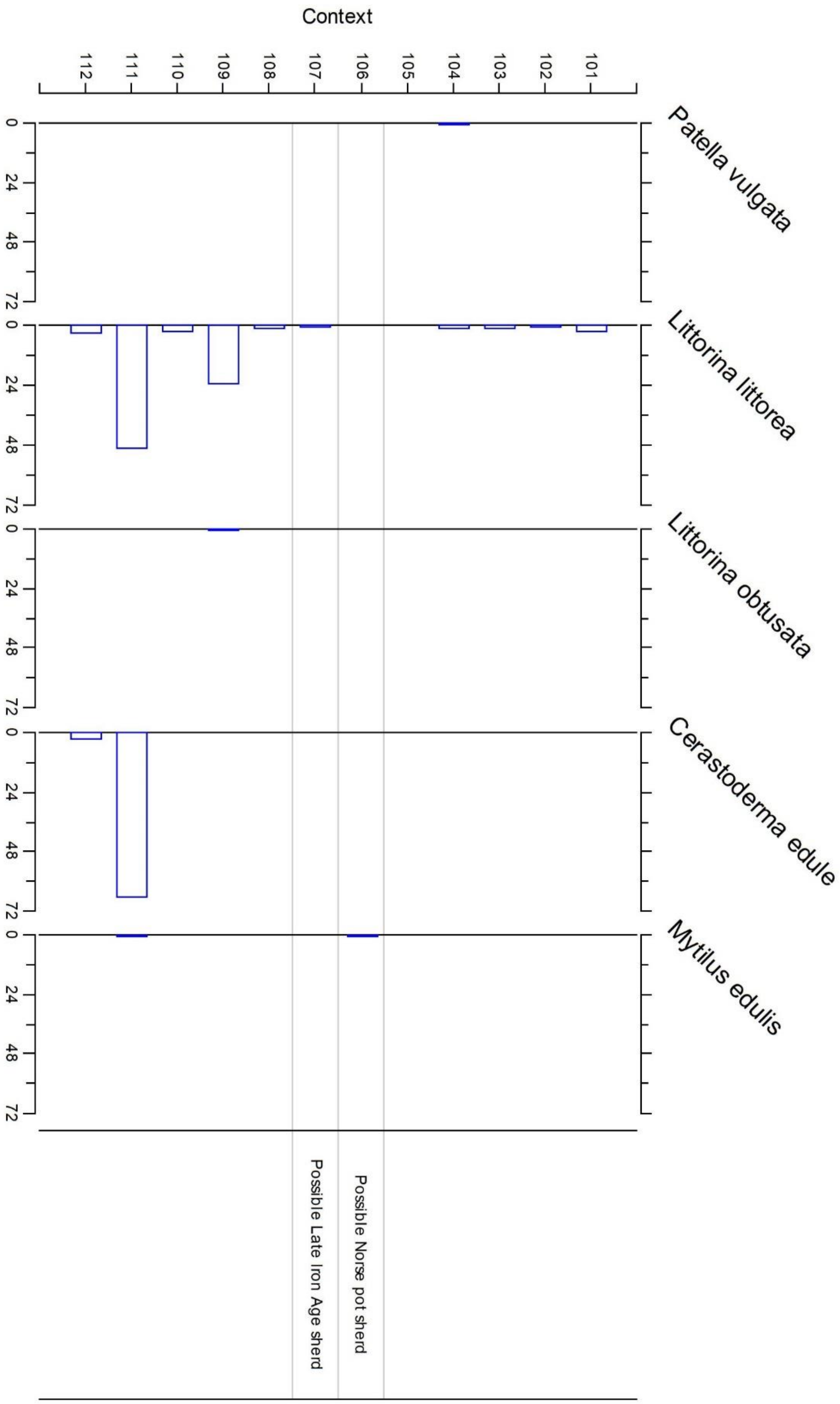


Figure 7.3: Marine shells from Section 1, Ceardach Ruadh, Baile Sear, minimum number of individuals presented as a biostratigraphic diagram.

7.3.4 General Observations

The assemblage is largely dominated by cockles and winkles. On comparison to the ceramic finds, this is likely to be a Late Iron Age midden, although the absence of the snails *Cochlicella acuta* and *Helicella itala*, which might be expected in a context of that date is of note. It seems likely that the prevalence of cockles reflects local availability.

7.4 MOUND 2 AND MOUND 2A, BORNAIS

7.4.1 Introduction and Methods

99,139 individual shells from the Norse period Mound 2 and Mound 2A, were identified. The shells were predominantly from bulk sediment samples, although some hand collected shells were also present. Shells were identified by comparison with a reference collection by ML with Emma Smith, Vicky Challes and Shoned Jones. The shells from samples derive from residues above 10mm, as such some smaller taxa and small fragments of larger taxa are likely to be under-represented. Small marine gastropods from a selection of sample flots from Mound 2A are considered along with the land snail assemblage in Chapter 6.9.

Three species were selected for special investigation, limpets, winkles and oysters. The first two are the dominant species in the assemblage. Oysters were chosen because they are commonly basibionts for a range of other marine invertebrates. To further understand the exploitation of limpets, three large samples were selected for special consideration due to the high number of shells they contained. These were sample **10664**, context **1649**, from block GAA, the primary cultivation soils of Mound 2A; sample **10409**, context **1764**, from block GBG, deposition associated with kilns on the edge of Mound 2A; and sample **7230**, also from context **1649**, the cultivation soil. Measurements (maximum height, maximum width, and maximum length) were taken from complete shells. Notes were also made on the presence of damage caused by epibiont organisms and possible human activity, as well as signs of growth checks in the shell. As some interesting breakage on the shells was seen, this was recorded following the zonation scheme described in Law (2014).

Winkle shells from sample **9892**, context **1057**, from stratigraphic block BCC, associated with the occupation of House 2, Mound 2, were also measured.

Oyster shells from 8 contexts in Mound 2A were also selected for special consideration. The valve (either left, lower, cupped valve or right, upper, flat valve) present was determined, and the maximum length and height of shell recorded following Claassen (1998). Again, notes were made about the presence of damage by epibiont organisms and human activities.

7.4.2 Results

The absolute abundance of taxa identified from Mound 2 and Mound 2A are presented in Figure 7.4 and Figure 7.5 respectively. To demonstrate how their dominance varies across different stratigraphic blocks, the relative abundance of the two most common taxa, limpets (*Patella vulgata*) and common periwinkle (*Littorina littorea*) for Mound 2 and Mound 2A are presented in Figures 7.6 and 7.7 respectively. Tables of results are presented in Appendix 2.

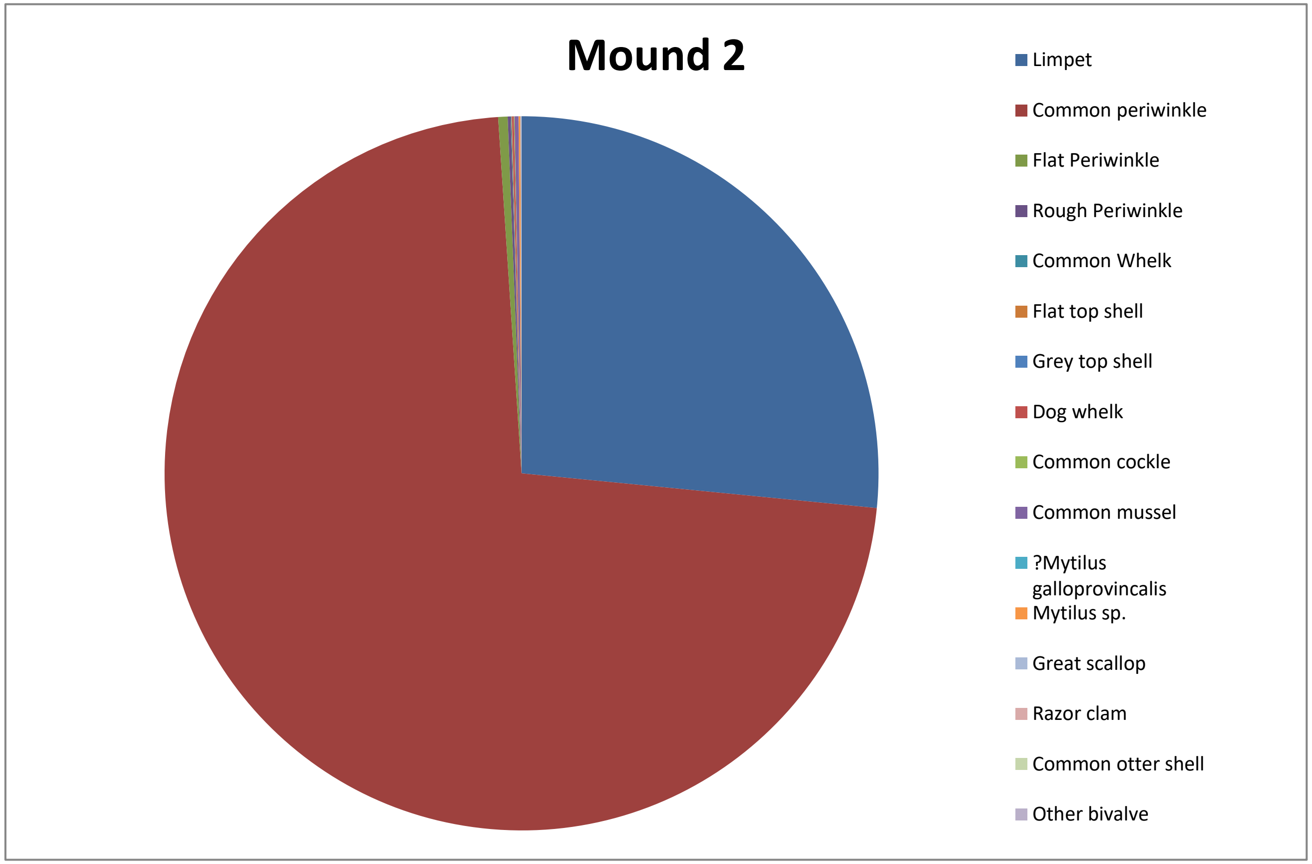


Figure 7.4: Absolute abundance of marine mollusc shells, Mound 2.

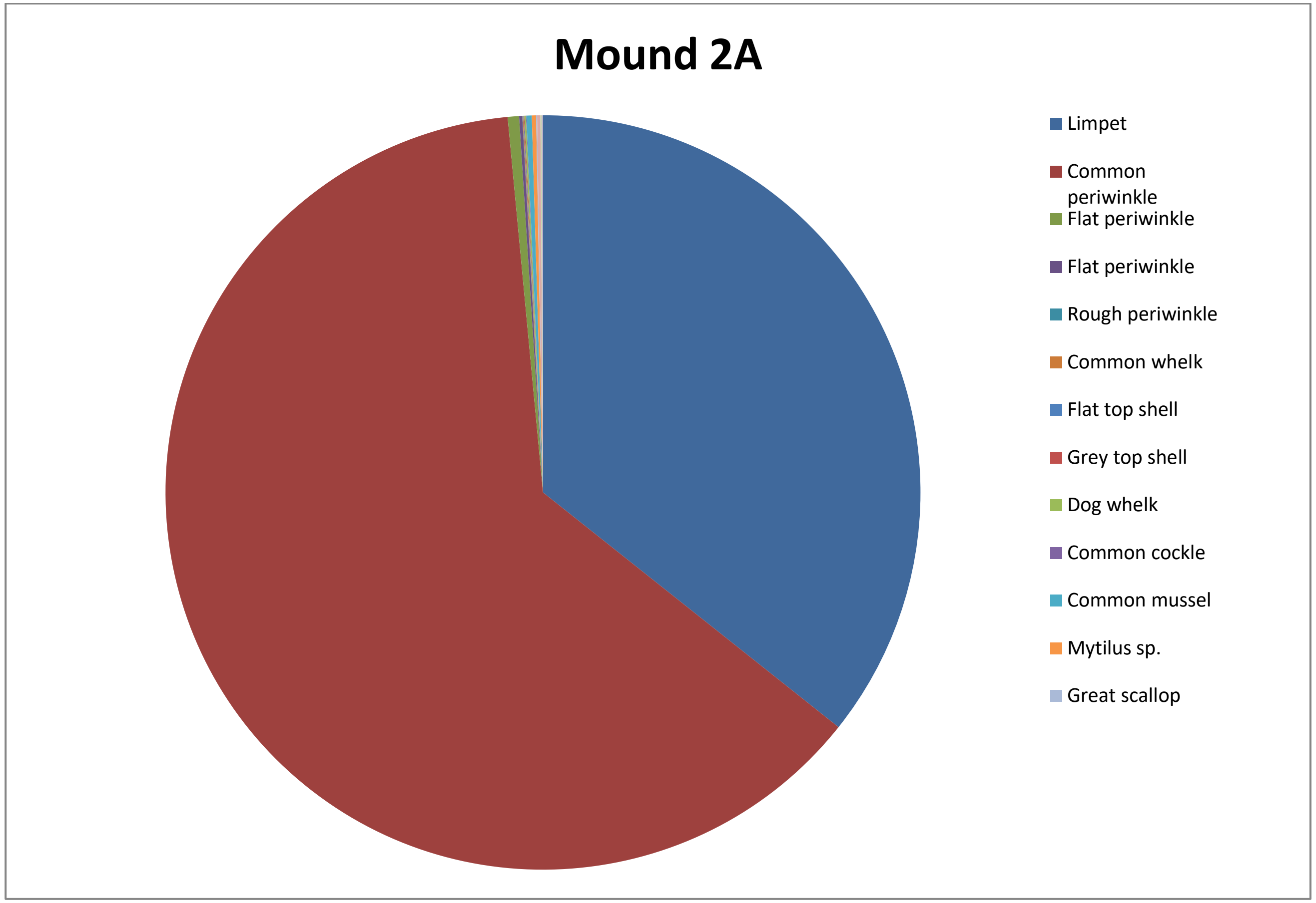


Figure 7.5: Absolute abundance of marine mollusc shells for Mound 2A

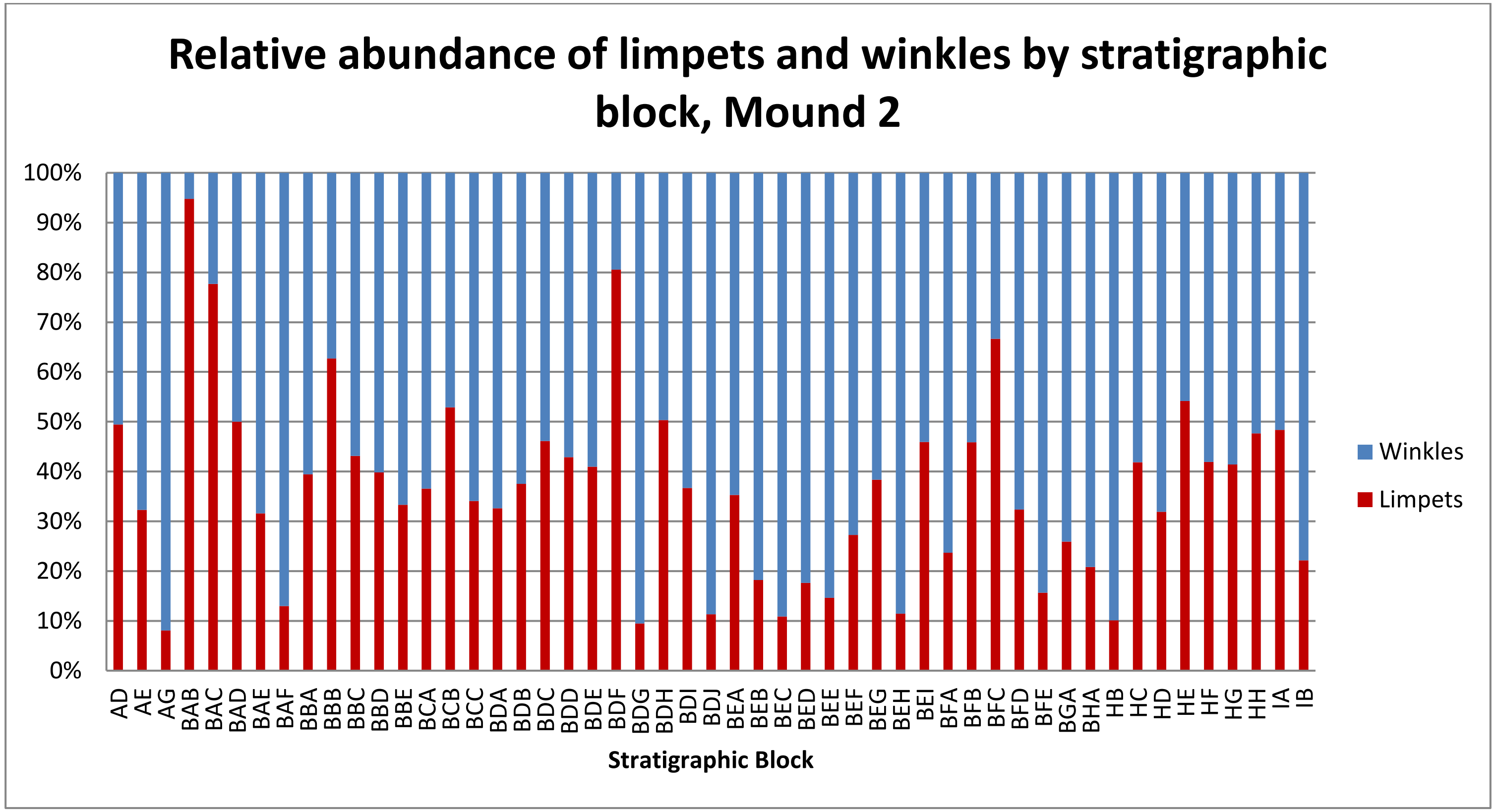


Figure 7.6: Relative abundance of limpets and winkles by stratigraphic block, Mound 2.

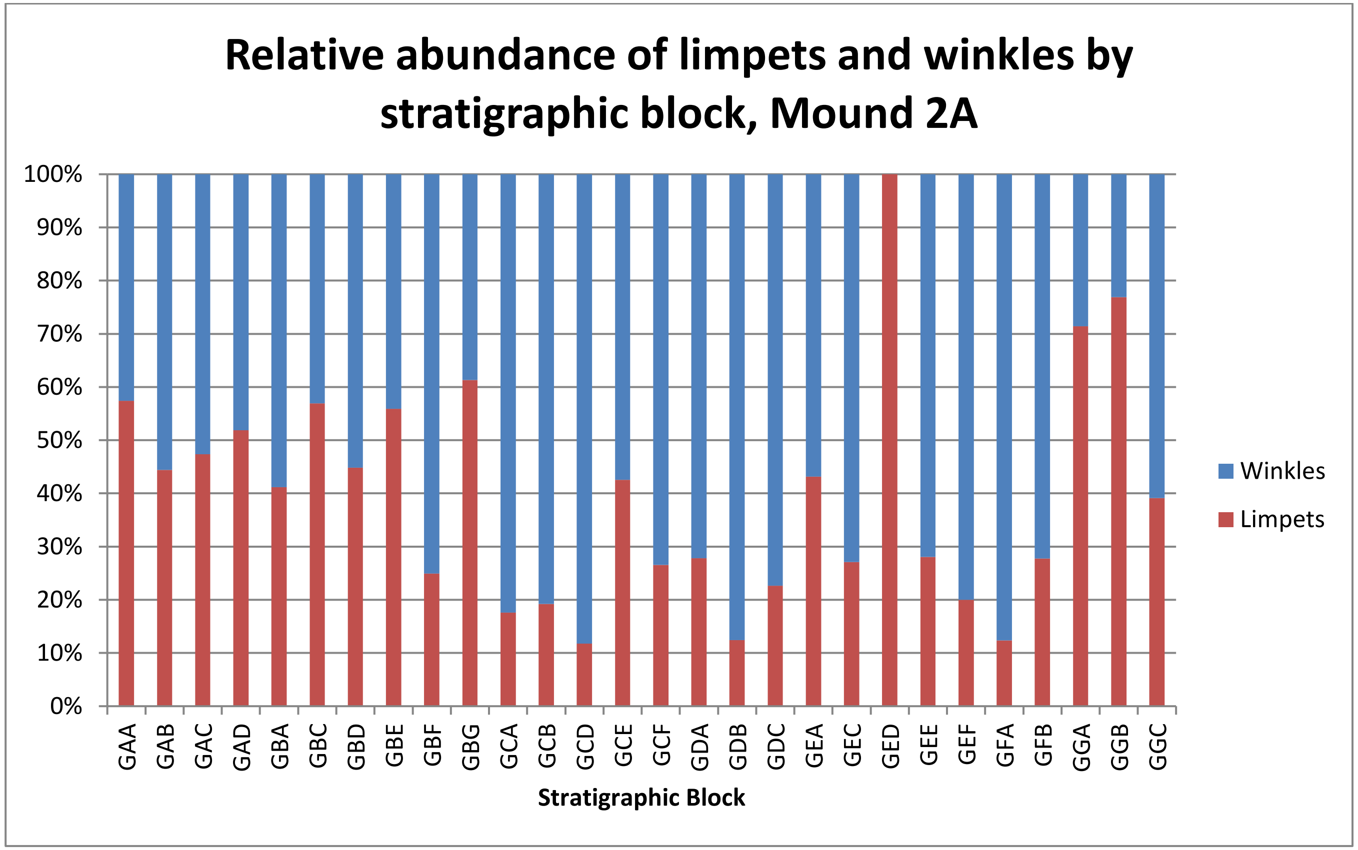


Figure 7.7: Relative abundance of limpets and winkles by stratigraphic block, Mound 2A.

7.4.3 General observations

A total of 73,797 individual shells from Mound 2 were identified, and 25,342 from Mound 2A. The samples are overwhelmingly dominated by limpets and winkles, winkles being most numerous overall.

The predominance of limpets and winkles at Mounds 2 and 2A is a shared trait with the previously analysed Late Iron Age Mound 1 (Sharples & Light 2012) and Norse period Mound 3 (Sharples 2005), where other taxa only make a small contribution to the assemblage. It is also a characteristic shared with prehistoric sites in the Western Isles, such as Sligeanach on South Uist (Chapter 7.1; Law 2012) and Cnip on Lewis (Cerón-Carrasco 2006); as well as other Norse sites in the Scottish islands, such as Quoygrew, Orkney (Milner & Barrett 2012) and Buckquoy, also on Orkney (Evans & Spencer 1977) (see Chapter 5.9 for a fuller discussion).

7.4.4 Limpets

7.4.4.1 Size

Measurements from the three samples are presented in Figure 7.8. The measured shells from samples <**7230**> and <**10664**>, both from context **1649**, have a mean length around 40 mm (Tables 7.4 and 7.5), which is toward the larger end of the size range of UK limpets (Hayward *et al.* (1995, 502) give a maximum size for *Patella vulgata* of 60 x 50 x 30 mm). These specimens are comparable in size to the limpets measured from Buckquoy (Evans & Spencer 1977), Area G of the Farm Mound at Quoygrew (Milner and Barrett 2012), and slightly larger than the shells from Floor 1 at Mound 3, Bornais (Sharples 2005).

The skewness of the mean lengths from these two samples is negative, however, showing that the data contains a long left tail, with shells considerably smaller than the mean shells.

Several shells are 20 mm or less in length, giving a negligible meat yield, although these smaller limpets may well have been preferentially selected as they would tend to be less rubbery. Milner and Barrett (2012, 113) rightly caution against projecting the modern view of palatability onto people in the past, however, and the selection of similarly sized limpets in other Norse assemblages from Scottish islands suggests a preference for larger limpets.

The shells from the later sample, **10409**, from pit fill **1764** in Block GBG, are considerably smaller, with a mean length of 32.6 mm (Table 7.3). A decline in limpet size through time was recorded by Sharples (2005) at Bornais Mound 3, but these limpets are even smaller still. This may be the result of an over-exploitation of limpets on the shore, or a change in taste towards small limpets. The sample size is probably too small to permit any firm conclusions about changes through time, however, and factors such as damage from the processes that led to the shells being buried in a particular context, excavation damage and damage during post-excavation sample processing are likely to be significant.

As mentioned above (Chapter 2.2.6.1), the shape of limpets can vary depending on environmental factors, including their position on the shore. The measured shell in the three samples are neither extremely conical or flat, perhaps suggesting a mid-shore position, or a relatively even rate of dampness.

<10409>			
	Mean	Standard Deviation	Skewness
Length (mm)	32.6	5.41	0.25
Width (mm)	27.3	5.13	-0.05
Height (mm)	10.6	2.56	0.17

Table 7.3: Limpet statistics from sample <10409>.

<10664>			
	Mean	Standard Deviation	Skewness
Length (mm)	40	6.28	-0.58
Width (mm)	33.1	5.83	-0.62
Height(mm)	12.8	3.23	0.07

Table 7.4: Limpet statistics from <10664>.

<7230>			
	Mean	Standard Deviation	Skewness
Length (mm)	40.1	5.1	-0.13
Width (mm)	34.3	4.77	-0.04
Height (mm)	13.7	2.88	0.16

Table 7.5: Limpet statistics from <7230>.

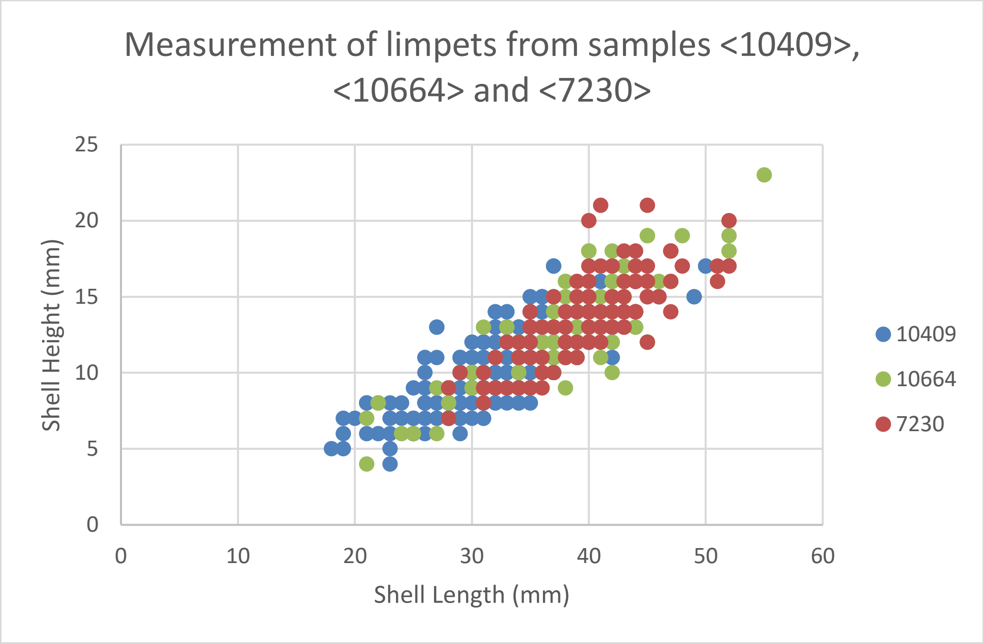


Figure 7.8: Length and height of limpets from samples <10409>, <10664> and <7230>.

7.4.4.2 Age

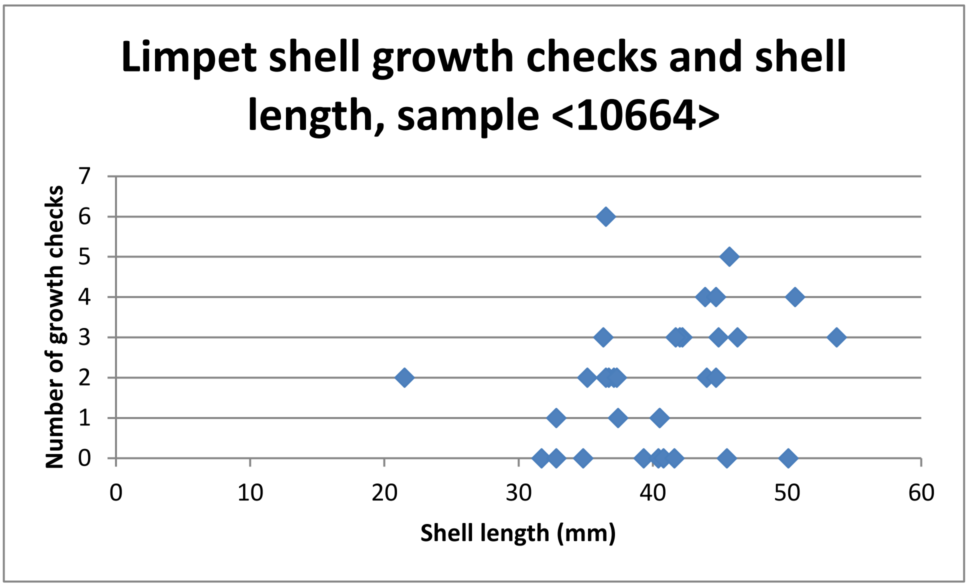


Figure 7.9: Limpet shell growth checks and maximum length, sample <10664>.

Visible growth checks said to occur in winter on the outside of limpet shells have been used in other studies to estimate the age of the animals (e.g. Milner *et al* 2007). In fact, the situation appears to be more complicated, with annual growth checks occurring in winter in limpets from cold-temperate seas, and in summer in limpets from warm-temperate seas (Surge *et al* 2013). Hebridean limpets would be expected to fall within the cold temperate seas group. Figure 7.9 presents growth check and shell size data for sample **10664**. Many of the shells examined did not have such growth checks, either due to poor preservation of the shell, or because they could not be identified on well-preserved shell. Those that did obviously bear such growth checks generally bore two or three, although some – including shells close to the lower end of the size range - bore as many as six. It may be that growth checks are not merely seasonally determined and that other environmental stresses are factors. Overall, there is a preference for limpets that appear to be about two to three years age.

7.4.4.3 Breakage

The distribution of breakage on shells from three samples is presented in Table 7.6. Breakage in zones 2 and 9, which represent the left anterior margin of the shell, predominate. This may be consistent with a lateral blow from a limpet hammer, or roughly levering a blade under the shell to dislodge the animal from rock. An alternative method for collecting limpets is to firmly strike the shell on the apex with a sharp tool, which releases the limpet's suction (Cunliffe & Hawkins 1988, 36). A small number of shells had holes at the apex (Zone 1) which may be indicative of such a blow, although in all cases, post-depositional breakage cannot be ruled out. The holes at Zone 1 are suggestive of the actions of a particular individual or group of individuals using a different technique to collect limpets.

ZONE	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
<10409>	0	**25**	22	14	8	12	15	22	24
<10664>	1	**13**	8	3	1	4	10	8	10
<7230>	4	7	4	3	3	6	6	6	**8**

Table 7.6: Total breaks per zone for limpet shells. For distribution of zones see Chapter 2.2.6.

7.4.4.4 Epibiont organisms

In order to investigate the likely shore position occupied by the limpets during life, 200 shells from sample **10664** were examined for signs of epibiont organisms. Two of the shells had smaller holes under the apex, which are likely to have been caused by a predatory gastropod. Four shells bore the tunnels of a large polychaete worm, possibly *Polydora hoplura*, and three were tunnelled by a smaller polychaete such as *Polydora ciliata*. Six shells showed borings typical of the sponge *Cliona celata*. *C.celata* in particular is a sublittoral species, suggesting the shells may be from a low shore location, where they would be submerged for much of the day. It is curious that there are no encrusting tubes of *Spirorbis*, which were reasonably common at Sligeanach (Chapter 7.1; Law 2012), in this sample. *Spirorbis* worms are associated with seaweed, and most species live below the mid tide mark (Law 2012, 249), and their absence lends support to a mid-tidal level location for limpet collection.

7.4.5 Winkles

The common periwinkle (*Littorina littorea*) is predominant in the assemblages from Mound 2 and Mound 2A. Winkles live intertidally on rocky shores, and are much easier to harvest than limpets as they do not have the same strong suction and require only a flick of the finger to dislodge them (Pollard 1994, 71).

7.4.5.1 Size

To investigate potential preference for size of winkles, mean width and length of 100 winkles from sample **9892** are presented in Table 7.7 and Figure 7.10. The sample of winkles measured falls close to the middle of their potential size range (Hayward *et al*. (1995, 512) give a maximum size of 32 x 25 mm), although both mean width and mean height have a negative skewness, showing that quite considerably smaller shells were present. The mean length in this sample is somewhat smaller than any of those from Quoygrew (Milner & Barrett 2012, 109). Again, the sample size is likely too small to permit any firm conclusions, but this may be the result of relatively intensive collection of winkles.

	Mean	Standard Deviation	Skewness
Width (mm)	17.9	2.15	-0.71
Height (mm)	23.2	3.15	-0.19

Table 7.7: Mean width and length of Littorina littorea *shells, sample 9892.*

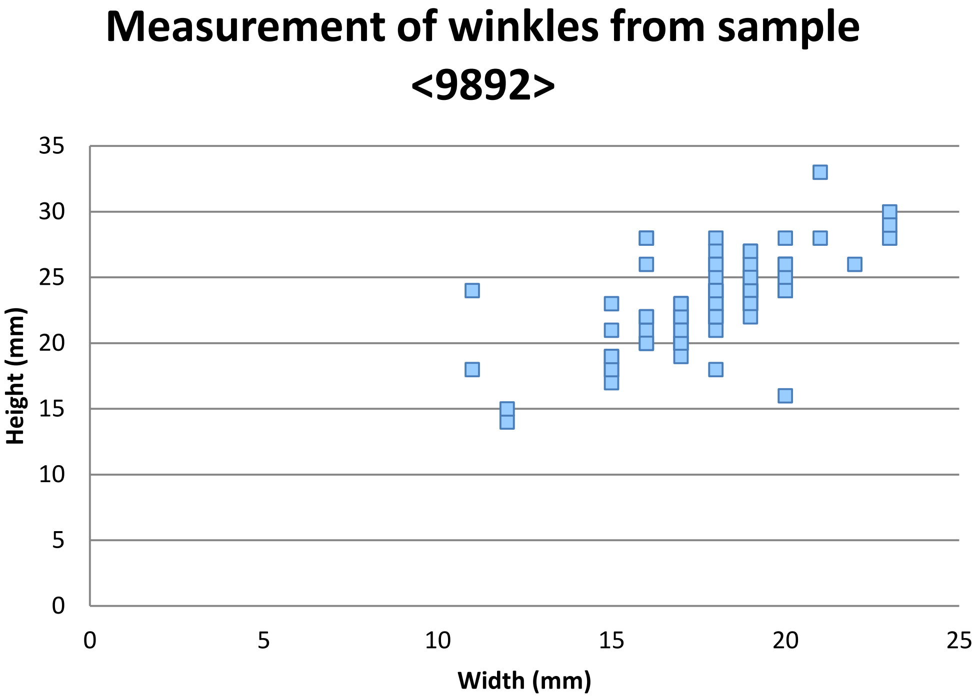


Figure 7.10: Measurements of Littorina littorea *in sample <9892>.*

7.4.6 Oysters

Oyster shell is not common at Bornais, in fact it is completely absent from Mound 2, and only 14 shells were present at Mound 2A. Oysters are found in sheltered bays and estuaries rather than rocky shores, and so imply exploitation of a different environment to winkles and limpets. Details of size, epibiont organisms, and presence of cuts or notches from 8 oyster valves are presented in Table 7.8. Cuts and notches at the margin of the shell are likely to be evidence that shell was opened and the adductor muscle severed using a knife blade or similar implement. The presence of epibiont organisms on the shell suggests that the oysters were harvested from natural oyster beds rather than farmed stocks.

CONTEXT	**Left valve**	**Right valve**	**Maximum length**	**Maximum height**	**Age**	***Polydora ciliata***	***Polydora hoplura***	**Calcareous tubes**	**Barnacles**	**Colour/stain**	**Irregular shape**	**Notches/cuts**	**COMMENTS**
2391		1	80	88		x							
1671		1	76	96			x						
1795	1												Fragments
1140		1	60	72		x							
1661		1	69	81		x	x					x	Cut across distal end and notch at hinge
1640	1		71	84		x					x	x	Notch; flat bottomed
1649	1		85	116		x	x						
1640	1		62	85		x		x	x	x			*Pomatamoceros ?triqueter*; barnacle scar

Table 7.8: Observations of 8 oyster valves from Mound 2A.

7.4.7 Other marine shell

Species other than limpets, winkles and oysters do not make a significant contribution to the assemblage. Additional edible taxa represented include razor shells, mussels, and whelks. Razor shells burrow into sand on the lower shore, and so suggest exploitation of shores other than the rocky coasts that are home to limpets and winkles. The flat winkles *Littorina obtusata* and *Littorina fabalis* are small intertidal gastropods with a low meat yield. It may be that shells of these species were accidentally introduced to the site with seaweed, as was thought to be the case at Bostadh Beach (Cerón- Carrasco 2005, 42). Similarly, the rough periwinkle *Littorina saxatalis* is likely to be an accidental introduction; unlike the other periwinkle species present, *L. saxatalis* is ovoviviparous, with the result that often the animal contains embryos which would lend an unpleasantly gritty texture to the meat.

Exploitation of subtidal waters is suggested by the presence of small numbers of great scallops, *Pecten maximus*, which live offshore (Chambers 2009, 141), although the possibility remains that the empty shells were collected from the shore rather than the live animal being harvested as a foodstuff. There are no epibionts on the inner surfaces of the shells, however. If present, these would prove the shells were harvested empty. A broken left valve of the common otter shell *Lutraria lutraria* is present in a floor deposit from Block BCC, the occupation of House 2, Mound 2. This is a lower shore to subtidal species, which burrows into sand and mud and so requires digging to collect live (Chambers 2009, 162). Its presence at Ardnave, Islay, was attributed to the shell being washed up after a storm (Evans 1983), however there are historical records of *Lutraria lutraria* being eaten on the Orcadian island of Stronsay (Coles 1971, 358).

7.4.8 Whale barnacle

Figure 7.11: Plate of the whale barnacle Coronula diademata.

A single, disarticulated, plate of a whale barnacle was hand collected during excavation in 2003 from context **908** of Mound 2 Extension, Bornais (Figure 7.11). This context falls within stratigraphic block BFD, deposits related to the abandonment of House 3, and is a windblown sand deposit. Owing to the relative density of the barnacle plate, it is likely to be a residual component of this context, lagging from previous aeolian erosion. This suggests that part of a whale carcass had been processed within the ancillary structure.

The barnacle was identified as *Coronula diademata* (Linnaeus, 1767) following the criteria listed in Pilsbry (1916, 272-5). The barnacle height was 44 mm, within the middle of the range reported by Pilsbry (1916, 274). Whale barnacles are generally specific to certain host species, in this case *C. diademata* lives on the humpback whale (*Megaptera novaeangliae* Borowski, 1781), a migratory rorqual which is present in all major oceans, typically spending summers in cooler, high latitude waters such as those around the Western Isles.

Whale barnacles are reasonably uncommon finds at archaeological sites, and their presence is invariably attributed to the processing of whale flesh at the site (e.g Holthuis *et al.* 1998, Álavarez-Fernandez *et al.* 2013). *C.*

diademata has previously been recorded in Europe at an Upper Magdalenian cave deposit in Asturias, northern Spain (Corchón *et al.* 2008), although this is believed to be the first find from a context in the British Isles, and the first medieval find in Europe.

C. diademata can occur in very large numbers and in high densities on a single whale. Pilsbry (1916, 274) reports 118 barnacles on a piece of preserved whale skin in the United States National Museum measuring 26 inches long by 5 inches wide. It does not burrow deep into the whale compared to some other barnacles, although to be removed it would still need to be cut out of whale flesh. The plate from context **908** does not show signs of wave abrasion on its interior face, suggesting that it was removed from whale flesh on land, rather than from a decomposing whale by the action of the sea.

Humpback whales are slow moving, rarely swimming faster than 12km/h, and may be hunted inshore. As such, they present a reasonably simple and attractive catch (Mulville 2002, 37). In addition to whale meat's value as food, whale bone is useful as a raw material for building and for tool and ornament production. Mulville (2002, 41) notes that very little of the whale bone that has been found archaeologically in the Western Isles is unmodified. Whalebone artefacts include combs, knifes, mattocks, pegs, plates, chopping boards and "pot lids" (Mulville 2002). Part of a sperm whale skull was used as a cover for a drain at Iron Age Dun Vulan, while at Cille Pheadair, also on South Uist, part of a blue whale humerus was incorporated into a stone wall (Mulville 2002, 40). The bone also has a high fat content, and is useful as fuel (blubber may also be used as fuel). At Iron Age Bornais, several burnt whale bones were found (Mulville 2002, 44). At the Norse period site of Quoygrew, Orkney, worked whale bone was used to create 2 spindle whorls, a weaving sword, a rope shortener or swivel and a possible pivot (Batey 2013, 240-3).

The whale barnacle fragment is evidence for the former presence of humpback whale flesh at the site. This was most likely part of a carcass that was being processed as a valuable resource, and indicates that after occupation had moved away from this part of the machair, monitoring of the shore for resources was still taking place. If this late phase of the Bornais sequence relates to a time of climate-induced stress, finds such as whale strandings would have been particularly valuable.

7.4.8 Conclusions

The marine shell assemblage at Bornais primarily represents food waste and shows a sustained interest in exploiting shellfish resources, especially from the intertidal zone of rocky shores, but also from muddier estuaries and bays and subtidal waters. In common with other Norse sites in the Western and Northern Isles, winkles are the dominant taxon, and this is likely to represent a change in tastes from later prehistoric societies, which tended to prefer limpets (although Bell and Godden (2014) report that the Bronze Age and Iron Age settlements at Cill Donnain yielded more winkles than limpets). This is perhaps due to increased contact with the Viking diaspora, a significant cultural change occurring at this time, which may have resulted in changes of taste. Limpets do remain significant however, perhaps suggesting that indigenous tastes did not fall completely out of favour. The limpet shells in these contexts are not likely to be derived from the use of limpets as bait, as they are some distance from the shore and closely associated with other food waste. This is not to say that the practice was not carried out at Norse period Bornais, however. Some of the shell is thought to have arrived into the site attached to seaweed, a fuller discussion of this for Mound 2A may be found in Chapter 6.9. The hand collected marine shell assemblage included a plate from a whale barnacle, evidence that part of a humpback whale carcass had been brought to the site during a late phase of its occupation.

7.5 CONCLUSIONS

The sites analysed as part of the present analysis add to a growing corpus of research on marine molluscs from archaeological contexts in the Western Isles, in particular associated with the SEARCH projects on the machair. Largely, assemblages are dominated by limpets and winkles, with a transition towards winkles being more dominant in the Late Iron Age, although this is by no means an absolute rule, and where cockles are likely to be locally available, as at Ceardach Ruadh, they tend to be more important. Other species are present in assemblages, however, and some of these (such as scallops and razor shells) show that a range of coastal environments were exploited for shellfish. A fuller discussion of marine molluscan taxa will be made in Chapter 8.5

The presence of a whale barnacle at Bornais may an interesting proxy for the processing of a whale on the site, which may have taken place at a time of increased storminess when the machair was largely abandoned.

8 DISCUSSION

Having outlined the results of this work, in this chapter I reflect upon the relative contributions of these analyses to an understanding of the archaeology of the Western Isles, and situate them alongside previous work on Hebridean mollusc shell assemblages. The results derive from the analysis of 9 sites across the islands from 4 periods presented in Chapters 6 and 7. The sites considered are predominantly situated on the machair, firstly because most excavated archaeological sites in the Western Isles are located there (Sharples 2015) and secondly due to the machair's preservational qualities.

I will begin by discussing the arrival and spread of the non-marine mollusc species and whether this can be used for relative dating of archaeological layers; as well as the site formation processes that occur on the islands; changes in vegetation and what agricultural practices have been detected; the Holocene climate history of the islands; and the contribution of marine molluscs to diet and everyday life. Finally, this chapter explores the possibility of using non-marine molluscan taxocenes as an aid to interpretation; and outlines some problems in molluscan analysis.

As we have seen, the geology of the Western Isles gives rise to acidic soils which are not promising for archaeological preservation of shell or bone. The shell sand of the machair plain provides a burial environment which is soft and poorly compacted with a high pH, however, in which shell and bone survive well. It also provides a suitable habitat for terrestrial molluscs, especially where sand blow is limited. Archaeology on the machair is liable to suffer from several taphonomic issues, in particular erosion and redeposition by the wind, and more recently disturbance by mammals, especially rabbits. This work has shown that taphonomic irregularities are detectable by taking several samples spatially distributed across the site, as well as through statistical methods, in particular comparison of diversity indices.

8.1 THE ARRIVAL OF THE HEBRIDEAN MALACOFAUNA, BIOSTRATIGRAPHY AND RELATIVE DATING

8.1.1 Where did the snails come from?

The Hebridean land snail fauna, in common with much of the terrestrial fauna, arrived during the Holocene, and many species may have been accidentally introduced by people. *Pupilla muscorum*, *Vallonia excentrica* and *Cochlicopa spp*. are the dominant species on the machair in the Neolithic and Early Bronze Age. They are largely replaced, however, by later arrivals (*Helicella itala* and *Cochlicella acuta*), which appear to have become established in the Late Bronze Age and Early Iron Age respectively. The arrival and spread of these species acts as a biostratigraphic marker which may be useful for relative dating (Chapter 5.2, 6.8, 6.9). In this section, I will consider the mechanisms by which non-marine molluscs may have arrived in the islands, and their movement between islands, before considering five key species in more detail.

As discussed in Chapter 3.1, the Western Isles were predominantly glaciated and certainly subject to harsh climatic conditions during the last cold stage. This would have made them inhospitable for the present-day non-marine malacofauna of the Isles. The terrestrial snail species are thus clearly post-glacial introductions. As oceans are the most effective barriers for the distribution of land animals that cannot fly (Cox & Moore 1993, 134), three possible vectors for their arrival may be postulated:

1. Rafting across the sea on driftwood and mats of vegetation
2. Being carried in the air, on (or in) the bodies of birds (*phoresy*), or by the wind.
3. Being transported accidentally (or intentionally) by humans (*anthropochory*).

Considering the first option, natural debris may be washed down river systems after heavy storms, especially in tropical regions, and entire trees may float considerable distances (Cox & Moore 1993, 135). The arrival of driftwood is certainly a feature of Hebridean shores (see Chapter 3.7), and it (along with other modern seaware such as plastic) is widely implicated in the dispersal of marine invertebrates today (e.g. Holmes *et al.* 2015).

Surviving a long sea journey would be a challenge for any terrestrial invertebrate as immersion in salt water for any period of time is likely to result in desiccation (leading to death) through osmosis (Dinnin 1996, 180). This is true of molluscs, with slugs particularly vulnerable, although snails that are able to seal themselves within their shells with hard or membranaceous opercula may be afforded some protection.

Most of the terrestrial species of mollusc that occur in the Western Isles during the Holocene would be unlikely to survive a sea crossing on debris such as driftwood. This is especially true of the long initial crossing from the Inner Hebrides.

Considering the second option, phoresy, records certainly exist of molluscs being transported attached to the bodies of birds. In a presidential address to the Malacological Society of London, W.J. Rees (1965) explored this phenomenon, finding that generally it is aquatic molluscs, and especially bivalves, that were found attached to the feet of birds (Rees 1965, 274-5).

Most promising for this study, he cites a record of three specimens of *Valvata piscinalis*, a freshwater snail with a hard operculum, attached to the plumage of a meadow-pipit (*Anthus pratensis* Linnaeus, 1758) on the Butt of Lewis in the Western Isles in 1915 (Rees 1965, Table 5). He also notes records of *Pomatias elegans*, a relatively large land snail with a hard operculum, being carried on the legs of bumble bees in southern England, although such transport could only have been very local (Rees 1965, 271-2). He goes on to mention several records of small freshwater limpets of the family Ancylidae being transported by water beetles (Rees 1965, 273) (although absent from the archaeological samples discussed here, *Ancylus fluviatilis* is certainly widely present across the Western Isles as, according to Waterston (1981, 270) are several species of the Dytiscidae family of beetles which are involved in this dispersal); as well as the tiny freshwater pea mussels *Sphaerium* and *Pisidium spp*. (Rees 1965, 273).

Transport by wind is less commonly reported. Rees notes a credible report of several of the freshwater mussel *Anodonta anatina* being transported, presumably by the wind, during a thunderstorm in Paderborn in Germany during the 1890s (Rees 1965, 271-2).

Perhaps most impressively, Gittenberger *et al.* (2006) present genetic evidence which suggests that the terrestrial snail family Baleinae originated in the western Palaearctic, were carried to the Azores, most likely on the plumage of birds, and were then further carried over 8500km to Gough Island and Tristan da Cunha in the South Atlantic Ocean. One Azorean species, *Balea heydeni*, then 'returned' to mainland Western Europe (Gittenberger *et al.* 2006, 409).

Birds can also transport snails internally (*endozoochory*), when a bird swallows a snail and then excretes it live. Van Leeuwen *et al*. (2012) fed live specimens of *Bathyomphalus contortus*, *Bithynia leachii*, *Peringia ulvae* and *Potamopyrgus antipodarum* to mallards (*Anas platyrhynchos* Linnaeus, 1758) to investigate the possible role of endozoochry in molluscan dispersal. Live specimens of *P. ulvae* were excreted up to five hours after ingestion. The authors note that 'prosobranch' snails, such as *Bithynia*, *Peringia* and *Potamopyrgus* have relatively thick shells and opercula, which help them avoid desiccation but may also confer the benefit of increasing resilience in the gizzard of a bird. The pulmonate *B. contortus* lacks those characteristics, and all shells of *Bathyomphalus* were destroyed during the course of the experiment (van Leeuwen *et al.* 2012, 5). Experimental studies also found that the western Pacific land snail *Tornatellides boeningi* (a pulmonate, but with a relatively strong, tall spired shell) could also survive passing through birds' digestive systems (Wada *et al.* 2012).

Passive dispersal by birds is likely in the case of some of the Hebridean molluscs, in particular aquatic species and especially small bivalves and opercula-bearing prosobranchs, which are either able to attach themselves to the outside of a bird by closing their shell/ operculum, or else can close themselves up and may survive passage within a bird.

Turning to the third possibility, accidental transport by humans, Dinnin (1996, 181) suggested that many of the Hebridean land snails were introduced with grass cut for hay or straw. This is likely in the case of grassland species, but implies that their arrival is linked to the movement of domesticated animals, placing it within the Neolithic. This is a difficult point to test, as the results from Mesolithic Northton in Chapter 6.2 demonstrate, snail assemblages that are older than the Neolithic are not currently known from the Western Isles (and may not exist to be found due to acidic conditions).

In terms of herbivores likely to be moved by humans, the Neolithic of the Western Isles saw the arrival of cattle, sheep and, as recently demonstrated by Stanton *et al.* (2016), red deer. The red deer do not originate from mainland Scotland, nor do they appear to originate from Ireland or Norway, although they share common haplotypes with red deer on Orkney. Finds of Unstan Ware pot at sites such as Eileann Domhnuill and Northton also suggest links with Orkney (Garrow & Sturt 2011, 66), while Henley (2005, 335) notes that the layout of the stone circle at Callanish on Lewis, and its associated monuments, references the form of ceremonial monument complexes in the Boyne, Ireland, and in Orkney. Links to Orkney are therefore recurrent, but in the case of the red deer, it is possible that the deer came to Orkney from the Western Isles *en route* from an as yet unidentified origin. Movement to and from the shores of the Western Isles clearly took place in many directions.

The ecological preferences of the species of snail already established in the Western Isles by the Early Bronze Age contributes to this discussion. Although *Pupilla muscorum*, *Vallonia costata*, *Vallonia excentrica* and *Vertigo pygmaea* may be readily associated with turves cut for stabling, many of the earliest snails present, at Northton for example, come from more shaded habitats, and the association between, for example *Carychium tridentatum* or *Euconulus fulvus*, and hay or straw may be harder to establish. Perhaps other botanical materials such as timber were imported during early stages of colonisation.

The later prehistoric arrivals, *Cochlicella acuta* and *Helicella itala*, can be related quite parsimoniously to the transport of livestock: both may be found on the stems and leaves of tall grass that would make suitable fodder. The arrival of *C. acuta* in Britain during the Early Bronze Age at sites like Gwithian in Cornwall and its subsequent spread to the Western Isles would appear to suggest a progressive movement of livestock with fodder up the west coast of the British Isles from its origin, perhaps on the Atlantic coast of France or Spain.

At present, it is not possible to say what species of livestock were being carried in these instances either. It may have been new forms of existing stock, i.e. sheep or cattle. Horses appear somewhat later in the Hebridean archaeological record, in Late Iron Age deposits at Bostadh and Udal (Serjeantson 2013, 68). Goats also first appear in the archaeological record in the Late Iron Age, at Mound 1 of Bornais (Serjeantson 2013, 67).

Ultimately, it is likely that a combination of all three processes resulted in the initial arrival of the Hebridean non-marine malacofauna, although phoresy and anthropochory will have been more important than rafting.

Having considered how snail species first arrived in the Western Isles, I will now turn my attention to their movement between the islands. As mentioned in Chapter 3.5, above, island biogeography theory states that diversity decreases with the available area of land (Cox & Moore 1993, 140; Spellerberg & Sawyer 1999, 63). In the Western Isles, this model does not hold true. Table 8.1 shows the number of taxa recorded on the largest six islands by Waterston (1981).

The largest island, Lewis, has the least taxa, with the most non-marine mollusc species being found on Barra, followed by North Uist (and reasonably closely by South Uist). This patterning may result from the physical geography of the islands. Lewis is largely made up of mountains and moors which are less amenable to calciphile molluscs than the machair of the Uists. Differences in average temperature may also have a role to play in the distribution of species across the islands. Alternatively, this may reflect a northward movement of species as a result of anthropochory. The shortest sea crossing from the Inner Hebrides is to North Uist, making it a likely first port of arrival for crossings from mainland Britain.

Island	**Lewis**	**Harris**	**North Uist**	**South Uist**	**Barra**
Area (km^2)	1770	408	303	320.3	58.75
No. of species	48	59	63	61	69

Table 8.1: Number of species of non-marine mollusc on the major islands of the Western Isles reported by Waterston (1981)

I will now look at the biogeography of some key species in more detail and evaluate the contribution that new information about them from this study makes to broader archaeological narratives.

8.1.2 Cochlicella acuta and *Helicella itala*

A focus of this study has been the arrival and spread of these two key species. The results support the arrival of *Helicella itala* in the Late Bronze Age at Baleshare, and the growing dominance of *Cochlicella acuta* in the machair of the Western Isles during the Iron Age (Thew 1989). Their earliest occurrences are intrusive events, evidenced by low numbers and the condition of the shells. They are present in the Mesolithic layers at Northton (Chapter 6.2), where they are obviously modern shells judging by their fresh appearance. In the Early Bronze Age cremation deposit at Allasdale, the two species are recent intrusions. *H. itala* is present in low numbers by the Early Iron Age, however (Chapter 6.5). *Cochlicella* and *Helicella* only ever appear in low numbers, and are probably intrusive, in Late Bronze Age samples from Cladh Hallan (Chapter 6.4). Only one shell of *Cochlicella* is present at Middle Iron Age Horgabost (Chapter 6.6). In the late Middle Iron Age at Cill Donnain, both species are present, although *Cochlicella* does not become the dominant species until the Late Iron Age (Chapter 6.8). The top of the two sequences from Bronze Age Sligeanach (Chapter 6.3) which are dominated by *Cochlicella* without a period where *Helicella* is the more numerous of the two species, represent a discontinuous sequence based on this apparent pattern which recurs between islands.

The evidence presented here and in previous studies suggests that *Helicella itala* is present in the Western Isles from the Late Bronze Age, although it does not become established in South Uist until the Middle Iron Age. Deposits dominated by large numbers of *Cochlicella* date to the Late Iron Age or later. In the case of the sequence at Ceardach Ruadh, Baile Sear (Chapter 6.7), it is probable that rapid sediment deposition has been detrimental to the range of snail species found in the sequence, rather than that it is older than Phase 4 of the 1980s excavation at Baleshare which is dominated by *Cochlicella acuta* (Thew 2003). The evidence from other sites of the timing and spread of the two species allows the snail assemblage in Northton NT10, which is intrusive, to be dated to a time before the Iron Age.

To visualize the spread of the two species, Figure 8.1 shows the occurrence of *Cochlicella* and *Helicella* plotted against the previously dominant species, *Pupilla* and *Vallonia spp*., in samples containing more than fifty shells from sites examined in Chapter 6. The earlier arrival of *Helicella* noted by Thew (2003) is reiterated, although in these sites it is in the Middle to Late Iron Age. The samples with *Helicella* but without *Cochlicella* are all from Cill Donnain on South Uist. *Helicella* is absent from samples at Cladh Hallan which are broadly contemporary with its arrival at the sites studied by Thew, which suggests that it arrived on North Uist before South Uist.

The arrival of *Helicella* coincides with a decline in *Pupilla*, which suggests that there is some degree of competition between the species. There is some support for this in the modern mollusc transect (Chapter 6.1), where *Helicella* is present in the short machair grassland sample from the Cladh Hallan houses, a situation that, in the Bronze Age, would have been dominated by *Pupilla*, *Cochlicopa* and *Vallonia*

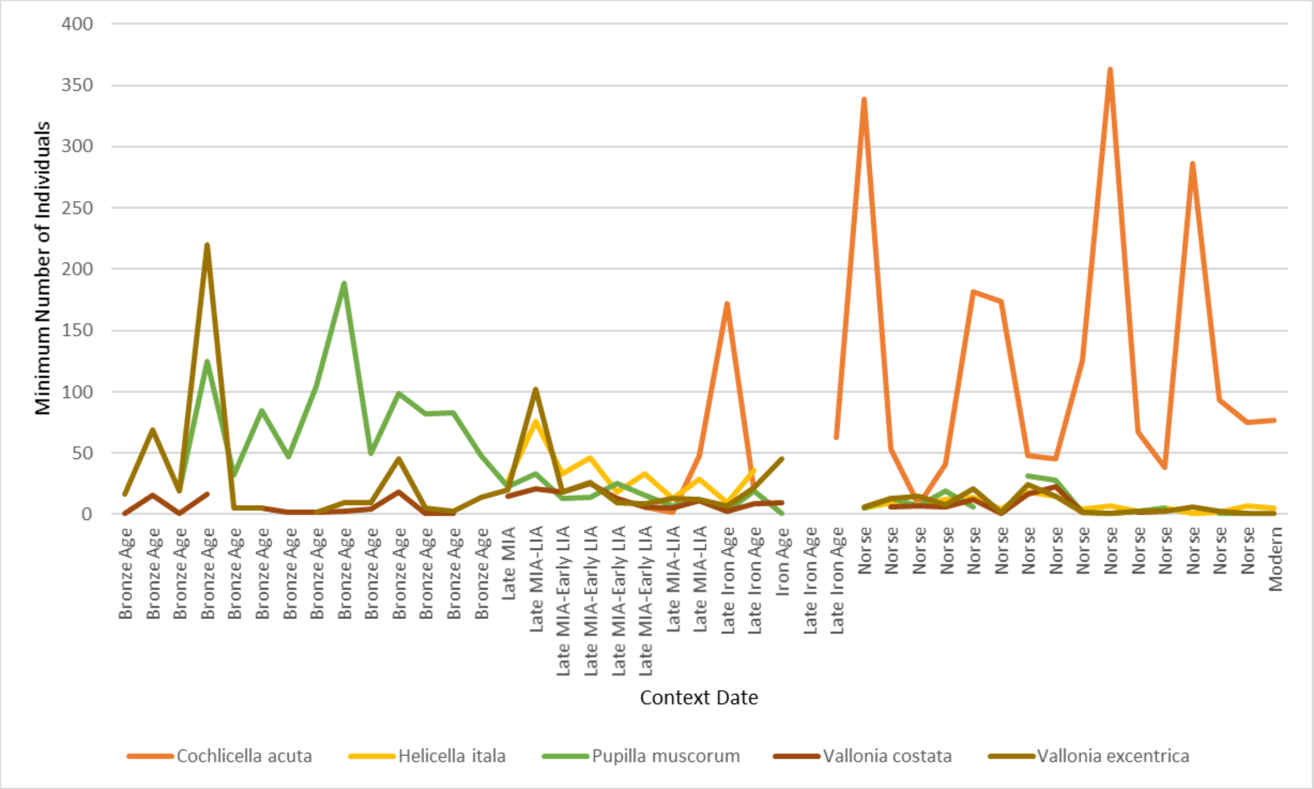


Figure 8.1: Chart showing occurrence of Cochlicella acuta*,* Helicella itala*,* Pupilla muscorum*,* Vallonia costata *and* Vallonia excentrica *in samples containing more than 50 shells analysed in Chapter* 6.

Figure 8.2: Cochlicella acuta *and* Helicella itala *on machair grassland at Cladh Hallan, September 2010.*

While the arrival and spread of the two species will have had ecological drivers, albeit mediated by human activity, their growing abundance will also have had impacts on human experience of the landscape. The *Cochlicella* – *Helicella* pairing are capable of obtaining high densities in the dune and machair grass and, although small, are just about large enough to be noticed from human height, especially with their often-striped shells and the fact that they are often found above ground on the stems and leaves of grasses (Figure 8.2). The experience of textures within the environment has been seldom acknowledged as a medium of social agency, yet it is precisely land-surface textures and distinctive ecological communities that separate individual locations (Evans 2003, 45). By accidentally transporting new species of snail to the Western Isles, the people of late prehistory unwittingly created a monument that references another place, whether it is their own ancestral homeland, or the location of partners with whom they traded livestock. It may never have been noticed as such, of course, but nonetheless the social connection became permanently enshrined in the landscape.

8.1.3 Lauria cylindracea

Evans (2004) discussed the relationship between *Pupilla muscorum* and *Lauria cylindracea* in the Western Isles, both of which are present in Neolithic contexts on the islands. He concluded that although *Pupilla* is favoured by stable, short-turf grazed grassland, while *Lauria* generally thrives in more broken unstable ground, shaded habitats and stone walls, the latter species has also expanded its ecological range in northern Britain to include grazed grassland where it can behave sympathetically with *Pupilla* (Evans 2004, 368-371).

This development seems to have taken place during the last 1500 years, between the Late Iron Age and post-medieval times (Thew 2003, 163). *Lauria* is scarce at Bornais (Chapter 6.9), only occurring in one context of the ploughsoils (**1617**), and one context of the midden deposits (**1688**), while *Pupilla* is rather more common in the ploughsoils. *Lauria* becomes a little more common in the grey sand accumulation (Block GAD) that overlies the ploughsoils. This suggests that its ecological expansion had not yet occurred when these sediments were accumulating, or perhaps was taking place at the time that Block GAD was accumulating.

Lauria cyclindracea's presence in earlier deposits in this study are more aligned to the types of situations in which it is found in southern Britain. In the Late Iron Age at Allasdale, it occurs in the midden (Chapter 6.5), and at Cill Donnain it is associated with the wheelhouse and midden deposits (Chapter 6.8). In the modern mollusc transect (Chapter 6.1), it is present among Group 4 taxa in a short-sward grassland environment.

8.1.4 Vertigo angustior

Vertigo angustior, a Group 5b marsh species, is present in a Beaker phase of woodland regeneration at Northton (Evans 1971), an Early Bronze Age cremation deposit at Allasdale (Chapter 6.5) and in a Late Bronze Age housefloor deposit at Cladh Hallan (Chapter 6.4). It has not been recorded in the Western Isles since then, and is likely to have become extinct on the islands in prehistory. This may be a result of a combination of loss of habitat and competition.

8.1.5 Cornu aspersum

Cornu aspersum is late arrival in the British fauna, which arrived in southern England during the Romano-British period (Davies 2010, Table 12). Its earliest (and only) archaeological record in the Western Isles is at Norse period Mound 2, Bornais (Chapter 6.10), however its large shell may result in it being more readily fragmented than other species, and so less likely to be identified.

8.1.6 Summary

The non-marine malacofauna of the Western Isles likely arrived during the Holocene, through a combination of human action, and transport through natural agency, in particular by birds. The two species which now dominate many machair areas, *Helicella itala* and *Cochlicella acuta*, arrived in the Late Bronze Age and Early Iron Age respectively, and achieve dominance across the islands by the Late Iron Age. Their arrival is very likely to have been human-mediated, and probably associated with the movement of livestock. Through competition, they caused a decline in the species that were previously dominant, and became very visibly abundant, creating a monument to the human cultural connections of later prehistory.

Other changes in the fauna can be seen from the results of archaeomalacological work in the islands. *Lauria cylindracea* expanded its range of ecological preferences in northern Britain to include more open grassland situations. This study has shown that at Bornais, this expansion takes place during the Norse period. The marsh snail *Vertigo angustior* appears to have become extinct in the Western Isles at some point after the Late Bronze Age. The evidence from this study suggests that *Cornu aspersum* arrives in the Norse period.

8.2 SITE FORMATION PROCESSES IN THE WESTERN ISLES

The traditional role of land snails in archaeology has been to offer insights into environmental changes through time at the site level. In the Western Isles, there is evidence in the land snail record for changes in vegetative cover, for phases of increased sand blow and for variations in precipitation. As Nigel Thew originally identified, spatially separated bulk sampling of contexts associated with occupation and activity in the Western Isles has identified evidence for site formation processes as well, such as erosion and the conflation of deposits through aeolian activity.

The poorly consolidated sands of the machair plain and tendency to experience strong winds make erosion, redeposition and spatial and temporal mixing particularly problematic in the Western Isles. To explore this, the study has used the condition of shells to assess their likely contemporaneity with the deposit under study. Shells which appear fresh, with intact periostraca, are probably recent intrusions, indicative of mixing, although there are also problems with more ancient intrusions, which require the use of analogy with other sequences from the same site, and low numbers of shells. Examples of this were recognised in the Mesolithic layers at Northton in 2010 (Chapter 6.2.1), by analogy to Evans's (1971) Northton sequence and the low number of specimens.

Similarly, consideration of the molluscan succession at Sligeanach suggests that the sequences are discontinuous in later prehistory (see Chapter 8.1.2). Taking lateral samples across extensive deposits in addition to vertical sequences will help make problems of spatial and temporal fidelity easier to detect (Law & Thew 2015, 125), but this study suggests that comparisons between sites or between sequences at the same site may be helpful. Therefore, more studies are needed, and this project has made a valuable contribution to expanding the role of non-marine molluscs in archaeological interpretation beyond providing a 'background' environmental picture to human activity at the site.

Phases dominated by aeolian deposition are often characterised by low numbers of snails, generally from low numbers of species, and, since the Late Iron Age, are dominated by *Cochlicella acuta*. This is seen, for example, in various deposits at Bornais, at the top of the sequences in Section 1 at Ceardach Ruadh, in John Evan's Northton sequence, at Northton (NT11), at Sligeanach, at Ensay, and in the modern sample from the coastal dune at Cladh Hallan. There are exceptions, where aeolian activity may produce an assemblage of very mixed character, as in the Neolithic II horizon in Evans's Northton work (see Chapter 8.3) and in the Beaker layers at Ensay. These are rare, however.

Analysis of diversity indices has suggested that these can be a powerful tool in revealing the compositional fidelity of assemblages. Large differences between the Shannon and Brillouin indices confirm the suspicion that deposits are mixed in the case of Northton (NT10), as well as certain contexts at Cladh Hallan, Allasdale and Horgabost.

Results from Cill Donnain, which suggest a coherent ecological picture despite having a difference between the two indices greater than Walker's (2014) suggested 'break point' of 0.1, indicate that slightly higher differences may be tolerable in the Western Isles. Where peaks in Fisher's Alpha coincide with dips in other diversity indices, as in some deposits at Cladh Hallan, Cill Donnain, and Bornais, this also suggests mixed inputs. Ideally, this will need to be tested against other assemblages in a wide range of situations.

8.3 VEGETATION AND AGRICULTURAL PRACTICES

8.3.1 Trees in the Hebridean landscape

Snails can be indicative of the former presence of wooded areas. The Hebridean landscape was never covered by closed canopy forest, however pollen analyses have shown that, until the Late Iron Age, trees were much more prevalent in the landscape than they are today (Chapter 3.4). Molluscan data can be used alongside pollen to give more detail to the picture of Holocene vegetation cover, at a finer spatial resolution.

The earliest sequences from the Western Isles, at Northton, contained snails such as *Aegopinella nitidula*, *Carychium tridentatum* and *Vertigo pusilla* interpreted as being indicative of open woodland (Evans 1971, 58). However, the same layers contain significant numbers of open country species such as *Pupilla muscorum, Vallonia excentrica* and *Vertigo pygmaea*. This contradiction is likely to relate to local conditions. There is blown sand present at this level, which suggests that the shade-demanding taxa may have been blown in from a nearby scrub woodland (Nigel Thew, pers. comm.). Molluscan results indicate that in this location, an episode of clearance follows, although significant numbers of shade-demanding taxa return in the Beaker II horizon and just before the Iron Age II horizon. Again, these are mixed faunas, with considerable aeolian sedimentary input, which suggests that there were wooded areas close by but that the layers accumulated in open conditions. Nonetheless, it seems clear that there was open/scrub woodland close to the site into the Iron Age, and that clearance began in the Neolithic. Unfortunately, the samples analysed from Northton as part of this thesis (Chapter 6.2) are not especially helpful for building on Evans's original sequence, due to the low number of snails and frequency of intrusive shells.

Elsewhere, the lowest Bronze Age levels on Ensay (Spencer 1974) include snails like *Acanthinula aculeata*, *Aegopinella pura*, and *Clausilia bidentata* that also indicate the presence of open scrub woodland in the vicinity. Results from other Bronze Age sites that have been examined, such as Sligeanach (Chapter 6.3) and Rosinish (Vaughan 1976) indicate that their setting is in more open agricultural land, associated with ploughsoils, although it is telling that some shade-demanding taxa (*Punctum pygmaeum*, *Carychium tridentatum*, *Vertigo substriata*) are present at these sites as well. At Cladh Hallan, shade-demanding taxa are associated with the midden deposits, which may suggest growth of tall vegetation around these areas.

After the Late Bronze Age, only Northton has a true woodland molluscan fauna (Appendix 3), although shade-demanding species continue to be present in low numbers through the Iron Age at Baleshare, Cladh Hallan, Cill Donnain, Horgabost and Rosinish.

Where Norse and later contexts have been examined, as at Bornais on South Uist, Rosinish on Benbecula (Vaughan 1976), and Newtonferry and the Udal on North Uist (Thew 2003; Spencer 1974), open country snails predominate, suggesting the sites sit in a grassland environment, as they do today. There are individual specimens of *Aegopinella pura* from Udal and of *Aegopinella nitidula* from Bornais, and occasional appearances of more mesophilic shade-demanding snails, which may suggest that there were periods where taller vegetation had been allowed to grow, perhaps through a relaxation of ploughing.

Interpretation of the presence of shade-demanding snails in low numbers requires caution. Aside from the ecological expansion of *Lauria cylindracea* noted by Thew (2003) and Evans (2004), other taxa we might associate with shade appear to exist in open conditions in Scottish dune grasslands. *Punctum pygmaeum* is certainly doing so today at Cladh Hallan (Chapter 6.1), and it was present alongside *Clausilia bidentata* and Zonitids in samples lacking evidence of anything more developed than damp grassland at Freswick Links in Caithness (O' Connor 1995, 216). It is likely that during fallow periods, these species can live in low numbers in the machair grassland.

Other species associated with shaded conditions may be more helpful, however. Comparing the results of this study and the distribution of snail species from previous assemblages with Waterston's (1981) survey reveals changes in species over time. *Carychium tridentatum* is present on Harris, Ensay and South Uist in prehistory, but has declined since the Norse period (when it was present at Bornais) and was only found living on Harris and Barra in recent times. *Acanthinula aculeata* disappears after the Iron Age, when it was present at Northton and Horgabost, and is not recorded in Waterston's survey. *Aegopinella pura* has declined since the post-medieval period, when it was present at the Udal. It was present in the Neolithic at Northton, and in the Bronze Age on Ensay and at Cladh Hallan, however it is only recorded by Waterston on Harris and the southern islands of Barra and Mingulay. Finally, *Leiostyla anglica* seems to have disappeared from the Uists, where it was present in the Bronze Age at Baleshare and Cladh Hallan. These declines are likely to reflect a combination of a decline in suitable habitats and the expansion of competitor species

The presence of shade-demanding snail species in the Late Iron Age alongside other proxy indicators of the presence of trees is mapped in Figure 8.3. This suggests that relict areas of woodland may still have existed, however the fact that pollen and snail records do not occur at the same site makes it difficult to meaningfully interpret the likely extent or distribution of tree cover.

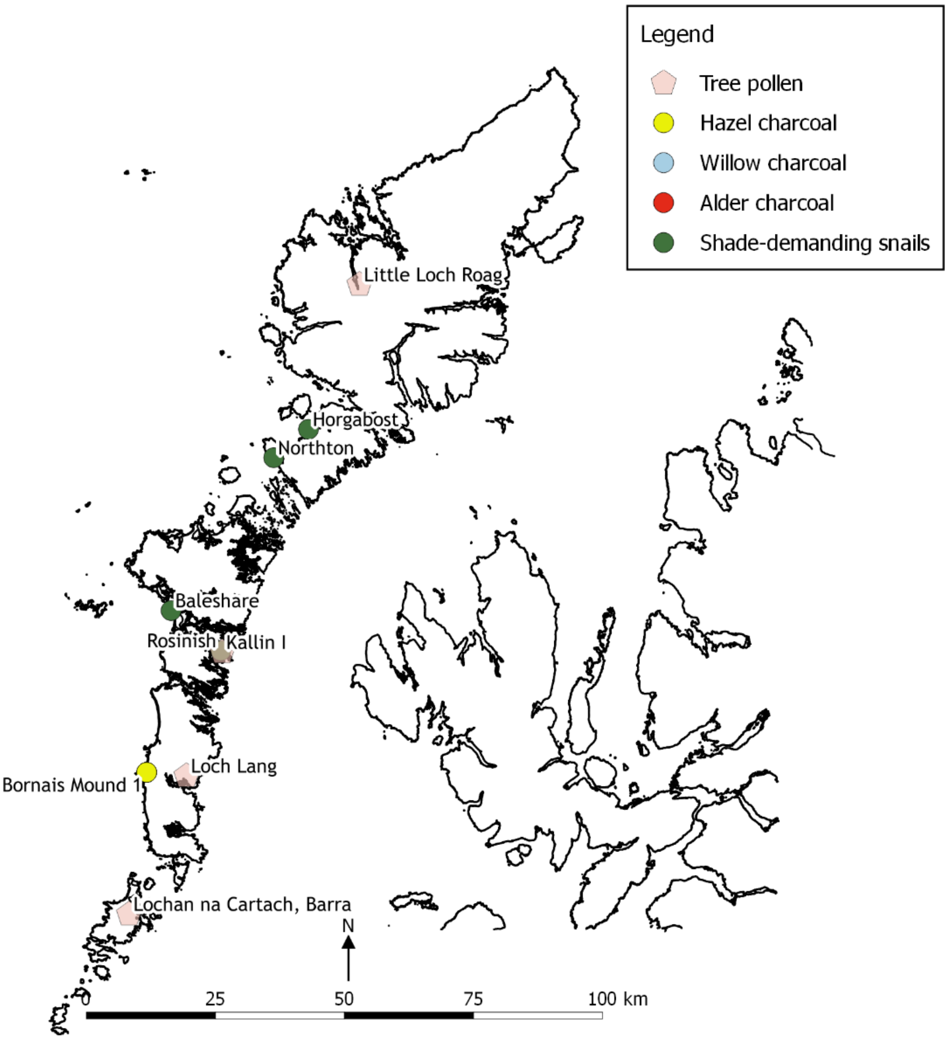


Figure 8.3: Map showing sites with tree pollen, charcoal of native species, or shade-demanding snails in the Western Isles during the Late Iron Age. Contains Ordnance Survey data. Crown © and database right 2017).

8.3.2 Ploughing

This study has used snails to contribute to an understanding of the intensity of the ploughing regime by contrasting the molluscan fauna present in a context with archaeological evidence for ploughing. There was no archaeological or molluscan evidence for ploughing at either Northton or Ensay, as both these sites were studied in section and not excavated in plan. This means the presence of ard marks cannot be ruled out. At Bronze Age Baleshare, numerous ard marks were noted, associated with the lowest excavated layer at the site (Block 22). This layer consisted of thick dark brown sands with small sherds of Bronze Age pottery, which have been interpreted as having been produced by manuring with midden material (James & Duffy 2003, 66-67). Radiocarbon results of 3285 ± 60 BP on marine shells and 3360 ± 80 BP on animal bone suggest a Middle Bronze Age date for this ploughsoil. The associated snail fauna are indicative of a mix of grassland and broken ground; thus, the ploughing was not very intensive, despite the large number of ard marks (Thew 2003).

Ard marks were also noted at Sligeanach. Context **103** is associated with plough marks; however, it also has the highest molluscan diversity of the sequence, suggesting that the ploughing was never intensive. The impoverished fauna in Context **18** of Trench A suggests relatively more intense ploughing, whilst the relative paucity of the *Pupilla*-*Vallonia* fauna in contexts **1626** and **1125** of Block GAA at Bornais is also indicative of more intensive ploughing

Where mesophilic/ shade-demanding molluscs such as *Carychium tridentatum*, *Euconulus fulvus* and *Punctum pygmaeum* appear together in sequences associated with ardmarks this is likely be the result of fallow periods. This was the case at both Sligeanach and Rosinish.

8.3.3 The use of seaweed

The use of seaweed as a fertiliser to stabilise the machair surface, as animal fodder or for fuel is well-attested in the Western Isles from both archaeological and ethnographic evidence (Pain & Thew 2003; Cerón-Carrasco 2005, 32; H. Smith 2012, 390-391). Various species of marine gastropod live in seaweed and are perhaps the most rapidly available source of evidence for its presence, as seaweed itself tends not to survive. These species are present at Horgabost and Mound 2A, Bornais. Interestingly, they are associated with buildings at Cladh Hallan and Cill Donnain, where they may reflect the use of seaweed as animal fodder (see Chapter 6.4 for a discussion of molluscan evidence for stabling in the houses at Cladh Hallan), or the drying of seaweed in advance of its use on the land (Bell 1981, 118) .

No snails indicative of seaweed have yet been found at earlier sites such as Northton, Ensay and Sligeanach, nor from pre-Iron Age contexts at Baleshare and Hornish Point, although they are present at Allasdale. This may indicate that use of seaweed in agriculture and settlements only developed and spread from the Iron Age in the Western Isles. There is, however, evidence for the use of seaweed in Bronze Age arable soils elsewhere in the north Atlantic isles. This includes the presence of carbonised seaweed of the *Fucus*/ *Ascophyllum* type, unburnt small marine snails and carbon stable isotope signatures indicative of a marine component at Tofts Ness, Sanday, Orkney (Dockrill *et al.* 1994, 122-130), algal spores which may be evidence of seaweed being used as manure, recovered from a Neolithic soil from Machrie Moor on the Isle of Arran (Guttman *et al*. 2004) and the presence of *Patina (*now *Patella) pellucida* and *Littorina littoralis* (now *L. obtusata*) in the middens at Knap of Howar, Papa Westray, which were possibly brought in on the fronds of seaweed, suggesting that seaweed collection was taking place in Orkney in the Neolithic (Evans & Vaughan 1983, 112-3).

Moving forwards in time, there is clear evidence that seaweed was added to middens in the Norse period. Not only are there snails indicative of seaweed in the midden deposits at Mound 2A Bornais, but also outside of the Western Isles at Quoygrew in Orkney (Chapter 5.1.13), Buckquoy, and at Freswick Links in Caithness (Murphy & Rackham 1995, 217). This may have been part of a process of enriching midden material before spreading across the field, although in his discussion of Freswick Links James Rackham notes the possibility that middens may have been used for drying seaweed prior to its use as fuel. Given the presence of midden material in fields, the former seems more likely.

There are challenges associated with using marine gastropods as a proxy for seaweed use. One problem is that we might expect a certain number of small marine shells to form part of the windblown sand. In practice, such shells could be recognised by taphonomic indicators, they may be fragmentary, or show signs of abrasion, but this cannot be relied upon alone. Accretions of smaller shells and shell fragments, along with foraminiferid tests, are likely to be found towards the rear of the area of active aeolian transport, as shell fragments have a lower specific density than the quartz component of the sand (Randall 2006, 52), this will especially apply to the smallest shells such as those in context **212** at Allasdale (Chapter 6.5) and small fragments of larger shells. The presence of a mixed size range of marine shells associated with seaweed, including larger shells like *Patella pellucida* and *Littorina spp.*, is likely to be the surest indicator of seaweed. The co-occurrence of small marine gastropods with snail species favoured by middening in the same context is also a strong indicator.

8.4 CLIMATE CHANGE IN THE WESTERN ISLES

Molluscan analysis undertaken here has revealed fluctuations in the Holocene climate history of the islands by looking at changes in species composition. For example, there was evidence of increased dampness in the Beaker period levels at Sligeanach where *Lauria cylindracea* and *Vertigo substriata* reach their peaks (Chapter 6.2). This data is in accord with Evans's sequences at Northton and at Ensay where an increase in the frequency and diversity of snails such as *Carychium minimum*, *Galba truncatula*, *Oxyloma elegans*, *Vertigo angustior* and *Zonitoides nitidus* is indicative of considerably damper conditions associated with the upper Beaker period levels, although both sites have evidence of similar but less intense flooding before and after this Beaker level. There is a problem with attributing changes to climatic rather than local change in the site environment, as the same snail fauna favoured by increasing dampness could also be favoured by middening practices, as spreading midden material increases surface humidity. Therefore, there is a problem of equifinality. In this case the evidence for a contemporaneous increase in dampness at three sites across the Western Isles, suggests that this is a change to a wetter climate.

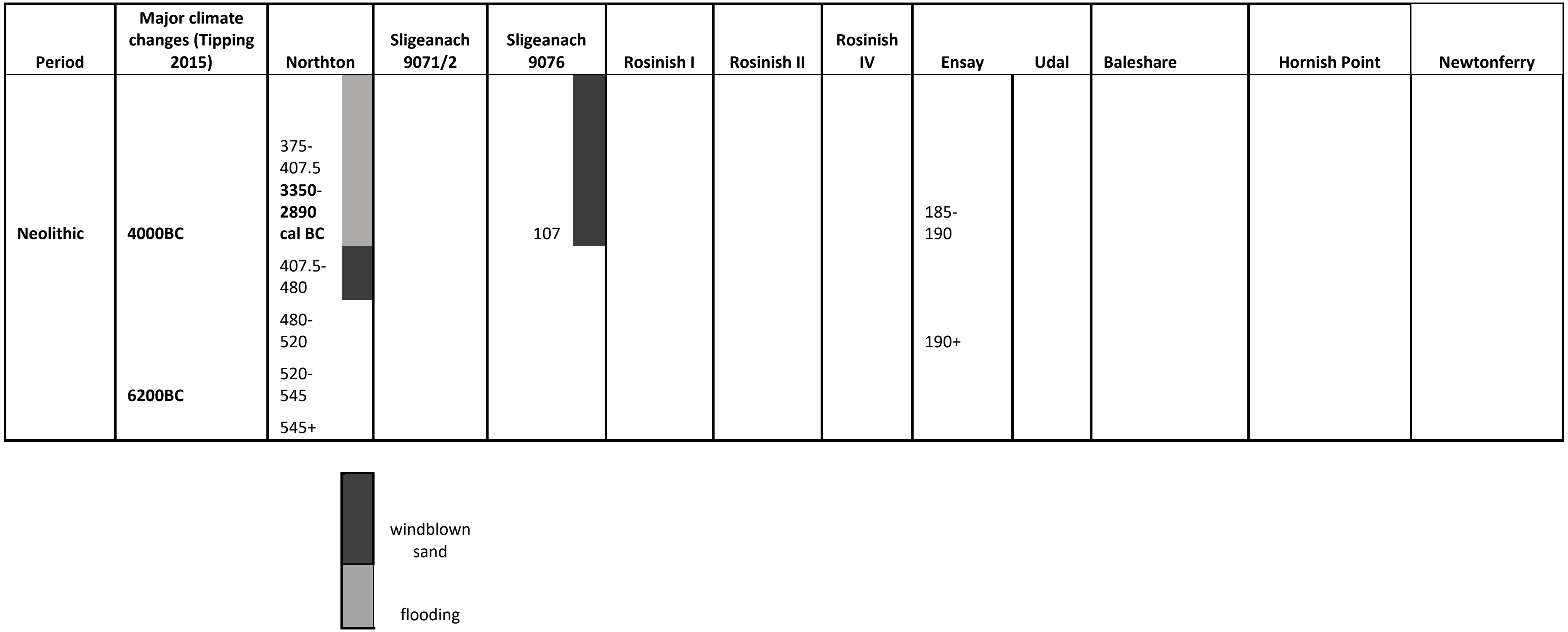
Low numbers of *Galba truncatula*, occasionally with *Zonitoides nitidus*, *Vertigo substriata* or *Oxyloma elegans* are present at Cladh Hallan, Allasdale, Ceardach Ruadh, Cill Donnain and Bornais. These are suggestive of seasonal flooding in at least parts of these sites, At Allasdale, Cladh Hallan, Cill Donnain and Bornais these species are associated with middens, which may alternatively suggest that herbaceous material from areas prone to flooding was being incorporated into middens. The presence of three burnt *Galba* shells in a single context at Cladh Hallan adds weight to this possibility, as this implies redeposition of burnt vegetation.

Figure 8.4 presents a summary of indications of increased wetness arising from this work and previously studied assemblages, as well as periods where sterile sands indicate increased aeolian activity across the Western Isles, along with major climatic events affecting Scotland (taken from Tipping 2015). The Early Bronze Age examples above roughly coincide with climatic deterioration around 2200BC, while a period of increased aeolian activity takes place at Sligeanach and Rosinish shortly before that. Northton and Hornish Point show evidence of increased deposition of windblown sand in the Early

Iron Age, perhaps around the time of climatic deterioration from 800-650 BC. Local phases of increased sand blow or flooding can be seen to be recurrent across the islands, although the mild climate of the earlier part of the Norse period is evident (see Chapter 3.4.3). Correlation between sites is difficult, however, as in most cases the resolution of the dating is not good enough. No single period of climatic change shows clearly in all sequences.

Period	Major climate changes (Tipping 2015)	Northton	Sligeanach 9071/2	Sligeanach 9076	Rosinish I	Rosinish II	Rosinish IV	Ensay	Udal	Baleshare	Hornish Point	Newtonferry
Modern		0-12.5 cms	Cxt 11	Cxt 100			0-10 cms ■	0-13 cms	0-20 cms			
Post-Medieval	**Little Ice Age AD1400-1850**	12.5-20					10-40 ■		20-172 ▨			
		30-30					40-60					
Viking/ Norse							60-70					
												Cxt 8 ▨
Late Iron Age	**AD600-700**	30-65										
Middle Iron Age		65-c.97					70-90			Block 15 **173 cal BC - cal AD 225** ▨		
		c.97-175					90-100			Block 21, Block 6 ■	Block 5, Block 8, Block 19 **394-10 cal BC (Block 5)** ▨	
Early Iron Age	**800-650BC**	175-195 ▨					100-110				Block 1, Block 9, Block 10, Block 12, Block 22 ▨	
Late Bronze Age		195-265					110-120	13-23		Block 23 ■		
								23-35		Block 22 **1881-1461 cal BC** ▨		
Early Bronze Age	**2200BC**							35-37 ▨				

Period	Major climate changes (Tipping 2015)	Northton	Sligeanach 9071/2	Sligeanach 9076	Rosinish I	Rosinish II	Rosinish IV	Ensay	Udal	Baleshare	Hornish Point	Newtonferry
Beaker		265-295 **1940-1680 cal BC** ▨	12 **2200-1910 cal BC**					47-58				
		295-325	72/77		0-7 cms	0-5 cms		58-70 ▨				
		325-355 **2140-1740 cal BC**	16		7-12 ■	5-12		70-119				
			18 **2470-1890 cal BC**		12-20	12-33		119-144				
			19 ■		20-35 ■	33-40		144-159				
				102 **2280-1960 cal BC**	35-50	40-51		159-185				
				103	50-70 ■	51+						
				104 ■								
				105								
		355-375 ■		106 ■								



Period	Major climate changes (Tipping 2015)	Northton	Sligeanach 9071/2	Sligeanach 9076	Rosinish I	Rosinish II	Rosinish IV	Ensay	Udal	Baleshare	Hornish Point	Newtonferry
Neolithic	**4000BC**	375-407.5 **3350-2890 cal BC** ▒		107 ■				185-190				
		407.5-480 ■										
		480-520						190+				
	6200BC	520-545										
		545+										

■ windblown sand

▒ flooding

Figure 8.4: Evidence for flooding and sand movement in Hebridean snail sequences.

8.5 *DIETARY CONTRIBUTION OF MOLLUSCS*

Marine molluscs have been a feature of the Hebridean diet since the earliest known sites. In particular, limpets, common on the rockier coasts, predominate through much of prehistory, although where local conditions lead to their abundance, as at Northton, Cill Donnain and Ceardach Ruadh, Baile Sear, cockles are common in the archaeological record (Chapters 5.9 and 7.3). At several sites, winkles become more significant from the Late Iron Age into the Norse period, although they do not entirely replace limpets (Chapters 5.9 and 7.4). In this section, I will consider the patterns that emerge, firstly from prehistoric contexts, and then from assemblages of Norse date.

8.5.1 Prehistory

In Beaker period and Early Iron Age contexts at Sligeanach, limpets predominated in all but two samples, winkles being the dominant mollusc in two samples from Middle Iron Age Trench X of Mound 16. Limpets similarly dominate most of the samples from late Iron Age contexts at Mound 1, Bornais (Sharples & Light 2012, 201). Limpets dominate the small collection of shells from two Iron Age domestic midden deposits at Allasdale, although winkles are almost as numerous in one (Chapter 7.2). Winkles are the dominant taxon from the Bronze Age through to the Late Iron Age at Cill Donnain (Bell & Godden 2014).

To explore the preferred size of limpet collected at archaeological sites, Table 8.2 shows the mean size of measured limpet shell from sites on South Uist. Evans and Spencer (1977, 216) note that it is the shell length which gives the best indication of the amount of meat within a limpet, as most of the animal is at the ventral part of the shell. Two samples of 100 limpet shells from Sligeanach were measured, giving mean lengths of 37.9 mm and 36.1 mm. This is roughly consistent with a limpet aged three to four years, growing in good conditions at a low tidal level. These measurements are slightly smaller than those given for Iron Age Dun Vulan (Sharples 2005, 161). Several of the limpet shells at Norse Mounds 2 and 2A at Bornais are less than 2 cm in their largest dimension (Chapter 7.4), and are therefore young. It may be that younger limpets were sought owing to their texture or flavour. Intriguingly, Sloan (1985, 143) states that larger limpets, above 48mm in length, are preferred by the modern population of Oronsay.

Limpets are especially likely to be susceptible to exploitation resource depletion as they are close to sessile. A preference for younger limpets may make exploitation resource depletion (*sensu* Charnov *et al.* 1976) a possible factor in the decline of limpets in Hebridean shell assemblages. Size at sexual maturity within a prey taxon has an influence on its resilience to over-exploitation (Lasiak 1991). If human populations prefer limpets that have not yet reached sexual maturity, this will have a detrimental effect on population size, however limpets as small as 10mm in length have been found to be sexually mature, especially males (Orton 1928).

Site	**Period**	**Mean height (mm)**	**Mean length (mm)**	**Reference**
Sligeanach <9039>	Early Iron Age	12.6	37.9	Law 2012; Chapter 7.1
Sligeanach <9042>	Early Iron Age	11.8	36.1	Law 2012; Chapter 7.1
Dun Vulan 508	Middle Iron Age	13.8	38.7	Sharples 2005
Dun Vulan 784	Middle Iron Age	11.2	34.8	Sharples 2005
Bornais M2A <10664>	Norse	12.8	40	Chapter 7.4
Bornais M2A <7230>	Norse	13.7	40.1	Chapter 7.4
Bornais M2A <10409>	Norse	10.6	32.6	Chapter 7.4
Bornais Mound 3 Block DD	Norse	13.5	37.9	Sharples 2005
Bornais Mound 3 Midden 347	Norse	13.6	37.2	Sharples 2005
Dun Vulan Context 10	?Post-Medieval	13.3	38.1	Sharples 2005

Table 8.2: Mean height and length of measured limpet shells from archaeological contexts on South Uist.

Cockles were a significant component of marine shell assemblages at some prehistoric sites. Bell and Godden (2014, 185) describe an 'incontrovertible' decline in cockles at all sites during late prehistory, but this is only true of the Cill Donnain and Cladh Hallan area of South Uist. At Northton

(Evans 1971) and Ceardach Ruadh, Baile Sear (Chapter 7.3) they remain popular into the Iron Age. Cockles, which require sandy shores rather than rocks, were only ever consumed in any number locally it seems, in contrast to limpets and winkles which were ubiquitous; and a picture emerges overall of the shore adjacent to sites being treated much like a garden, with whatever fruits are locally available harvested. Evans (1999, 87) has warned that "in… models which are both progress-oriented and micro-regionalised one tends to underestimate the diversity of settlement and subsistence strategies engendered by the playing out of interactions within individual communities". This warning seems appropriate in relation to attempts to describe patterns in Hebridean shellfish consumption.

So it is that limpets remain popular throughout the Western Isles into the Norse period, as they are locally abundant, and were presumably well-liked. The local availability may play a role, however, with cockles favoured in some sites. Cultural influences come into play in the Late Iron Age, however, when a Scandinavian preference for winkles shows through in an increase in their abundance at archaeological sites, even if they do not become dominant at all sites in the Western Isles or elsewhere in Scotland.

8.5.2 Norse

A preponderance of winkles is a feature of Norse assemblages from the Scottish islands in general. In later phases at Mound 1 and all but Block FB at Mound 3, winkles are the dominant taxon (Sharples & Light 2012; Sharples 2005). This rise in popularity of winkles appears to be a feature of Scottish islands around the same time as the beginning of Norse occupation, or perhaps shortly before. At Buckquoy, Orkney, winkles overtake limpets in abundance during the Pre-Norse phases. Evans and Spencer (1977, 215) state that the situation is reversed during Norse occupation, but this is only true during one of the three Norse phases. At Quoygrew, Orkney, limpets are dominant, but winkles become increasingly prevalent in Phases 2 and 3 of the Farm Mound, and in the coastal midden (Milner and Barrett 2012). Measurement of winkles at Quoygrew showed a slight increase in size through time. This was interpreted as being indicative of an effort to increase yield by collecting a second-choice species more widely (Milner *et al.* 2007, 1470). At Old Scatness, Shetland, limpets remain dominant until Late Norse Phase 9, when winkles take over, although winkles grow in significance in Viking Phase 8 (Cussans 2010, 176). Although winkles are very frequent in the samples, limpets are dominant in the Norse midden at Freswick Links, Caithness, which was formerly part of the Norse Earldom of Orkney (Rackham *et al*. 1984; Murphy & Rackham 1995, 217).

Rather than a shift towards exploitation of a second-choice species, the growing dominance of winkles is likely to represent a culturally-mediated change in taste more closely aligned to present-day preferences in north-western Europe. As well as the growing body of evidence for changes in taste from islands in the Viking diaspora, there is potential evidence for the Viking predilection for periwinkles across the Atlantic in North America. *Littorina littorea* is not a native species in North America, and it is only in the mid-nineteenth century that it underwent a dramatic increase in range from Nova Scotia southwards to New England, most likely signalling its introduction at that time (Chapman *et al.* 2007). There are, however, approximately 19 shells of *Littorina littorea* in Nova Scotia from archaeological contexts which predate Columbus, despite an absence of the shell in North American raised beaches, where it would be expected to occur were it native (Chapman *et al.* 2007, 997). Three of these occurrences are of exceptionally early date; two from below the L'Anse aux Meadows Norse settlement which were not radiocarbon dated and have been subsequently lost, and another from southwestern Nova Scotia which was dated to between 33, 000 BP and 44, 000 BP from its presumed *in situ* presence in mid-Wisconsian deposits. The remainder have been dated by association with artefacts or by radiocarbon to between AD 1000 – AD 1500 (Chapman *et al.* 2007, 997).

It seems possible that periwinkles were initially introduced to North America by Vikings but subsequently became extinct before being reintroduced in the nineteenth century. There is additional evidence that Vikings were deliberately transporting live shellfish on long journeys in the presence of the soft clam *Mya arenaria* L., a North American native introduced to Europe, in a context older than the fifteenth century in northern Denmark (Petersen *et al.* 1992, 679). There is also a puzzling record of a hand-collected specimen of *Mya arenaria* from a Bronze Age context at the Central Excavation Unit's excavations at Baleshare (Pain & Thew 2003, Table 28). It seems likely that this is a misidentification, or perhaps intrusive in that context.

This is not to say that winkles are an integral part of a 'Viking' cultural package, however. York was the largest, wealthiest and most important town in Viking Britain (Carroll *et al.* 2014, 89), and so if winkles were a particular favourite, it may be reasonable to expect them in shell assemblages there. Assemblages there are dominated by oyster (*Ostrea edulis*), however (e.g. O' Connor 1985; O' Connor 1984). *Littorina littorea* is present among shells in the 9th and 10th century AD at 16-22 Coppergate, but it is only a minor component (O' Connor 1984). It may be the case, however that the coasts preferred by winkles were less frequently exploited overall. In all cases, local availability will have been the major factor determining the most popular shellfish.

There may be a social aspect to eating winkles that is not present when eating limpets or cockles. Interviewing a winkle seller on the streets of London in the 1840s for his ethnography *London Labour and the London Poor* (1851), John Mayhew reports the observation that:

> *""Old people, I think, that lives by themselves, and has perhaps an annuity or the like of that, and nothing to do pertickler, loves winks, for they likes a pleasant way of making time long over a meal."*

Because removing winkles from their shells can be time-consuming, their consumption entails lingering over meals, perhaps making them well-suited to meals where the opportunity for social interaction was important.

Taxon	**Summary Environment**	**Neolithic**	**Early Bronze Age**	**Middle- Late Bronze Age**	**Early-Middle Iron Age**	**Late Iron Age**	**Norse**
Patella spp. (Limpets)	Rocky shores, intertidal	Northton	**Northton**; Cill Donnain III; **Sligeanach**; **Allasdale**	**Northton**; **Allasdale**	Northton; Cill Donnain III	Northton; Cill Donnain III; **Bornais M1**; **Allasdale**	*Baile Sear*; Bornais M1; M2; M2A; M3
Patella pellucida (Blue-rayed limpet)	Intertidally, on *Laminaria*, all coasts					*Bornais M1*	*Bornais M1*
Topshells (*Calliostoma* and *Gibbula* spp.)	On rocky shores, on weeds and under stones		*Cill Donnain III; Sligeanach*	*Cill Donnain III*		*Cill Donnain III; Bornais M1*	*Bornais M1; M2; M2A; M3*
Littorina littorea (Common periwinkle)	Rocky shores, intertidal	Northton	Northton; Cill Donnain III; Sligeanach; *Allasdale*	Northton; **Cill Donnain III**; *Allasdale*	Northton; **Cill Donnain III**	Baile Sear**;** **Cill Donnain III**; Bornais M1; *Allasdale*	**Baile Sear; Bornais M1; M2; M2A; M3**
Littorina obtusata/ mariae (Flat periwinkles)	On seaweed, intertidal		Cill Donnain III; *Sligeanach*	Cill Donnain III		*Baile Sear*; Cill Donnain III; Bornais M1	Bornais M1; M2; M2A; M3
Littorina saxatalis agg. (Rough periwinkle)	Rocky shores, intertidal						Bornais M2; *M2A; M3*
Trivia arctica (Northern cowrie)	Rocky shores, intertidal				*Cill Donnain III*	*Cill Donnain III; Bornais M1*	*Bornais M1*

Taxon	**Summary Environment**	**Neolithic**	**Early Bronze Age**	**Middle- Late Bronze Age**	**Early-Middle Iron Age**	**Late Iron Age**	**Norse**
Nucella lapillus (Dog whelk)	Rocky shores, intertidal	*Northton*	*Northton; Cill Donnain III*	*Northton; Cill Donnain III*	*Northton; Cill Donnain III*	*Northton;* Cill Donnain III; *Bornais M1*	*Bornais M1;* M2*; M2A; M3*
Neptunea antiqua (Red whelk)	Sublittoral, mainly on soft substrata, from 15 to 1200m						*Bornais M3*
Buccinum undatum (Common whelk)	On hard and soft substrata, sublittoral down to 1200m		*Sligeanach*		*Cill Donnain III*	*Cill Donnain III; Bornais M1*	*Bornais M1; M2; M2A; M3*
Hinia reticulata (Netted dog whelk)	Intertidal to sublittoral, on rocky shores					*Bornais M1*	
Mytilus spp. (Mussels)	Upper shore to shallow sublittoral		*Cill Donnain III*	*Cill Donnain III*	*Cill Donnain III*	*Baile Sear; Cill Donnain III; Bornais M1*	*Baile Sear; Bornais M1;* M2; M2A*; M3*
Modiolus modiolus (horse mussel)	Low shore to about 100m						*Bornais M3*
Ostrea edulis (Oyster)	Lower shore to about 80m	*Northton*	*Northton*		*Northton*	*Northton; Cill Donnain III; Bornais M1*	*Bornais M1; M2A; M3*
Pecten maximus (Great scallop)	Sand or fine gravel, offshore to 100m			*Allasdale*		*Northton; Bornais M1*	*Bornais M2; M2A; M3*

Taxon	**Summary Environment**	**Neolithic**	**Early Bronze Age**	**Middle- Late Bronze Age**	**Early-Middle Iron Age**	**Late Iron Age**	**Norse**
Aequipecten opercularis (Queen scallop)	Sand or fine gravel, offshore to 100m					*Bornais M1*	*Bornais M3*
Scallop indet.			*Cill Donnain III*	*Cill Donnain III*	*Cill Donnain III*	*Cill Donnain III*	
Arctica islandica (Icelandic cyprine)	Offshore in sand or muddy sand						*Bornais M1; Bornais M3*
Cerastoderma edule (Cockle)	Sandy mud, sand or fine gravel. Mid-tidal level-ELWS	**Northton**	*Northton; Cill Donnain III; Sligeanach*	*Northton;* Cill Donnain III	**Northton**; Cill Donnain III	**Northton**; **Baile Sear**; Cill Donnain III; *Bornais M1*	*Bornais M1; M2; M2A*
Ruditapes decussatus (Chequered carpet shell)	Lower shore, in sand and mud					*Bornais M1*	
Lutraria lutraria (Common otter shell)	Soft substrates, lower shore to 100m.						*Bornais M2*
Solenidae (Razor clams)	In fine sand. Lower shore and sublittoral		*Sligeanach*	*Allasdale*		*Allasdale*	*Bornais M1; M2; M2A; M3*

Table 8.3. Marine molluscs (hand-collected and >10mm fractions) from archaeological sites in the Western Isles. Bold type is used where a species is predominant at that site in that phase. Italics where fewer than 100 shells of that species occur at that site in that phase.

8. 5.3 Exploited habitats and implications for social organization and co-operation

By looking at the habitats of species consumed at archaeological sites, we can infer areas that shellfish collectors would have visited, and from that consider territoriality and social connections. Most of the shells, especially the dominant limpets and winkles, come from rocky coasts. The area with the highest concentration of sites examined, the machair of South Uist around Bornais, Cill Donnain and Sligeanach, lies to the east of predominantly sandy beaches, with a rocky outcrop surrounding Dun Mhulan (Dun Vulan), and a second area of rock south of Cill Donnain, called Trolaisgeir (Figure 8.5). On Barra, Allasdale lies due east of the interface between rocky shore and sandy beach. Baile Sear is bounded entirely by sandy beach (the habitat of the dominant cockles), with rocky outcrops over 5km north west on North Uist or 6km south on Benbecula. Toe Head, Northton, has rocky outcrops and sandy beach.

Sharples (2005; 2012, 228) has previously discussed the fact that visits to shore to procure driftwood and other resources would have been routine (see Chapter 3.9), perhaps especially for women and children, and that shellfish collection would provide a guaranteed return from the visits. The unpredictable nature of, for example, driftwood landings, would have required vigilant monitoring of the shore (Sharples 2005, 162), and that the bringing of shellfish from the shore to the settlement creates “a relationship between the community and particular parts of the shore whose exploitation is likely to have been carefully controlled” (Sharples 2012, 228). Under Norse Udal law, access to foreshore resources was controlled by landowners whose property abuts the shore. Today, in Shetland and Orkney, Udal law still permits landowners ancillary rights to wreck and seaware on the foreshore (Registers of Scotland n.d., 32.8). To take the Middle Iron Age as an example, for the inhabitants of Bornais, and perhaps also Cill Donnain and the later inhabitants at Sligeanach, it seems reasonable to infer that the procurement of shellfish was part of a wider network of social and economic interaction with the community of Dun Vulan, who presumably would have controlled the most immediate source of limpets and winkles. That said, Sligeanach lies roughly equidistant between two areas of rock, and Cill Donnain III is slightly closer to the southern outcrop (Trolaisgeir) (Figure 8.5).

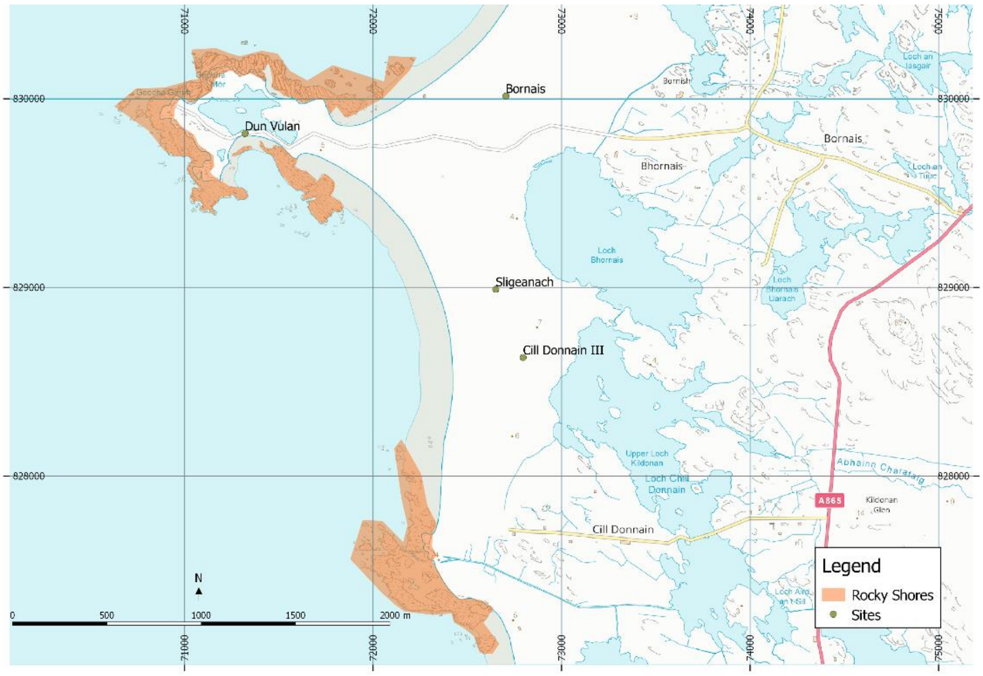


Figure 8.5: Map showing coastal rock outcrops around the Cill Donnain/ Bornais area of South Uist, which may have been sources of limpets and winkles. Contains Ordnance Survey data. Crown © and database right 2016.

Most of the shellfish species consumed are upper shore, intertidal species, which would have been easy to harvest at low tide. Lower shore species, such as oysters or whelks like *Buccinum undatum,* do not occur in high numbers, nor do razor shells, which require skill to harvest as they burrow rapidly into sand when disturbed. At Ardnave, Evans (2005a, 173) saw this as evidence that shellfish were only ever collected on a casual basis, perhaps reinforcing Sharples's (2012, 228) point about harvesting shellfish as being part of a wider strategy of resource procurement from the shore. Cussans (2010, 178) notes another potential reason for the avoidance of bivalves: a food taboo based around their tendency to accumulate toxic phytoplankton. It may be that such a taboo existed, particularly around the summer months when phytoplankton blooms are likely to be at their highest, however cockles and mussels appear throughout the Hebridean assemblages in numbers that would suggest the taboo, if it existed, was not total.

If we assume that the scallops, *Pecten maximus* and *Aequipecten opercularis*, were collected live and eaten, that implies that there was some offshore diving or dredging for shellfish, possibly from the Bronze Age where they appear at Cill Donnain III. The alternative, however, is that the shells were collected empty either as curios or functional vessels. and Evans (2005a, 173) considered the latter to be the case for the scallops and *Arctica islandica* shells (which occur in high numbers there) for the assemblage from Ardnave, Islay. He noted the fragmentary nature of the thick shells of *A. islandica* there, which suggested that they may have been heated. Many of the *Pecten* shells and the *Lutraria lutraria* shell from Bornais were similarly fragmentary, perhaps suggestive of heating. This may mean that they had been used as utensils or cooked for consumption.

Marine shells also have a long history as objects of interest. Pierced and worked shells are notable in the Late Iron Age at Bornais, Mound 1; and shells which would not have been food remains, but may have been decorative curios, are found at Allasdale (Chapter 7.2).

8.6 NON-MARINE MOLLUSCAN TAXOCENES OF THE WESTERN ISLES

In Chapter 2.3, the concept of taxocenes as an interpretative tool for working with sub-fossil snail assemblages was introduced. These are associations of species that can be shown to recur between samples and perhaps locales, although they may be subject to spatial or temporal limitations. Here I describe five taxocenes, called 'Western Isles Taxocenes' (WIT), which recur across the sites analysed from the Western Isles, and which can be used as aids to interpretation of future assemblages. It is worth repeating Davies's (2006, 178) note that taxocenes and assemblages are not the same – the presence of a taxocene does not preclude other species being present in an assemblage – indeed these taxocenes are not mutually exclusive: WIT-3, WIT-4 and WIT-5 often exist within assemblages dominated by WIT-1 and WIT-2. The taxocenes, with a description of their environmental and occasionally chronological interpretation, are:

WIT-1 *Cochlicella acuta*-dominant, with smaller numbers of *Helicella itala*, *Cochlicopa spp.*, *Vallonia spp.* and *Pupilla muscorum*. Indicative of open grassland with active sand accumulation. Restricted to samples from the Late Iron Age and later. WIT-1 tends to dominate the top of vertical sequences (e.g. Northton, Ensay, Sligeanach, Ceardach Ruadh).

WIT-2 *Pupilla muscorum* - *Vallonia spp.* dominant. Smaller numbers of *Vertigo pygmaea* and *Cochlicopa spp.* Indicative of open grassland, especially where numbers are high. Occurs earlier than the Late Iron Age. This taxocene is a prominent feature of the assemblages at Cladh Hallan, Sligeanach, Rosinish and other prehistoric sites.

WIT-3 *Lauria cylindracea* with *Oxychilus alliarius* or *Cochlicopa spp.* prevalent (but not always occurring together). This taxocene gives somewhat mixed signals with open country fauna and lower numbers of *Nesovitrea hammonis*, *Clausilia bidentata* or *Galba truncatula*. Generally Norse or earlier, where it is associated with complex habitats around structures and midden material, for example the Late Iron Age midden (Context **408**) at Allasdale, and the midden context **4077** at Cladh Hallan (although *Oxychilus* is absent). More recently this taxocene may be associated with grassland towards the rear of machair.

WIT-4 *Acanthinula aculeata* - *Aegopinella pura* - *Carychium tridentatum* present, usually among open country and mesophilic species. This is indicative of a shaded habitat with likely scrub/ wooded element. Generally Iron Age or earlier. Occurs in the windblown sand underlying the Iron Age II horizon at Northton (Evans 1971), and between 111-119 cms depth at Ensay (Spencer 1974).

WIT-5 *Galba truncatula* present. A damp habitat associated with seasonal flooding. Despite the prodigious reproductive ability of *Galba*, it is only present in low numbers. It is interesting to note that *Galba* does not occur in association with *Zonitoides nitidus*, another snail of seasonally wet environments.

8.6.1 Comparison with Detrended Correspondence Analysis

In Chapter 6.12, samples with more than 50 snails from across the original analyses in this thesis were explored using Detrended Correspondence Analysis. This is a method of statistical ordination that arranges the snails within an assemblage along two axes according to variation between samples, and so provides another tool for interpretation. The composition of the taxocenes (which in this study is a subjective, *a posteriori* grouping) and the groupings that emerge from DCA (which are objectively determined by an algorithm) can be compared. The distinction between WIT-2 and *Cochlicella acuta* shows in their placing on opposite ends of the ordination along Axis 1.

The other taxocenes are less clear, however, with the species named in WIT 3, 4 and 5 clustering towards the centre of the diagram, or being present in fewer than 10% of the samples from the present analysis and so not plotted. This is to be expected due to the degree of overlap within the taxocene structure (only WIT-1 and WIT-2 are mutually exclusive). The Western Isles taxocenes proposed here are more sensitive to the occurrence of minor species that have markedly different ecological tolerances from most species in an assemblage. This is largely because subjective reference has been made to species ecology in assigning taxocenes. The use of both approaches is recommended to interpret variation in future work on snails from the islands.

8.7 CHALLENGES IN MOLLUSCAN ANALYSIS

One of the greatest challenges in molluscan analysis is the lack of control on temporal resolution. Molluscan assemblages in the Western Isles may be time averaged due to several factors, from earthworm action in the case of smaller shells, to aeolian conflation. Thew (2003) suggested that lateral sampling of extensive deposits would make problems easier to detect. To attempt to overcome this problem, this study used samples derived from lateral sampling at six sites, along with vertical sequences from three sites, two of which encompassed two sequences, and the other (Northton) was relatable to a previously published sequence. Because of this approach, it was possible to cross-check and identify intrusive species (such as at Northton), or interruptions in the sequence where deflation was likely (such as the tops of the sequences at Northton NT11, Sligeanach and Ceardach Ruadh).

When looking for evidence of regional climate change, localised events may present misleading responses from the molluscs present. Orme *et al.* (2016) considered this problem when analysing sedimentary input in ombrotrophic bogs, and analysed replicate cores to provide some means of control for this problem. For future work, analysis of replicate vertical sequences from the same site would be recommended. In the case of Northton, contrast with Evans's (1971) section was instrumental in interpreting much of the NT10 fauna as intrusive.

A number of methodological issues are apparent when dealing with marine shell analysis. To the excavator, marine mollusc shells could perhaps appear overwhelming in number and a bit underwhelming in interpretative potential. This has resulted in many excavations not having recorded assemblages of marine shells, such as the Central Excavation Unit’s 1980s excavations on North Uist and Benbecula. Shells were abundantly present, though, as they were the primary medium used for radiocarbon dating.

Also, sampling, collection and retention policies vary wildly from site to site. At Cill Donnain, Sligeanach and Bornais, the shells analysed were collected from a 10mm mesh sieve and in the case of Cill Donnain, disposed of on site. The Bornais shells were retained and have been revisited several times to clarify various points Where marine shells have been collected on 10mm mesh sieves, easily fragmented bivalves such as cockles and mussels may be under-represented.

The adoption of standardised methodologies, as proposed by Campbell (2015) is surely to be commended as this gives guidance over the types of marine shell assemblages that should be retained for future analysis. Future projects that combine analysis of archive material with newly excavated shells and previously published reports, will be able to carry out more reliable meta-analyses if standard procedures are adhered to.

Early on in this research, I was interested in the breakage of limpet shells – limpets can be removed from rock by a sharp lateral blow, or by breaking the apex. To record this, I devised a rather rough zonation scheme for limpet shells (Figure 2.2) which was trialled on a sub-sample of the limpets from Bornais. Apical breaks are not common, but they do recur in clusters in some contexts at some sites, suggesting perhaps that in each case an individual or individuals with different ideas about how to do things is at work.

9. CONCLUSIONS

9.1 FINDINGS OF THIS THESIS

In this thesis, I set out to demonstrate that mollusc shells, as much as pot sherds or lithic implements, are a part of the human history of a place, notwithstanding the agency held by the living animal, or the influence of extrinsic environmental changes on both the molluscs and the people.

I have shown that studying non-marine and marine molluscs from a wide range of sites across the islands in relation to previous work can make important contributions to the archaeology of the Western Isles. The movement of new species of snail into and across the islands emphasises the connectedness of prehistoric communities to wider social networks on the Atlantic coast of Europe, and mirrors the movement of people and livestock throughout prehistory.

The study of non-marine molluscs and the use of statistical analysis contributes to a broader understanding of taphonomy and site formation processes, detecting periods of instability and conflation, and identifying human inputs into deposits. This is especially critical in such a dynamic climate as the Western Isles, where coastal sites are exposed by storms and erode through the aeolian attrition of Atlantic gales.

Combined analysis of marine and non-marine mollusc shells highlights the ways in which prehistoric and Norse-period farmers managed the land and made it productive in a difficult climate. Studies of larger marine shells indicate changing tastes at the time of increasing contact with the Norse diaspora, but also emphasise the importance of local resources. Barnacles can be proxies for archaeologically-invisible whale meat. The procurement of marine shells gives a glimpse into the requirements of social organisation in different places at different times.

Evans (2005b, 56), in emphasising the beauty of land snail assemblages for revealing changes at a very local level, bemoaned the fact that people “try to squeeze the data into regional faunal schemes, as if snails were tree pollen”. This is slightly unfair. Certainly, we have seen from the presence of snails that might be expected in woodland in Late Bronze Age and Iron Age contexts at sites like Horgabost, Cladh Hallan and Rosinish, that individual species might not be responding to quite the environmental variable we would like to explore (the presence of *Aegopinella pura* at Cladh Hallan and Rosinish in later prehistory is not as flawless an indicator of the presence of trees as the presence of preserved pine stumps on Lewis dating to the early Bronze Age). Analysis of land snail data has allowed regional themes to emerge however.

This thesis has related mollusc shells to people and places, at a range of scales from the context level to the level of the diaspora (be it Norse who may have really liked winkles, or that of the late Bronze Age and early Iron Age people who introduced new snail species to the machair).

Complexity looms large over the molluscan analysis. With regard to the non-marine molluscs, snails may be responding to several environmental variables, or have grown to exploit habitats that do not closely resemble their 'typical' habitat in mainland Britain. *Punctum pygmaeum* (broadly shade-demanding) may live alongside *Helicella itala* (supposedly an open-country xerophile) in machair grassland. This pattern is revealed in the low eigenvalues of the various axes in the Detrended Correspondence Analyses of Chapter 6, and the consequent difficulty determining meaningful species associations. In relation to marine molluscs, cultural preferences may exist, but they may be superseded by local tastes, or even more likely by local availability.

Despite this, ecological sense can be found in the molluscan assemblages. Meaningful species associations (the taxocenes proposed in Chapter 8.6) do exist, and recur; signals of environmental change and of changes in land use and agricultural practice through time emerge; the movement of people and of livestock is reflected in the spread of snail species. Marine shells reveal regional patterns of changing consumption, but those patterns are complicated by the agency of individuals or individual communities.

Mollusc shells are thus meaningful parts of the archaeological site assemblage. The Western Isles machair constitutes an excellent scenario for their preservation, and future archaeological projects on the machair should be devised with the intention to collect samples for analysis of shells, both marine and non-marine, from the outset. Through doing this, and broadening the range of data available, important insights into past human lives and archaeological site formation processes, can be gained, and the interpretations made in this thesis strengthened.

9.2 SUSTAINABLE LAND USE IN THE WESTERN ISLES

Agriculture in the Western Isles has developed over thousands of years in an environment where climatic instability is expected and soils are prone to nutrient deficiency. The work summarised in Chapter 8.4 shows that periods of increased wetness and/or increased windiness have been recurrent. There is much that can be learnt from archaeological, historical and palaeoecological evidence for future adaptation, both within the Western Isles but also in other locations that may be subject to decreasingly stable climates.

This climate instability may take many forms. Climate models predict a eustatic rise in mean sea level as a result of thermal expansion and melting ice (IPCC 2013, 25). In the case of the Western Isles, which are not experiencing isostatic uplift, this has been predicted to be in the order of between 9cm and 69cm by the period 2071-2100 (Angus & Hansom 2006, 32). Saline flooding of arable machair land thus presents a challenge to future land use as many crop types may be fatally affected by osmotic stress. At present, arable crops grown on the machair tend to be rye and oats, with some bere (Owen *et al*. 2000, 156; Angus & Hansom 2006, 30).

An increase in precipitation of up to 8% by 2071-2100 is also predicted under a medium-high emissions scenario. Angus and Hansom (2006, 32) note that it is possible that even a slight change of precipitation could have 'serious implications for seasonal standing water'. An increase in flooding area, or duration of flooding, could be detrimental to ploughing of arable land (Angus & Hansom 2006, 33).

An increase in storminess is also likely with suggestions that the number of deep atmospheric depressions passing over the UK could increase by 40% by 2071-2100, with an attendant likely increase in storm surges (Angus & Hansom 2006). Another factor not addressed by Angus and Hansom (2006) in the face of increased storminess is the likelihood of increased sand mobility.

This study has shown that the Western Isles machair has always been a fragile resource and that agriculture was adapted to preserve soil stability where possible. Where ard marks are present in archaeological ploughsoils, the snail assemblages suggest that the ploughing regime was not intensive, and that stable conditions at ground level allowed a diverse community of molluscs to flourish.

Analysis of small gastropods from sites shows that midden material and seaweed have been used to consolidate the soil from at least the Iron Age. If the use of seaweed for this purpose really was developed in the Western Isles during the Iron Age, it may have come at a time when Orme *et al*. (2016) record sand movement in their bog records, and when Thew (2003) records increased blow at Block 21 and Block 6 at Baleshare (Figure 8.4).

It is clear from this study that organic consolidants were a feature of Hebridean agriculture through prehistory and the Norse period, and their use may enable agriculture to continue in the uncertain climate of the future

9.3 IMPLICATIONS AND FUTURE DIRECTIONS

This is the largest synthesis of archaeological studies of non-marine and marine molluscs from the Western Isles carried out to date, and it has made important contributions to the wider archaeology of the islands and the cultural palaeoecology of insular societies in general.

This project has highlighted several directions for further research. Understanding of the faunal successions within machair contexts has developed quite substantially since the early work of the 1960s and 1970s, however there remains a need for both more observations of modern fauna and the habitats they inhabit (the example of *Lauria cylindracea* in Thew (2003) provides a reminder that species may occupy quite different ecological niches at some of the extremes of their geographical range) and access to more archaeological material. The call made by Davies (2008, 158) for modern studies of land snails targeting small-scale environmental changes (for example, seasonal flooding, areas around structures, changes in land use between ploughed fields and grazed pasture) bears repeating. The modern mollusc transect of Chapter 6.1 makes a contribution to this important work.

The unstable nature of machair and sand dune deposits leads to spatial and temporal mixing. Recent intrusions may be detectable when shells are particularly fresh looking (translucent, or with intact periostracum). A graded scale of shell decay could be developed, which may provide a more formal framework for qualifying mixed degrees of preservation in a sample, and drawing attention to potentially intrusive or reworked shells. Such a scale may also help differentiate windblown marine gastropods from those which arrived at a site attached to seaweed and were quickly incorporated into a deposit. Analysis of this kind is common in vertebrate zooarchaeology and human osteoarchaeology; molluscs deserve to be taken as seriously as bones.

The arrival of new species in the Western Isles is very likely to relate to issues of wider archaeological significance, such as the movement of people and livestock along prehistoric seaways. DNA analysis of living populations of latecomers to the Hebridean fauna across their European range will pinpoint their origin. Such work has been undertaken for *Cepaea nemoralis* in Ireland revealing an Iberian origin for populations there (Grindon & Davison 2013). In this way, snails can reveal livestock trade networks that are not easily visible the archaeological record.

Most importantly, the significance of molluscs as a central tool for the interpretation of archaeological sites and their value in creating narratives is reiterated by this study. The methods used here could profitably be applied to archaeological sites, and collections of archaeological sites, in blown sand coastal settings globally.

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APPENDICES

APPENDIX 1: THE NON-MARINE MOLLUSCA OF THE WESTERN ISLES

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
Acanthinula aculeata (O. F. Müller, 1774)		**Grassland and midden deposit** (Ensay, Spencer 1974 Table 16)	**Open country** (Northton, Evans 1971); **Tall vegetation** (Horgabost, Chapter 6.6)			
Aegopinella nitidula (Draparnaud, 1805)	**Shaded habitat** (Northton, Chapter 6.2)	**Grassland and midden deposit** (Ensay, Spencer 1974 Table 16)	**Wheelhouse fills and midden** (Cill Donnain, Chapter 6.8)	**Ploughsoils** (Bornais M2A, Chapter 6.9)		Mingulay (Robinson *et al.* 2015); St Kilda, Lewis, Harris, South Uist, Barra, Vatersay, Mingulay (Waterston 1981)
Aegopinella pura (Alder, 1830)	**Shaded habitat** (Northton, Chapter 6.2)	**Grassland and midden deposit** (Ensay, Spencer 1974 Table 16); **House floor**			**Grassland and midden** (Udal, Spencer 1974, Table 17)	Mingulay (Robinson *et al.* 2015), Harris, Barra, Mingulay (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
		(Cladh Hallan, Chapter 6.4)				
Ancylus fluviatilis O. F. Müller, 1774						Lewis, Harris, North Uist, South Uist, Barra (Waterston 1981)
Anisus leucostoma (Millet, 1813)			**Wheelhouse fill** (Cill Donnain, Chapter 6.8)			**Loch margin** (Loch Hallan, Chapter 6.1); Harris, North Uist, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Anisus spirorbis (Linnaeus, 1758)						**In a grassy stream** (Pabbay, Elton 1938, 293) [This species does not appear on Waterson's 1981 list]
Arianta arbustorum (Linnaeus, 1758)				**Ploughsoils** (Bornais, Chapter 6.9)		St Kilda, Harris, North Uist, Barra (Waterston 1981)
Ashfordia granulata (Alder, 1830)						Barra (Waterston 1981)
Balea perversa (Linnaeus, 1758)					**Geophobic, walled, byre** (Howmore-Smith 1994, 136)	**Under a log in boggy larch and hazel woodland** (Glen Rodel, Evans 1965, 33); St. Kilda, Harris, North Uist, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
Bathyomphalus contortus (Linnaeus, 1758)						Harris, Barra (Waterston 1981)
Candidula intersecta (Poiret, 1801)			**Wheelhouse** Cnip (dubious) (Cerón-Carrasco 2006)			Mingulay (Robinson *et al.* 2015); Harris, North Uist, South Uist, Barra (Waterston 1981)
Carychium minimum O. F. Müller, 1774		**Grassland with tall vegetation** (Ensay, Spencer 1974 Table 16); **Cremation deposit** (Allasdale, Chapter 6.5)	**Wheelhouse** Cnip (Cerón-Carrasco 2006)			**Damp meadow** (Northton, Evans 1965,32), **Under a log in boggy larch and hazel woodland** (Glen Rodel, Evans 1965, 33); Lewis, Harris, North Uist, Monach Isles, South Uist, Barra (Waterston 1981) **Loch margin** (Loch

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
						Hallan, Chapter 6.1)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Carychium tridentatum (Risso, 1826)	**Woodland** (Northton, Evans 1971, 57)	**Arable land with fallow periods and tall herbage** (Sligeanach, Evans *et al.*, 2012)**;** **Grassland and midden deposit** (Ensay, Spencer 1974 Table 16); **Grassland** (Northton, Chapter 6.2). **House floor** (Cladh Hallan, Chapter 6.4)	**Tall vegetation** (Horgabost, Chapter 6.6)	**Grassland** (Bornais M2A, Chapter 6.9)		Harris, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
Cepaea hortensis (O. F. Müller, 1774)	**Woodland** (Northton, Evans 1971, 57)	**Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 40), **Midden** (Baleshare, Thew 2003); **Midden and house floor** (Cladh Hallan, Chapter 6.4)	**Midden** (Baile Sear, Chapter 6.7)	**Blown sand** (Baile Sear, Chapter 6.7)	**Grassland** (Udal, Spencer 1974, Table 17)	**Sand dunes** (Harris, Evans 1965,30); **grassland** (Cladh Hallan, Chapter 6.1); Mingulay (Robinson *et al.* 2015); Lewis, Harris, North Uist, Benbecula, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Clausilia bidentata bidentata (Ström, 1765)		**Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 45); **House floor** (Cladh Hallan, Chapter 6.4)	**Midden** (Rosinish, Vaughan 1976, 49); **Wheelhouse fill** (Cill Donnain, Chapter 6.8); **Wheelhouse** Cnip (Cerón-Carrasco 2006	**Midden** (Rosinish, Vaughan 1976, 49); **Grassland** (Bornais M2A, Chapter 6.9)		**Wall in a damp meadow** (Northton, Evans 1965,32) **on shell mortar on wall in acidic peatland** (Teampull na Trionaid, Law 2010); Harris, North Uist, Barra (Waterston 1981)
Clausilia dubia Draparnaud, 1805						Harris (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Cochlicella acuta (O. F. Müller, 1774)		**Open country, rapid deposition** (Northton, Evans 1971, 54-55), **Damp grassland and midden deposit** (Ensay, Spencer 1974 Table 16)	**Open country, stability** (Northton, Evans 1971, 54-55), **Midden site deposit** (Hornish Point, Thew 2003); **Tall vegetation** (Horgabost, Chapter 6.6); **Wheelhouse fills and middens** (Cill Donnain, Chapter 6.8)	**Midden** (Rosinish, Vaughan 1976, 49); **Ploughsoils and middens** (Bornais, Chapter 6.9)	**Dry calcareous grassland** (Howmore, Smith 1994, 136), **Grassland and midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	**Sand dunes** (Harris, Evans 1965,30) – **bare sand with grass** (Scarista, Evans 1965, 33), **in moderately tall grass on machair** (Cladh Hallan, Law 2010), **on dunes** (Pabbay, Elton 1938, 292); **Blown sand** (Baile Sear, Chapter 6.7); **Dune and grassland** (Cladh Hallan, Chapter 6.1); Mingulay (Robinson *et al.* 2015); Lewis, Harris, North Uist, Monach Isles, Benbecula, South Uist, Barra, Vatersay, Mingulay (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Cochlicopa lubrica (O. F. Müller, 1774)	**Woodland** (Northton, Evans 1971, 54-55); **Shaded habitat** (Northton, Chapter 6.2)	**Dry, short grassland** (Sligeanach, Evans *et al.*, 2012)**,** **Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 40), **Midden and Grave Pit** (Baleshare, Thew 2003), Cremation deposit (Allasdale, Chapter 6.5); **Midden and house floor**	**Midden** (Rosinish, Vaughan 1976, 49), **Cultivation layer and midden site deposit** (Hornish Point, Thew 2003); **Midden** (Allasdale, Chapter 6.5); **Tall vegetation** (Horgabost, Chapter 6.6); **Wheelhouse fills and middens** (Cill Donnain, Chapter 6.8); **Wheelhouse** Cnip (Cerón-Carrasco 2006	**Midden** (Rosinish, Vaughan 1976, 49); **Ploughsoils and middens** (Bornais, Chapter 6.9); **Blown sand** (Baile Sear, Chapter 6.7)	**Grassland** (Udal, Spencer 1974, Table 17), Midden (Newtonferry, Thew 2003)	**Damp meadow** (Northton, Evans 1965,32), **damp dune** (Scarista, Evans 1965, 33), **Wall** (Borrodale, Law 2010); **grassland** (Cladh Hallan, Chapter 6.1); Mingulay (Robinson *et al.* 2015)

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
		(Cladh Hallan, Chapter 6.4)				

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
Cochlicopa lubricella (Rossmässler, 1834)	**Woodland** (Northton, Evans 1971, 54-55); **Shaded habitat** (Northton, Chapter 6.2)	**Dry, short grassland** (Sligeanach, Evans *et al.*, 2012), **Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 40), **Cultivation layers, midden and grave Pit** (Baleshare, Thew 2003); **Midden and house floor** (Cladh Hallan, Chapter 6.4)	**Midden** (Rosinish, Vaughan 1976, 49), **Cultivation layer and midden site deposit** (Hornish Point, Thew 2003); **Tall vegetation** (Horgabost, Chapter 6.6); **Wheelhouse** Cnip (Cerón-Carrasco 2006	**Midden** (Rosinish, Vaughan 1976, 49); **Ploughsoils and middens** (Bornais, Chapter 6.9)	**Grassland and Midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	**Damp meadow** (Northton, Evans 1965,32), **damp dune** (Scarista, Evans 1965, 33), **tending to favour more open habitats than *C. lubrica*** (Evans 1971, 56); Mingulay (Robinson *et al.* 2015)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Columella aspera Waldén, 1966			**Wheelhouse** Cnip (Cerón-Carrasco 2006)			St. Kilda, Harris, North Uist, South Uist, Barra (Waterston 1981)
Columella edentula (Draparnaud, 1805)			**Cultivation layer and midden site deposit** (Hornish Point, Thew 2003)		**Grassland** (Udal, Spencer 1974, Table 17)	**Wall in a damp meadow** (Northton, Evans 1965,32); St Kilda, Lewis, Harris, North Uist, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Cornu aspersum (O. F. Müller, 1774)				**House floor deposit** (Bornais M2, this study)		**Sand dunes** (Harris, Evans 1965,30). **Wall** (Borrodale, Law 2010), **on shell mortar on wall in acidic peatland** (Howmore, Law 2010, Teampull na Trionaid, Law 2010). **On marram grass and in a garden** (Pabbay, Elton 1938, 292); Mingulay (Robinson *et al.* 2015); Lewis, Harris, North Uist, Monach Isles, Benbecula, South Uist, Barra, Vatersay, Mingulay (Waterston 1981)
Discus rotundatus rotundatus (O. F. Müller, 1774)	**Shaded habitat** (Northton, Chapter 6.2)	**Midden and house floor** (Cladh Hallan, Chapter 6.4)	**Midden** (Rosinish, Vaughan 1976, 49)			Mingulay (Robinson *et al.* 2015); St Kilda, Lewis, Harris, North Uist, South Uist, Barra, Vatersay,

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
						Mingulay (Waterston 1981)
Ecrobia ventrosa (Montagu, 1803)						Lewis, Harris, North Uist, South Uist (Waterston 1981)
Euconulus alderi Davies, 1979		**Midden** (Cladh Hallan, Chapter 6.4)				
Euconulus fulvus (O. F. Müller, 1774)	**Woodland** (Northton, Evans 1971, 57); **Shaded habitat** (Northton,	**Grassland and midden deposit** (Ensay, Spencer 1974 Table 16); **Cremation deposit**	**Cultivation layer** (Hornish Point, Thew 2003)	**Grassland** (Bornais M2A, Chapter 6.9)		**Damp meadow** (Northton, Evans 1965,32; Harris, North Uist, South Uist, Barra (Waterston 1981))

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
	Chapter 6.2)	(Allasdale, Chapter 6.5)				
Galba truncatula (O. F. Müller, 1774)	**Woodland** (Northton, Evans 1971, 57)	**Damp grassland and midden deposit** (Ensay, Spencer 1974 Table 16); **Cremation deposit** (Allasdale, Chapter 6.5); **Midden and house floor** (Cladh Hallan, Chapter 6.4)	**Midden site deposit** (Hornish Point, Thew 2003); **Midden** (Allasdale, Chapter 6.5); **Midden** (Cill Donnain, Chapter 6.8); **Burnt sand** (Baile Sear, Chapter 6.7)	**Ploughsoils and middens** (Bornais, Chapter 6.9)	**Grassland and midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	**In a grassy stream** (Pabbay, Elton 1938, 293); **Loch margin** (Loch Hallan, Chapter 6.1); Mingulay (Robinson *et al.* 2015); Lewis, Harris, North Uist, Monach Isles, Benbecula, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Gyraulus crista (Linnaeus, 1758)						**Loch margin** (Loch Hallan, Chapter 6.1); North Uist, Monach Isles, Benbecula, South Uist, Barra (Waterston 1981)
Gyraulus laevis (Alder, 1838)						**Loch margin** (Loch Hallan, Chapter 6.1); Harris, North Uist, Monach Isles, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Helicella itala itala (Linnaeus, 1758)		**Open country, rapid deposition** (Northton, Evans 1971, 54-55); **Damp grassland and midden deposit** (Ensay, Spencer 1974 Table 16)**,** **Midden and grave pit** (Baleshare, Thew 2003)	**Open country, stability** (Northton, Evans 1971, 54-55), **Midden** (Rosinish, Vaughan 1976, 49), **Cultivation layer and midden site deposit** (Hornish Point, Thew 2003), **midden deposit** (Allasdale, Wessex Archaeology 2008, 24); **Wheelhouse fills and middens** (Cill Donnain, Chapter 6.8); **Blown sand**	**Ploughsoils and middens** (Bornais, Chapter 6.9); **Wheelhouse** Cnip (Cerón-Carrasco 2006	**Dry calcareous grassland** (Howmore, Smith 1994, 135), Grassland **and midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	**Sand dunes** (Harris, Evans 1965,30) – **bare sand with grass** (Scarista, Evans 1965, 33), **moderately tall grass on machair** (Cladh Hallan, Law 2010), **on dunes** (var. *instabilis*) (Pabbay, Elton 1938, 292); **Dune and grassland** (Cladh Hallan, Chapter 6.1); Mingulay (Robinson *et al.* 2015); Lewis, Harris, North Uist, Monach Isles, Benbecula, South Uist, Barra, Vatersay, Mingulay (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
			(Baile Sear, Chapter 6.7)			
Hydrobia acuta neglecta Muus, 1963						North UIst, South Uist (Waterston 1981)

Lauria cylindracea (da Costa, 1778)	**Woodland** (Northton, Evans 1971, 57); **Shaded habitat** (Northton, Chapter 6.2)	**Shade-loving** (Northton – Evans 2004, 370), **Woodland regeneration, stability** (Northton, Evans 1971, 54-55), **Arable land with fallow periods and tall herbage** (Sligeanach, Evans *et al.*, 2012); Cremation deposit (Allasdale, Chapter 6.5)**;** **Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish,	**Midden** (Rosinish, Vaughan 1976, 49), **Cultivation layer and midden site deposit** (Hornish Point, Thew 2003), **midden deposit** (Allasdale, Chapter 6.5); **Tall vegetation** (Horgabost, Chapter 6.6); **Wheelhouse fills and middens** (Cill Donnain, Chapter 6.8); **Wheelhouse** Cnip (Cerón-Carrasco 2006	**Midden** (Rosinish, Vaughan 1976, 49); **Ploughsoils and middens** (Bornais, Chapter 6.9); **Blown sand** (Baile Sear, Chapter 6.7)	**Dry open fixed-dune pasture and sand-dune habitats and midden** (Newtonferry; Thew 2003, 163), **Moist and shaded environment in a kiln** (Howmore, Smith 1994), **Grassland and midden** (Udal, Spencer 1974, Table 17)	**Damp meadow** (Northton, Evans 1965,32), on **shell mortar on wall in acidic peatland** (Teampull na Trionaid, Law 2010); **grassland** (Cladh Hallan, Chapter 6.1); St Kilda, North Rona, Lewis, Harris, North Uist, Monach Isles, Benbecula, South Uist, Barra, Vatersay, Mingulay (Waterston 1981) Mingulay (Robinson *et al.* 2015)

		Vaughan 1976, 40), **Dumped deposit and grassland** (Baleshare, Thew 2003); **Midden and house floor** (Cladh Hallan, Chapter 6.4)					

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
Leiostyla anglica (A. Férussac, 1821)	**Woodland clearance** (Northton, Evans 1971); **Shaded habitat** (Northton, Chapter 6.2)	**Dumped deposit** (Baleshare, Thew 2003); **Midden** (Cladh Hallan, Chapter 6.4)				**Wall in damp meadow** (Northton, Evans 1965,32); St Kilda, Harris, Barra (Waterston 1981)
Nesovitrea hammonis (Ström, 1765)	**Woodland** (Northton, Evans 1971, 57); **Shaded habitat** (Northton, Chapter 6.2)	**Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Cultivation layer** (Baleshare, Thew 2003); **Midden and house floor** (Cladh Hallan, Chapter 6.4)	**Cultivation layer and midden site deposit** (Hornish Point, Thew 2003); **Midden and floor deposit** (Allasdale, Chapter 6.5); **Tall vegetation** (Horgabost, Chapter 6.6); **Windblown sand** (Cill	**Ploughsoils and middens** (Bornais, Chapter 6.9)	**Midden** (Newtonferry, Thew 2003)	**Damp meadow** (Northton, Evans 1965,32); St Kilda, Lewis, Harris, North Uist, Benbecula, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
			Donnain, Chapter 6.8)			

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Oxychilus alliarius (J. S. Miller, 1822)	**Woodland** (Northton, Evans 1971, 57); **Shaded habitat** (Northton, Chapter 6.2	**Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Cultivation layer, midden and grave pit** (Baleshare, Thew 2003); **Cremation deposit** (Allasdale, Chapter 6.5); **Midden and house floor** (Cladh Hallan, Chapter 6.4)	**Cultivation layer and midden site deposit** (Hornish Point, Thew 2003); **Midden** (Allasdale, Chapter 6.5); **Tall vegetation** (Horgabost, Chapter 6.6); **Wheelhouse fills and midden** (Cill Donnain, Chapter 6.8); **Wheelhouse** Cnip (Cerón-Carrasco 2006	**Ploughsoils and middens** (Bornais, Chapter 6.9); **Burnt sand** (Baile Sear, Chapter 6.7)	**Walled environment of the byre** (Howmore, Smith 1994, 135), **Grassland and midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	**Damp meadow** (Northton, Evans 1965,32), **Under a log in boggy larch and hazel woodland** (Glen Rodel, Evans 1965, 33), **on shell mortar on wall in acidic peatland** (Teampull na Trionaid, Law 2010); Mingulay (Robinson *et al.* 2015); St Kilda, North Rona, Flannan Isles, Lewis, Harris, North Uist, Monach Isles, South Uist, Barra, Vatersay, Mingulay (Waterston 1981)
Oxychilus cellarius (O. F. Müller, 1774)	**Shaded habitat** (Northton,		**Wheelhouse fill** (Cill Donnain, Chapter 6.8); **Wheelhouse**		**Moist and shaded environment in a kiln**	**Damp meadow** (Northton, Evans 1965,32). **Seeks darker places than O. alliarius**

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
	Chapter 6.2		Cnip (Cerón-Carrasco 2006		(Howmore, Smith 1994)	(Evans 1965, 35); Mingulay (Robinson *et al.* 2015); St Kilda, Lewis, Harris, North Uist, South Uist, Barra, Mingulay (Waterston 1981)
Oxychilus draparnaudi (H. Beck, 1837)						Lewis, South Uist, Barra (Waterston 1981)
Oxyloma elegans elegans (Risso, 1826)	**Woodland clearance** (Northton, Evans 1971)	**Damp grassland and midden deposit** (Ensay, Spencer 1974 Table 16)	**Cultivation layer** (Hornish Point, Thew 2003); **Midden** (Allasdale, Chapter 6.5); **Wheelhouse** Cnip (listed dubiously as *Catinella arenaria* (Cerón-Carrasco 2006			**Damp meadow** (Northton, Evans 1965,32); Lewis, Harris, North Uist, Monach Isles, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Peringia ulvae (Pennant, 1777)						**Sands of a brackish water inlet** (Clachan, North Uist, Knowlton 1977, 94); Lewis, Harris, North Uist, South Uist, Barra (Waterston 1981)
Potamopyrgus antipodarum (J. E. Gray 1843)						Lewis, Harris, North Uist, Monach Isles, Benbecula, South Uist, Barra (Waterston 1981)
Punctum pygmaeum (Draparnaud, 1801)	**Woodland** (Northton, Evans 1971, 57); **Shaded habitat** (Northton, Chapter 6.2)	**Dry, short grassland** (Sligeanach, Evans *et al.*, 2012), **Grassland and midden deposit** (Ensay, Spencer 1974	**Midden** (Rosinish, Vaughan 1976, 49), **Cultivation layer** (Hornish Point, Thew 2003); **Wheelhouse**	**Midden** (Rosinish, Vaughan 1976, 49); **Ploughsoils** (Bornais, Chapter 6.9)	**Moist and shaded environment in a kiln** (Howmore, Smith 1994), **Grassland** (Udal, Spencer 1974, Table 17)	**Damp meadow** (Northton, Evans 1965,32), **damp dune** (Scarista, Evans 1965, 33); **grassland** (Cladh Hallan, Chapter 6.1); Harris, North Uist, Monach Isles, Benbecula, South

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
		Table 16); **Cremation deposit** (Allasdale, Chapter 6.4); **Midden and house floor** (Cladh Hallan, Chapter 6.4)	Cnip (Cerón-Carrasco 2006			Uist, Barra (Waterston 1981)

Pupilla muscorum (Linnaeus, 1758)	**Open country** (Northton, Evans 1971, 57)	**Open country** (Northton – Evans 2004, 370); **Short-turved, sheep-grazed grassland** (Sligeanach, Evans *et al.* 2012), **Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 40), **Midden and grave pit** (Baleshare, Thew 2003), **Within a Cist** (Allasdale, Chapter 6.5); **Midden and house floor**	**Open country, slow deposition** (Northton, Evans 1971, 54-55), **Midden** (Rosinish, Vaughan 1976, 49), **Cultivation layer and midden site deposit** (Hornish Point, Thew 2003); **Tall vegetation** (Horgabost, Chapter 6.6); **Wheelhouse fills and middens** (Cill Donnain, Chapter 6.8); **Blown sand** (Baile Sear, Chapter 6.7)	**Midden** (Rosinish, Vaughan 1976, 49); **Ploughsoils and middens** (Bornais, Chapter 6.9)	**Open country, short-turved grassland** (Howmore, Smith 1994, 135), **Grassland and midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	North Uist, (Waterston 1981)

		(Cladh Hallan, Chapter 6.4)				

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Radix balthica (Linnaeus, 1758)						St Kilda, Lewis, Harris, North Uist, Monach Isles, Benbecula, South Uist, Barra (Waterston 1981)
Stagnicola palustris (O. F. Müller, 1774)						North Uist, (Waterston 1981)
Trochulus hispidus (Linnaeus, 1758)						Lewis, Harris, North Uist, Benbecula, South Uist, Barra (Waterston 1981)

Trochulus striolatus (Pfeiffer, 1828)						**On dunes** (Pabbay, Elton 1938, 292); Lewis, North Uist, Barra (Waterston 1981)

Vallonia costata (O. F. Müller, 1774)	**Open country, stable** (Northton, Evans 1971, 54-55)	**Open country, rapid deposition** (Northton, Evans 1971, 54-55), **Woodland regeneration, stability** (Northton, Evans 1971, 54-55), **Arable land with fallow periods and tall herbage** (Sligeanach, Evans *et al.*, 2012)**;** **Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 40),	**Open country, slow deposition** (Northton, Evans 1971, 54-55), **Midden** (Rosinish, Vaughan 1976, 49), **Cultivation layer and midden site deposit** (Hornish Point, Thew 2003); **Tall vegetation** (Horgabost, Chapter 6.6); **Wheelhouse fills and middens** (Cill Donnain, Chapter 6.8); **Blown sand** (Baile Sear, Chapter 6.7)	**Midden** (Rosinish, Vaughan 1976, 49); **Ploughsoils and middens** (Bornais, Chapter 6.9)	**Open country, short-turved grassland** (Howmore, Smith 1994, 135), **Grassland and midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	Mingulay (Robinson *et al.* 2015); Harris, Barra, Mingulay (Waterston 1981)

		Cultivation layer, midden and grave pit (Baleshare, Thew 2003); **Midden and house floor** (Cladh Hallan, Chapter 6.4)				

Appendix 1: The non-marine molluscs of the Western Isles

Vallonia cf. excentrica Sterki, 1893	**Open grassland** (Northton, Evans 1971, 58)	**Dry, short grassland** (Sligeanach, Evans *et al.*, 2012), **Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 40), **Cultivation layer and midden** (Baleshare, Thew 2003), **Cremation deposit** (Allasdale, Chapter 6.5); **Midden and house floor** (Cladh Hallan, Chapter 6.4)	**Midden** (Rosinish, Vaughan 1976, 49), **Cultivation layer and midden site deposit** (Hornish Point, Thew 2003), **Floor** (Allasdale, Chapter 6.5); **Tall vegetation** (Horgabost, Chapter 6.6); **Wheelhouse fills and middens** (Cill Donnain, Chapter 6.8); **Blown sand** (Baile Sear, Chapter 6.7); **Wheelhouse** Cnip (Cerón-Carrasco 2006	**Midden** (Rosinish, Vaughan 1976, 49); **Ploughsoils and middens** (Bornais, Chapter 6.9)	**Grassland and midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	**Grassland** (Northton, Evans 1965, 32), **damp dune** (Scarista, Evans 1965, 33); **Dune and grassland** (Cladh Hallan, Chapter 6.1); Lewis, Harris, North Uist, Monach Isles, South Uist, Barra, Vatersay (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
Vallonia pulchella (O. F. Müller, 1774)		**Dry, short grassland** (Sligeanach, Evans *et al.*, 2012); **Midden and house floor** (Cladh Hallan, Chapter 6.4)				
Valvata piscinalis (O. F. Müller, 1774)						Lewis, Harris and South Uist (Waterston 1981)
Vertigo angustior Jeffreys, 1830		**Woodland regeneration** (Northton, Evans 1971); **House floor** (Cladh Hallan, Chapter 6.4), **Cremation deposit** (Allasdale, Chapter 6.5)				

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Vertigo antivertigo (Draparnaud, 1801)		**Midden** (Baleshare, Thew 2003)	**Wind blown sand and midden site deposit** (Hornish Point, Thew 2003); **Floor deposit** (Allasdale, Chapter 6.5)			**Loch margin** (Loch Hallan, Chapter 6.1); North Uist, South Uist, Barra (Waterston 1981)
Vertigo lilljeborgi (Westerlund, 1871)						North Uist, Barra (Waterston 1981)
Vertigo pusilla O. F. Müller, 1774	**Woodland** (Northton, Evans 1971, 57); **Shaded habitat** (Northton, Chapter 6.2)	**Grassland and midden deposit** (Ensay, Spencer 1974 Table 16); **Cremation deposit** (Allasdale, Chapter 6.5)				Harris (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
Vertigo pygmaea (Draparnaud, 1801)	**Open country, stable** (Northton, Evans 1971, 57)	**Dry, short grassland** (Sligeanach, Evans *et al.*, 2012) **Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 40), **Cremation deposit** (Allasdale, Chapter 6.5); **Midden and house floor** (Cladh Hallan, Chapter 6.4)	**Open country, slow deposition** (Northton, Evans 1971, 54-55), **Cultivation layer and midden site deposit** (Hornish Point, Thew 2003), **Midden** (Allasdale, Chapter 6.5); **Tall vegetation** (Horgabost, Chapter 6.6); **Wheelhouse fills and middens** (Cill Donnain, Chapter 6.8); **Blown sand** (Baile Sear, Chapter 6.7); **Wheelhouse**	**Midden** (Rosinish, Vaughan 1976, 49); **Ploughsoils** (Bornais, Chapter 6.9)	**Open country, short-turved grassland** (Howmore, Smith 1994, 135), **Grassland and midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	**Dune and grassland** (Cladh Hallan, Chapter 6.1); Harris, North Uist, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	Neolithic	Bronze Age/ Beaker	Iron Age	Norse	Post-medieval	Modern
			Cnip (Cerón-Carrasco 2006			

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Vertigo substriata (Jeffreys, 1833)	**Woodland** (Northton, Evans 1971, 57); **Shaded habitat** (Northton, Chapter 6.2); **Midden** (Cladh Hallan, Chapter 6.4)	**Organic material spread over ground surface** (Sligeanach, Evans *et al.* 2012), **Grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 40), **dump deposit** (Baleshare, Thew 2003); **House floor** (Cladh Hallan, Chapter 6.4)	**Cultivation layer and midden site deposit** (Hornish Point, Thew 2003); **Tall vegetation** (Horgabost, Chapter 6.6)	**Ploughsoils** (Bornais, Chapter 6.9)	**Grassland and midden** (Udal, Spencer 1974, Table 17); **Midden** (Newtonferry, Thew 2003)	St Kilda, Harris, North Uist, South Uist, Barra (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Vitrea contracta (Westerlund, 1871)	**Shaded habitat** (Northton, Chapter 6.2)	**House floor** (Cladh Hallan, Chapter 6.4)	**Wheelhouse fills** (Cill Donnain, Chapter 6.8)	**Grassland** (Bornais M2A, Chapter 6.9)		Mingulay (Robinson *et al.* 2015); Lewis, Harris, North Uist, South Uist, Barra, Mingulay (Waterston 1981)
Vitrea crystallina (O. F. Müller, 1774)						**Damp meadow** (Northton, Evans 1965,32); Mingulay (Robinson *et al.* 2015), St Kilda, Lewis, Harris, North Uist, Barra, Mingulay (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Vitrina pellucida (O. F. Müller, 1774)	**Damp hollows** (Northton, Evans 1971)	**Damp grassland and midden deposit** (Ensay, Spencer 1974 Table 16), **Stable grassland** (Rosinish, Vaughan 1976, 45), **Grassland** (Baleshare, Thew 2003); **Midden and house floor** (Cladh Hallan, Chapter 6.4)	**Cultivation layer** (Hornish Point, Thew 2003); **Tall vegetation** (Horgabost, Chapter 6.6); **Windblown sand** (Cill Donnain, Chapter 6.8)	**Grassland** (Bornais M2A, Chapter 6.9)	**Damp hollows** (Howmore, Smith 1994, 135), **Grassland and midden** (Udal, Spencer 1974, Table 17), **Midden** (Newtonferry, Thew 2003)	**Sand dunes – in damp hollows amongst damp herbage** (Harris, Evans 1965,30-31), **bare sand with grass** (Scarista, Evans 1965, 33), **damp dune** (Scarista, Evans 1965, 33) **Damp meadow** (Northton, Evans 1965,32); Mingulay (Robinson *et al.* 2015); St Kilda, Lewis, Harris, North Uist, Monach Isles, Benbecula, South Uist, Barra, Vatersay, Mingulay (Waterston 1981)

Appendix 1: The non-marine molluscs of the Western Isles

Species	**Neolithic**	**Bronze Age/ Beaker**	**Iron Age**	**Norse**	**Post-medieval**	**Modern**
Zenobiella subrufescans (J. S. Miller, 1822)						Harris (Waterston 1981)
Zonitoides excavatus (Alder, 1830)						South Uist, Barra (Waterston 1981)
Zonitoides nitidus (O. F. Müller, 1774)		**Midden** (Cladh Hallan, Chapter 6.4)	**Wind blown sand and midden site deposit** (Hornish Point, Thew 2003)	**Grassland** (Bornais M2A, Chapter 6.9)		Lewis (Waterston 1981)

APPENDIX 2: MOLLUSC TABLES FROM LARGER ASSEMBLAGES

APPENDIX 2.1: SNAILS FROM CLADH HALLAN

Appendix 2.1.1 Middens

Appendix 2.1.1: Snails from Cladh Hallan middens

	Sample Number	**4678**	**2467**	**3299**	**4105**	**3114**	**3296**	**4102**	**4200**	**2465**	**4676**	**4673**	**4672**	**4674**	**4072**	**4535**	**4081**	**4078**	**4537**	**4080**	**4077**	**4534**	**4082**	**4083**	**4075**	**4070**	**4079**	**4073**	**4071**	**4076**	**4536**
	Context Number	**412**	**1442**	**1999**	**473**	**1790**	**1975**	**471**	**518**	**1449**	**738**	**741**	**740**	**742**	**903**	**1055**	**924**	**922**	**1058**	**923**	**921**	**1054**	**926**	**928**	**908**	**901**	**931**	**904**	**902**	**913**	**1056**
Ecological Group																															
1a	*Nesovitrea hammonis*																			1									1		
	Oxychilus alliarius				3		1							2										1			2				
	Vitrina pellucida														1					1			1						10		
1c	*Discus rotundatus*				1		1														1										
	Euconulus alderi																	1													
	Lauria cylindracea						1							1	1			1			39			1				2	1		
	Leiostyla anglica																								1			1			

Appendix 2.1.1: Snails from Cladh Hallan middens

	Sample Number	**4678**	**2467**	**3299**	**4105**	**3114**	**3296**	**4102**	**4200**	**2465**	**4676**	**4673**	**4672**	**4674**	**4072**	**4535**	**4081**	**4078**	**4537**	**4080**	**4077**	**4534**	**4082**	**4083**	**4075**	**4070**	**4079**	**4073**	**4071**	**4076**	**4536**
	Context Number	**412**	**1442**	**1999**	**473**	**1790**	**1975**	**471**	**518**	**1449**	**738**	**741**	**740**	**742**	**903**	**1055**	**924**	**922**	**1058**	**923**	**921**	**1054**	**926**	**928**	**908**	**901**	**931**	**904**	**902**	**913**	**1056**
Ecological Group																															
	Punctum pygmaeum																	1			2										
	Vertigo substriata						1											1			5			1							
3	*Cepaea hortensis*									1										1											
	Cochlicopa lubrica	1	1		4						41		2	12	2			8		8	77			10	3	21	10	4	23	1	
	Cochlicopa lubricella	1			1					1	18		1	5		1		1			61			1		5		2	2		1
4	*Pupilla muscorum*		1	1	2	1	1	1			4		1			4	3	20	1	14	125	3	16	20	27		9	21	32	85	
	Vallonia costata	1			1			1			1		1	16		1		1			17	1					1	1		5	

Appendix 2.1.1: Snails from Cladh Hallan middens

	Sample Number	**4678**	**2467**	**3299**	**4105**	**3114**	**3296**	**4102**	**4200**	**2465**	**4676**	**4673**	**4672**	**4674**	**4072**	**4535**	**4081**	**4078**	**4537**	**4080**	**4077**	**4534**	**4082**	**4083**	**4075**	**4070**	**4079**	**4073**	**4071**	**4076**	**4536**
	Context Number	**412**	**1442**	**1999**	**473**	**1790**	**1975**	**471**	**518**	**1449**	**738**	**741**	**740**	**742**	**903**	**1055**	**924**	**922**	**1058**	**923**	**921**	**1054**	**926**	**928**	**908**	**901**	**931**	**904**	**902**	**913**	**1056**
Ecological Group																															
	Vallonia cf excentrica	1		2	8		4	1		1	18	1	6	69	3	3		19		2	220	5	2	6	5		2	3	5	5	
	Vallonia pulchella													1																	
	Vertigo pygmaea	1								1							1	1		1	24		1	2	1		2	1	1	5	
	Cochlicella acuta											1	2		2		1			9	1				6		2	9			
	Helicella itala			1	1								2						1						1		1				
5a	*Galba truncatula*	1						1															1					6			
5b	*Zonitoides nitidus*												1																		

Appendix 2.1.1: Snails from Cladh Hallan middens

	Sample Number	**4678**	**2467**	**3299**	**4105**	**3114**	**3296**	**4102**	**4200**	**2465**	**4676**	**4673**	**4672**	**4674**	**4072**	**4535**	**4081**	**4078**	**4537**	**4080**	**4077**	**4534**	**4082**	**4083**	**4075**	**4070**	**4079**	**4073**	**4071**	**4076**	**4536**	
	Context Number	**412**	**1442**	**1999**	**473**	**1790**	**1975**	**471**	**518**	**1449**	**738**	**741**	**740**	**742**	**903**	**1055**	**924**	**922**	**1058**	**923**	**921**	**1054**	**926**	**928**	**908**	**901**	**931**	**904**	**902**	**913**	**1056**	
Ecological Group	**Total**	**6**	**2**	**4**	**21**	**1**	**9**	**4**	**0**	**4**	**82**	**2**	**16**	**106**	**9**	**9**	**5**	**54**	**2**	**37**	**572**	**9**	**21**	**42**	**44**	**26**	**29**	**50**	**75**	**101**	**1**	
	Taxa S	6	2	3	8	1	6	4	0	4	5	2	8	7	5	4	3	10	2	8	11	3	5	8	7	2	8	10	8	5	1	
	Seaweed snails			*	*	*			*		*				*			*					*				*	*	*			**1343**
	Littorina saxatalis					1																										24
	Rissoa parva								2																							

Appendix.2.1.2: House 1370 Floor

Appendix 2.1.2 – Snails from Cladh Hallan House 1370 floor

	Sample Number	**3728**	**3743**	**3745**	**3747**	**3750**	**3756**	**3758**	**3762**	**3764**	**3770**	**3968**	**3969**	**3981**	**3985**	**3999**	**4006**	**4016**	**4026**	**4032**	**4034**	**4043**	**4044**	**4052**	**4078**	**4082**	**4089**	**4090**	**4099**
	Context Number	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**
Ecological Group																													
1a	*Oxychilus alliarius*															1						1							
1d	*Clausilia bidentata*																									1			
	Lauria cylindracea	1													2														
3	*Cochlicopa lubrica*					1	1				1				2							1	1				1	1	1
	Cochlicopa lubricella					1		1		1																			
4	*Pupilla muscorum*		1	7		3	3	14	15		1	1	3	2	2		1	1	1	2		1	2		1			1	1
	Vallonia costata							1	1																				
	Vallonia cf excentrica			2		2		3	1		1				2										1	1			

Appendix 2.1.2 – Snails from Cladh Hallan House 1370 floor

	Sample Number	**3728**	**3743**	**3745**	**3747**	**3750**	**3756**	**3758**	**3762**	**3764**	**3770**	**3968**	**3969**	**3981**	**3985**	**3999**	**4006**	**4016**	**4026**	**4032**	**4034**	**4043**	**4044**	**4052**	**4078**	**4082**	**4089**	**4090**	**4099**
	Context Number	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**	**2211**
	Vallonia pulchella																												
	Vertigo pygmaea														3									1		3			
	Cochlicella acuta														1														
5a	*Galba truncatula*				1																					2			
	Total	**1**	**1**	**9**	**1**	**7**	**4**	**19**	**17**	**1**	**3**	**1**	**3**	**2**	**12**	**1**	**1**	**1**	**1**	**2**	**0**	**2**	**3**	**1**	**2**	**7**	**1**	**2**	**2**
	Taxa s	1	1	2	1	4	2	4	3	1	3	1	1	1	6	1	1	1	1	1	0	3	2	1	2	4	1	2	2
Seaweed snails	Seaweed snails																											*	
	Risssoa ?parva								2						1						1								

Appendix 2.1.3: House 401 Floors

Appendix 2.1.3 – Snails from Cladh Hallan House 401 floors

	Sample Number	**2925**	**2925**	**2932**	**2971**	**2973**	**2989**	**3001**	**3006**	**3013**	**3015**	**3030**	**3043**	**3048**	**3049**	**3051**	**3079**	**3059**	**3061**	**3063**	**3066**	**3068**	**3078**	**3079**	**3085**	**3089**	**3099**	**3100**	**3102**	**3105**	**3107**	**3129**	**3135**	**3231**	**3241**	**3245**
	Context Number	**1311**	**1698**	**1698**	**1624**	**1624**	**1624**	**1690**	**1311**	**1690**	**1690**	**1311**	**1311**	**1704**	**1705**	**1705**	**1311**		**1311**	**1311**	**1705**	**1765**	**1706**	**1311**	**1311**	**1705**	**1775**	**1311**	**1704**	**1704**	**1311**	**1311**	**1311**	**1311**	**1311**	**1311**
Ecological Group																																				
1a	*Aegopinella pura*										1																									
	Nesovitrea hammonis															1									1		1								1	
	Oxychilus alliarius					1				1					1		3			17			4	2	3	8	3	3		3	6	2	15	2		
	Vitrea contracta										1	1	1			1				2														1		
	Vitrina pellucida																																3			
1b	*Carychium tridentatum*																																2			

Appendix 2.1.3 – Snails from Cladh Hallan House 401 floors

	Sample Number	**2925**	**2925**	**2932**	**2971**	**2973**	**2989**	**3001**	**3006**	**3013**	**3015**	**3030**	**3043**	**3048**	**3049**	**3051**	**3079**	**3059**	**3061**	**3063**	**3066**	**3068**	**3078**	**3079**	**3085**	**3089**	**3099**	**3100**	**3102**	**3105**	**3107**	**3129**	**3135**	**3231**	**3241**	**3245**
	Context Number	**1311**	**1698**	**1698**	**1624**	**1624**	**1624**	**1690**	**1311**	**1690**	**1690**	**1311**	**1311**	**1704**	**1705**	**1705**	**1311**		**1311**	**1311**	**1705**	**1765**	**1706**	**1311**	**1311**	**1705**	**1775**	**1311**	**1704**	**1704**	**1311**	**1311**	**1311**	**1311**	**1311**	**1311**
1c	*Discus rotundatus*										4														1											
1d	*Clausilia bidentata*									1	3																								1	
	Lauria cylindracea						1		1		1				2					9				3	1			1			3		2			
	Punctum pygmaeum																																1			
3	*Cepaea hortensis*				1					1		1					1		1	1	1			5		3		5								3
	Cochlicopa lubrica				1				1	2	4			1	3	1	2	6	1	9		1	6	1	3	4	2	2			9	1	19		2	3
	Cochlicopa lubricella											1			1				1	14		1	1	4				1			2		9			

Appendix 2.1.3 – Snails from Cladh Hallan House 401 floors

	Sample Number	**2925**	**2925**	**2932**	**2971**	**2973**	**2989**	**3001**	**3006**	**3013**	**3015**	**3030**	**3043**	**3048**	**3049**	**3051**	**3079**	**3059**	**3061**	**3063**	**3066**	**3068**	**3078**	**3079**	**3085**	**3089**	**3099**	**3100**	**3102**	**3105**	**3107**	**3129**	**3135**	**3231**	**3241**	**3245**
	Context Number	**1311**	**1698**	**1698**	**1624**	**1624**	**1624**	**1690**	**1311**	**1690**	**1690**	**1311**	**1311**	**1704**	**1705**	**1705**	**1311**		**1311**	**1311**	**1705**	**1765**	**1706**	**1311**	**1311**	**1705**	**1775**	**1311**	**1704**	**1704**	**1311**	**1311**	**1311**	**1311**	**1311**	**1311**
4	*Pupilla muscorum*	1	1		2			1	1	5	10		3	12	47	23	19	19		105		10	2	189	25	12	6	50			2	25	99	4	14	23
	Vallonia costata				1				1						2	1		2		2				3	1			4			2		18	2	1	
	Vallonia cf excentrica										2		2	3		1	2	3	2	2			1	10	2	2	1	10	1	2		1	47	12	1	2
	Vertigo pygmaea													1				1						1			2	2					7			3
	Cochlicella acuta		1						2				1																				2			
	Helicella itala											1																								
5a	*Galba truncatula*										1															1							2		1	1
5b	*Vertigo*																																1			

Appendix 2.1.3 – Snails from Cladh Hallan House 401 floors

	Sample Number	**2925**	**2925**	**2932**	**2971**	**2973**	**2989**	**3001**	**3006**	**3013**	**3015**	**3030**	**3043**	**3048**	**3049**	**3051**	**3079**	**3059**	**3061**	**3063**	**3066**	**3068**	**3078**	**3079**	**3085**	**3089**	**3099**	**3100**	**3102**	**3105**	**3107**	**3129**	**3135**	**3231**	**3241**	**3245**
	Context Number	**1311**	**1698**	**1698**	**1624**	**1624**	**1624**	**1690**	**1311**	**1690**	**1690**	**1311**	**1311**	**1704**	**1705**	**1705**	**1311**		**1311**	**1311**	**1705**	**1765**	**1706**	**1311**	**1311**	**1705**	**1775**	**1311**	**1704**	**1704**	**1311**	**1311**	**1311**	**1311**	**1311**	**1311**
	antivertigo																																			
	Total	**1**	**2**	**0**	**5**	**1**	**1**	**1**	**6**	**10**	**27**	**4**	**7**	**17**	**56**	**28**	**27**	**31**	**5**	**161**	**1**	**12**	**14**	**218**	**37**	**30**	**15**	**78**	**1**	**5**	**24**	**29**	**226**	**21**	**21**	**35**
	Taxa S	1	2	0	4	1	1	1	5	5	9	4	4	4	6	6	5	5	4	9	1	3	5	9	8	6	6	9	1	2	6	4	14	5	7	6
Seaweed snails	*Littorina saxatalis*			1							4	1		2	3			1		4					3	2	1					1	2			
	Rissoa ?parva									1				3	2		1	1	1	2					3			1			1				6	1
	?seaweed snail																			1						1	1								1	
Marine worm	Spirorbis																																1			

APPENDIX 2.2: SNAILS FROM CILL DONNAIN

Appendix 2.2 – Snails from Cill Donnain

		Context	1	2	4	4	6	6	7	8	12	15
		Square	69	46	15	16	15	16	16	15	85	58
		Sample	19	6	7	15	5	9	13	8	19	16
		Context Description	Midden	Windblown sand	Wheelhouse fills	Wheelhouse fills	Wheelhouse wall core	Wheelhouse wall core	Windblown sand	Fill outside house	Peat ash lens	Midden layer
GROUP	***TAXON***	**Period**	LIA (210-400 cal AD)	Late MIA-LIA	Late MIA-Early LIA	Late MIA-Early LIA	Late MIA-Early LIA	Late MIA-Early LIA	Late MIA-LIA	Late MIA	Late MIA-LIA	LIA (570-660 cal AD)
1a	*Aegopinella nitidula*				6	8	10			1		2
	Nesovitrea hammonis								2			
	Oxychilus alliarius		1	1	31	25		9	4	4	2	5
	Vitrea contracta				6	4					1	
	Vitrina pellucida			1								
1d	*Clausilia bidentata*					1						
	Lauria cylindracea				20	16	4	8	5	7	8	3
3	*Cochlicopa lubrica*		2	67	10	20	13	9	6	23	13	10
4	*Pupilla muscorum*		3	33	13	14	25	16	7	23	11	19
	Vallonia costata		3	21	18	25	13	6	5	15	11	9
	Vallonia excentrica		7	102	18	26	10	9	13	20	12	22

Appendix 2.2 – Snails from Cill Donnain

		Context	1	2	4	4	6	6	7	8	12	15
		Square	69	46	15	16	15	16	16	15	85	58
		Sample	19	6	7	15	5	9	13	8	19	16
		Context Description	Midden	Windblown sand	Wheelhouse fills	Wheelhouse fills	Wheelhouse wall core	Wheelhouse wall core	Windblown sand	Fill outside house	Peat ash lens	Midden layer
GROUP	***TAXON***	**Period**	LIA (210-400 cal AD)	Late MIA-LIA	Late MIA-Early LIA	Late MIA-Early LIA	Late MIA-Early LIA	Late MIA-Early LIA	Late MIA-LIA	Late MIA	Late MIA-LIA	LIA (570-660 cal AD)
	Vertigo pygmaea			10	2	1	1				1	3
	Cochlicella acuta		180	14	1	5	2	6	2	2	48	20
	Helicella itala		10	77	33	46	18	33	13	27	29	36
5a	*Galba truncatula*											1
6a	*Anisus leucostoma*					1						
	Total		206	326	158	192	96	96	57	122	136	130
	Taxa s		7	9	11	13	9	8	9	9	10	11
	MARINE SNAILS											
	Rissoa parva			3	6		4	4		6	1	1

APPENDIX 2.3: SNAILS FROM BORNAIS

Appendix 2.3.1: Unit GAA (Ploughsoils)

Appendix 2.3.1: Snails from Bornais Block GAA

Context		**1192**	**1195**	**1196**	**1199**	**1605**	**1626**	**969**	**990**	**1617**	**1125**	**1146**	**1789**	**1791**	**1790**	**1795**
Sample		**7020**	**7028**	**7030**	**7038**	**7044**	**7157**	**9253**	**9263**	**7094**	**9275**	**9302**	**10704**	**10720**	**10728**	**10803**
Sample size (litres)		41	40	26	38	51	34	22	26	32	21	22	26	41	10	38
Group	**Species**															
1a	*Aegopinella nitidula*				1											
	Nesovitrea hammonis					1							2			
	Oxychilus alliarius	2	2		1		1			2			1		1	
1d	*Clausilia bidentata*					4							1			
	Lauria cylindracea									3						
	Punctum pygmaeum							1								
	Vertigo substriata			1												
3	*Arianta arbustorum*	1														
	Cochlicopa lubrica		2	2	3					2		1	30	2		
	Cochlicopa lubricella			1		4				4		2	6			
4	*Pupilla muscorum*	5	13	2	7	7		2	1	19		8		3		1
	Vallonia costata		6	4	7	7	2	1	2	6	1	5			3	1

Appendix 2.3.1: Snails from Bornais Block GAA

Context		**1192**	**1195**	**1196**	**1199**	**1605**	**1626**	**969**	**990**	**1617**	**1125**	**1146**	**1789**	**1791**	**1790**	**1795**
Sample		**7020**	**7028**	**7030**	**7038**	**7044**	**7157**	**9253**	**9263**	**7094**	**9275**	**9302**	**10704**	**10720**	**10728**	**10803**
Sample size (litres)		41	40	26	38	51	34	22	26	32	21	22	26	41	10	38
Group	**Species**															
	Vallonia excentrica	6	13	5	5	15		1	2	8	1	4	5	6	3	3
	Vertigo pygmaea		1	1	2					1						
	Cochlicella acuta	339	53	13	9	8	1	4	1	41	3		322	11	1	5
	Helicella itala	5	10	5		8	5	5	2	12	3	1	2	2		
Total		**358**	**100**	**34**	**35**	**54**	**9**	**14**	**8**	**98**	**8**	**21**	**369**	**24**	**8**	**10**
Taxa s		**6**	**8**	**9**	**8**	**8**	**4**	**6**	**5**	**10**	**4**	**6**	**8**	**5**	**4**	**4**
Marine snails	*Peringia ulvae*				3					4						1
	Rissoa parva		7	3		3	1									
Marine worm	*Spirorbis* sp.				2											
Notes				1 burnt *Cochlicella*	1 recent *Cochlicella*								2 recent *C. lubrica*			

Appendix 2.3.2: Unit GAD

Appendix 2.3.2: Snails from Bornais Block GAD

Context		**954**	**1625**	**896**	**1611**	**2305**	**1747**	**1747**	**1714**	**960**	**1707**	**979**	**2328**	**1729**	**2353**	**2330**
Sample		**9228**	**7155**	**9221**	**7072**	**11005**	**11022**	**10223**	**7760**	**9212**	**7752**	**9238**	**11024**	**7926**	**11046**	**11026**
Sample size (litres)		41	38	15	38	14	22	35	41	15	33	23	23	32	28	13
Ecological Group	**Species**															
1a	*Nesovitrea hammonis*								1							2
	Oxychilus alliarius		1	2	3	5		1	2	1	2		1	5		
	Vitrea contracta			3		1	1						1			
	Vitrina pellucida		4								1					1
1b	*Carychium tridentatum*			2			1		1							
1d	*Clausilia bidentata*										1					
	Euconulus fulvus			2												
	Lauria cylindracea			3			1	6	2							
	Punctum pygmaeum		1					1								
3	*Cochlicopa lubrica*	7	44	8	3	3		4	6		16				19	5
	Cochlicopa lubricella	4	63	1			1	2	2	1	1			1	2	4
4	*Pupilla muscorum*	4	2	25	6		2	31	28		2	1	3	5		
	Vallonia costata	1		24	12	1	4	17	23	1	2		2	3		
	Vallonia excentrica	6	6	29	21	2	11	24	15	2	2	1	3	3	6	1
	Vertigo pygmaea			3	1		2	2	4			1				
	Cochlicella acuta	503	738	40	182	174	19	48	45	15	126	363	67	38	286	20
	Helicella itala	3	4	27	14	4	3	18	15	3	4	7	3	5	1	
5a	*Galba truncatula*			1	1			2	1							

Appendix 2.3.2: Snails from Bornais Block GAD

Context		**954**	**1625**	**896**	**1611**	**2305**	**1747**	**1747**	**1714**	**960**	**1707**	**979**	**2328**	**1729**	**2353**	**2330**
Sample		**9228**	**7155**	**9221**	**7072**	**11005**	**11022**	**10223**	**7760**	**9212**	**7752**	**9238**	**11024**	**7926**	**11046**	**11026**
Sample size (litres)		41	38	15	38	14	22	35	41	15	33	23	23	32	28	13
Ecological Group	**Species**															
5b	*Zonitoides nitidus*		1													
Total		**528**	**859**	**163**	**240**	**184**	**43**	**155**	**141**	**22**	**154**	**373**	**78**	**55**	**314**	**30**
Number of species		**7**	**10**	**14**	**9**	**7**	**10**	**12**	**13**	**6**	**10**	**5**	**7**	**7**	**5**	**6**
Marine snails	*Peringia ulvae*						1						9			
	Rissoa parva	2	1	10	8			6	5	2				3		1
Notes		1 recent *C. lubrica*	1 recent *Cochlicella*			1 burnt *Cochlicella*										

Appendix 2.3.3: Unit GDC

Appendix 2.3.3: Snails from Bornais Block GDC

Context		**1691**	**1688**	**1637**	**1664**	**899**	**1624**	**862**	**796**	**790**	**779**	**1619**	**1615**	**1608**
Sample		**7907**	**7605**	**7196**	**7269**	**9214**	**7153**	**9197**	**9193**	**9190**	**9211**	**7113**	**7093**	**7070**
Sample size (litres)		35	30	38	19	20	35	20	26	28	18	29	26	38
Ecological Group	**Species**													
1a	*Nesovitrea hammonis*	1												
	Oxychilus alliarius			2							1		1	
1d	*Lauria cylindracea*		1											
3	*Cochlicopa lubrica*		4	2		4	2		1	3		3		6
	Cochlicopa lubricella									1		2		
4	*Pupilla muscorum*					1						1		1
	Vallonia costata										1			
	Vallonia excentrica	2		2		3	2		1	1		1		1
	Cochlicella acuta	28	24	19	2	92	19	1	10	23		37	1	75
	Helicella itala	1	1	5		2	2			2		5	1	7
5a	*Galba truncatula*								3					
	Total	**31**	**29**	**28**	**2**	**102**	**25**	**1**	**15**	**30**	**1**	**49**	**2**	**90**
	Number of species	**4**	**4**	**5**	**1**	**5**	**4**	**1**	**3**	**5**	**2**	**6**	**3**	**5**
Marine snails	*Littorina saxatalis* agg.		1							1				
	Rissoa parva	2	1			2			2					2
	Lacuna vincta				1									
	Peringia ulvae											1		

Appendix 2.3.3: Snails from Bornais Block GDC

	Bivalve frag. indet.												1	

Appendix 2.3.4: House floors

Appendix 2.3.4: Snails from Bornais House Floors

Context		**1514**	**1378**
Sample		**7602**	**7735**
Context description		**House 1 Floor**	**House 3 Late Occupation**
Stratigraphic unit		**BBC**	**BED**
Sample size (litres)		6	6
Ecological Group	**Species**		
1d	*Lauria cylindracea*	1	
3	*Cochlicopa lubrica*		3
	Cochlicopa lubricella	3	
4	*Pupilla muscorum*	1	
	Vallonia costata		3
	Cochlicella acuta	2	19
	Helicella itala	1	2
5a	*Galba truncatula*		10
	Total	**7**	**37**
	Number of species	**4**	**5**

APPENDIX 2.4: MARINE SHELL FROM ALLASDALE

Appendix 2.4: Marine Shell from Allasdale

	Context Number	124	125	201	203	212	214	216	217	228	243	255	255	301 Quad B	308	401	408	410	422
	Sample Number	2	9		16	4	6	7			8	Found with SF 11		29			14	13	
	Sample Volume (L.)	16	8		10	2	8	3			Not given			0.75			6	4	
	Context description	Upper fill of cist grave	Lower fill of cist grave	Wind-blown sand	Deposit	Possible cremation deposit within cist	Upper floor surface within roundhouse	Possible peat and sand floor surface	Cultivation layer	Post-abandonment fill	Deliberate backfill	?Topsoil formation during abandonment	?Topsoil formation during abandonment	Cremation deposit	Pit fill	Topsoil and wind-blown sand	Midden	Midden	Midden
	Provisional date	Early Bronze Age	Early Bronze Age		Bronze Age	Early Bronze Age	Early Iron Age	Early Iron Age		?Late Iron Age		?Late Bronze Age	?Late Bronze Age	Early Bronze Age			Late Iron Age	Late Iron age	Late Iron Age
TAXON																			
GASTROPODA																			
Patella spp. (Limpets)		5	3	2		3	7	1	1	1	5	2		1			30	27	
Littorina littorea (Linnaeus,			2	1	1		2	2			2						24	5	

Appendix 2.4: Marine Shell from Allasdale

	Context Number	124	125	201	203	212	214	216	217	228	243	255	255	301 Quad B	308	401	408	410	422
	Sample Number	2	9		16	4	6	7			8	Found with SF 11		29			14	13	
	Sample Volume (L.)	16	8		10	2	8	3			Not given			0.75			6	4	
	Context description	Upper fill of cist grave	Lower fill of cist grave	Wind-blown sand	Deposit	Possible cremation deposit within cist	Upper floor surface within roundhouse	Possible peat and sand floor surface	Cultivation layer	Post-abandonment fill	Deliberate backfill	?Topsoil formation during abandonment	?Topsoil formation during abandonment	Cremation deposit	Pit fill	Topsoil and wind-blown sand	Midden	Midden	Midden
	Provisional date	Early Bronze Age	Early Bronze Age		Bronze Age	Early Bronze Age	Early Iron Age	Early Iron Age		?Late Iron Age		?Late Bronze Age	?Late Bronze Age	Early Bronze Age			Late Iron Age	Late Iron age	Late Iron Age
1758)(Periwinkles)																			
Trivia arctica (Pulteney, 1799)(Northern cowrie)				2															
BIVALVIA																			

Appendix 2.4: Marine Shell from Allasdale

	Context Number	124	125	201	203	212	214	216	217	228	243	255	255	301 Quad B	308	401	408	410	422
	Sample Number	2	9		16	4	6	7			8	Found with SF 11		29			14	13	
	Sample Volume (L.)	16	8		10	2	8	3			Not given			0.75			6	4	
	Context description	Upper fill of cist grave	Lower fill of cist grave	Wind-blown sand	Deposit	Possible cremation deposit within cist	Upper floor surface within roundhouse	Possible peat and sand floor surface	Cultivation layer	Post-abandonment fill	Deliberate backfill	?Topsoil formation during abandonment	?Topsoil formation during abandonment	Cremation deposit	Pit fill	Topsoil and wind-blown sand	Midden	Midden	Midden
	Provisional date	Early Bronze Age	Early Bronze Age		Bronze Age	Early Bronze Age	Early Iron Age	Early Iron Age		?Late Iron Age		?Late Bronze Age	?Late Bronze Age	Early Bronze Age			Late Iron Age	Late Iron age	Late Iron Age
Pecten maximus (Linnaeus, 1758) (Great scallop)									1				1						
Solenidae sp. (Razor clam)									1				1			1			1

Appendix 2.4: Marine Shell from Allasdale

	Context Number	124	125	201	203	212	214	216	217	228	243	255	255	301 Quad B	308	401	408	410	422
	Sample Number	2	9		16	4	6	7			8	Found with SF 11		29			14	13	
	Sample Volume (L.)	16	8		10	2	8	3			Not given			0.75			6	4	
	Context description	Upper fill of cist grave	Lower fill of cist grave	Wind-blown sand	Deposit	Possible cremation deposit within cist	Upper floor surface within roundhouse	Possible peat and sand floor surface	Cultivation layer	Post-abandonment fill	Deliberate backfill	?Topsoil formation during abandonment	?Topsoil formation during abandonment	Cremation deposit	Pit fill	Topsoil and wind-blown sand	Midden	Midden	Midden
	Provisional date	Early Bronze Age	Early Bronze Age		Bronze Age	Early Bronze Age	Early Iron Age	Early Iron Age		?Late Iron Age		?Late Bronze Age	?Late Bronze Age	Early Bronze Age			Late Iron Age	Late Iron age	Late Iron Age
?Cerastoderma sp (Cockle)															1				

APPENDIX 2.5: MARINE SHELL FROM MOUND 2, BORNAIS (TOTALS PER BLOCK)

Appendix 2.5.1: Blocks AD-BDJ

Appendix 2.5.1: Marine Shell from Bornais Mound 2, Blocks AD - BDJ

TAXON	AD	AE	AG	BAB	BAC	BAD	BAE	BAF	BBA	BBB	BBC	BBD	BBE	BCA	BCB	BCC	BDA	BDB	BDC	BDD	BDE	BDF	BDG	BDH	BDI	BDJ								
Patella vulgata (Linnaeus, 1758) Common limpet	678	346	50	127	87	3	6	494	43	205	482	529	1	1202	1207	6218	147	12	12	18	288	513	75	78	534	21								
Littorina littorea (Linnaeus, 1758). Common periwinkle	693	725	568	7	25	3	13	3306	66	122	636	800	2	2086	1075	12022	304	20	14	24	415	124	714	77	920	164								
Littorina obtusata (Linnaeus, 1758). Flat periwinkle								24		1		1		17	9	97	2				1	5			14	8								
Littorina saxatalis (Olivi, 1792). Rough periwinkle										1		6		2	1	43									1									

Appendix 2.5.1: Marine Shell from Bornais Mound 2, Blocks AD - BDJ

Buccinum undatum Linnaeus, 1758. Common whelk													2		8						1													
Gibbula umbilicalis (da Costa, 1778). Flat top shell									3				3		10																			
Gibbula cineraria (Linnaeus, 1758). Grey top shell							1						2	1																				
Nucella lapillus (Linnaeus, 1758). Dog whelk							13				1		3	2	18	1																		
Cerastoderma edule (Linnaeus, 1758). Common cockle					1						2		4	1	7					1														

Appendix 2.5.1: Marine Shell from Bornais Mound 2, Blocks AD - BDJ

Mytilus edulis Linnaeus, 1758. Common mussel									1	2	1	4		10		54	1	1	1						5	1								
?Mytilus galloprovincalis														1																				
Mytilus sp.								2			1			5	3	36									1									
Pecten maximus (Linnaeus, 1758).Great scallop								1			1			2	1	13																		
Ensis sp. Razor clams																2																		
Lutraria lutraria (Linnaeus, 1758). Common otter shell																1																		
Bivalve indet.														1																				

Appendix 2.5.2: Blocks BEA – IB and Total

Appendix 2.5.3: Marine Shell from Bornais Mound 2, Blocks BEA – IB and Totals

TAXON	BEA	BEB	BEC	BED	BEE	BEF	BEG	BEH	BEI	BFA	BFB	BFC	BFD	BFE	BGA	BHA	HB	HC	HD	HE	HF	HG	HH	IA	IB	TOTAL
Patella vulgata (Linnaeus, 1758) Common limpet	96	93	1434	55	1354	355	153	45	233	46	384	6	11	592	14	5	9	72	639	104	39	41	379	30	29	19594
Littorina littorea (Linnaeus, 1758). Common periwinkle	176	418	11753	257	7912	948	246	347	274	148	453	3	23	3194	40	19	80	100	1365	88	54	58	416	32	102	53431
Littorina obtusata (Linnaeus, 1758). Flat periwinkle	2		29		39	22	7	2	3		3			24				2	1	1			1			315
Littorina saxatalis (Olivi, 1792). Rough periwinkle			1		19	1					23															98

Appendix 2.5.3: Marine Shell from Bornais Mound 2, Blocks BEA – IB and Totals

TAXON	BEA	BEB	BEC	BED	BEE	BEF	BEG	BEH	BEI	BFA	BFB	BFC	BFD	BFE	BGA	BHA	HB	HC	HD	HE	HF	HG	HH	IA	IB	TOTAL
Buccinum undatum Linnaeus, 1758. Common whelk			1		4	2	1																1			20
Gibbula umbilicalis (da Costa, 1778). Flat top shell					3	2																				21
Gibbula cineraria (Linnaeus, 1758). Grey top shell					2																					6
Nucella lapillus (Linnaeus, 1758). Dog whelk			5		6	2					4			1					1							57

Appendix 2.5.3: Marine Shell from Bornais Mound 2, Blocks BEA – IB and Totals

TAXON	BEA	BEB	BEC	BED	BEE	BEF	BEG	BEH	BEI	BFA	BFB	BFC	BFD	BFE	BGA	BHA	HB	HC	HD	HE	HF	HG	HH	IA	IB	TOTAL
Cerastoderma edule (Linnaeus, 1758). Common cockle			3		2														1							22
Mytilus edulis Linnaeus, 1758. Common mussel			8		26	6	2	1	1		2			1				1	1	2			1			133
?Mytilus galloprovincalis														1												2
Mytilus sp.		1	1		4	2	4					1											1			62
Pecten maximus (Linnaeus, 1758).Great scallop			5		5	2																				30
Ensis sp. Razor clams					1																					3

Appendix 2.5.3: Marine Shell from Bornais Mound 2, Blocks BEA – IB and Totals

TAXON	BEA	BEB	BEC	BED	BEE	BEF	BEG	BEH	BEI	BFA	BFB	BFC	BFD	BFE	BGA	BHA	HB	HC	HD	HE	HF	HG	HH	IA	IB	TOTAL
Lutraria lutraria (Linnaeus, 1758). Common otter shell																										1
Bivalve indet.														1												2

APPENDIX 2.6: MARINE SHELL FROM BORNAIS MOUND 2A BY BLOCK

Appendix 2.6: Marine Shell from Bornais Mound 2A

	GAA	GAB	GAC	GAD	GBA	GBC	GBD	GBE	GBF	GBG	GCA	GCB	GCD	GCE	GCF	GDA	GDB	GDC	GEA	GEC	GED	GEE	GEF	GFA	GFB	GGA	GGB	GGC	TOTALS
Patella vulgata (Linnaeus, 1758) Common limpet	1375	8	18	630	14	37	13	33	398	3250	173	204	205	103	315	975	48	707	95	276	1	39	3	48	33	15	10	18	9044
Littorina littorea (Linnaeus, 1758). Common periwinkle	1021	10	20	584	20	28	16	26	1200	2050	809	858	1538	139	872	2531	338	2417	125	742		100	12	340	86	6	3	28	15919
Littorina obtusata (Linnaeus, 1758). Flat periwinkle	1	1		3	1				25	25	12	7	1	5	2	19	3	10				1		3	2		2		123
Littorina fabalis (Turton, 1835). Flat periwinkle	1									2			4		17	2	6	2											34
Littorina saxatalis (Olivi, 1792). Rough periwinkle	1									1	1																		3
Buccinum undatum Linnaeus, 1758. Common whelk	2			1					1	1	1							1						1					8

Appendix 2.6: Marine Shell from Bornais Mound 2A

	GAA	GAB	GAC	GAD	GBA	GBC	GBD	GBE	GBF	GBG	GCA	GCB	GCD	GCE	GCF	GDA	GDB	GDC	GEA	GEC	GED	GEE	GEF	GFA	GFB	GGA	GGB	GGC	TOTALS
Gibbula umbilicalis (da Costa, 1778). Flat top shell										2		3																	5
Gibbula cineraria (Linnaeus, 1758). Grey top shell	1								2	1	1							1											6
Nucella lapillus (Linnaeus, 1758). Dog whelk									3	5					4	3		2											17
Cerastoderma edule (Linnaeus, 1758). Common cockle				1					1	1					2														5
Mytilus edulis Linnaeus, 1758. Common mussel	36		1	5	1					1			2	1		1		2	1	2		1	3		1				58
Mytilus sp.	8	2		2	1			1	2	3	3		14	4		3	1	2											46

Appendix 2.6: Marine Shell from Bornais Mound 2A

	GAA	GAB	GAC	GAD	GBA	GBC	GBD	GBE	GBF	GBG	GCA	GCB	GCD	GCE	GCF	GDA	GDB	GDC	GEA	GEC	GED	GEE	GEF	GFA	GFB	GGA	GGB	GGC	TOTALS
Pecten maximus (Linnaeus, 1758).Great scallop	6			2											1	1								1					11
Ensis sp. Razor clams	33										1					1													35
Ostrea edulis Linnaeus, 1758. Flat oyster	4			2						1	1			1		1	2	2											14
indet.	1				11										2														14

APPENDIX 3: SNAILS FROM QUOYGREW, ORKNEY

Appendix 3: Snails from Quoygrew, Orkney

		Sample number	**7070**	**7095**	**7119**	**7144**	**7156**	**7188**	**7317**	**7321**	**7343**	**7358**	**7372**	**7375**	**7380**	**7388**	**7390**
		Context number	**G016**	**G013**	**6013/ 6015**	**G015**	**G020**	**G022**	**G048**	**G048**	**G052**	**G052**	**G055**	**G034**	**G054**	**G056**	**G014/G019**
		Context type	**Stone**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden**	**Farm mound midden/ stone**
		Phase	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**	**02/03/10**
Taxa	**Ecological notes**																
MARINE and BRACKISH WATER																	
Littorina mariae Sacchi and Rastelli, 1966 Flat periwinkle	Rocky shores, lower to mid shore, on weeds		2	2	-	1	5	1	-	-	3	-	-	1	-	1	1

Appendix 3: Snails from Quoygrew, Orkney

		Sample number	**7070**	**7095**	**7119**	**7144**	**7156**	**7188**	**7317**	**7321**	**7343**	**7358**	**7372**	**7375**	**7380**	**7388**	**7390**
		Context number	**G016**	**G013**	**6013/ 6015**	**G015**	**G020**	**G022**	**G048**	**G048**	**G052**	**G052**	**G055**	**G034**	**G054**	**G056**	**G014/G019**
Littorina saxatalis (Olivi, 1792) Rough periwinkle	Rocky shores, upper shore, in crevices, on weeds		-	-	-	2	-	-	-	-	-	-	-	-		-	1
Rissoa parva (da Costa, 1778)	Rocky shores, among weeds, common in summer		2	-	1	-	-	-	-	1	-	-	1	-	-	-	-
Onoba aculeus (Gould, 1841) Pointed cingula	Rocky shores, on weeds		-	-	-	-	-	-	-	-	-	-	-	-	1	-	-
Skeneopsis planorbis (Fabricius,	Rocky shores, lower shores		-	1	1	8	9	3	-	-	-	-	-	-	-	3	-

Appendix 3: Snails from Quoygrew, Orkney

		Sample number	**7070**	**7095**	**7119**	**7144**	**7156**	**7188**	**7317**	**7321**	**7343**	**7358**	**7372**	**7375**	**7380**	**7388**	**7390**
		Context number	**G016**	**G013**	**6013/ 6015**	**G015**	**G020**	**G022**	**G048**	**G048**	**G052**	**G052**	**G055**	**G034**	**G054**	**G056**	**G014/G019**
1780) Flat skenea	and sublittoral, on weeds																
Odostomia eulimoides Hanley, 1844	Parasitic on other Mollusca		-	-	-	1	-	-	-	-	-	-	-	-		-	-
cf. Rissoa/ Alvaria sp. juvenile			-	-	-	-	-	-	-	-	-	1	-	-	-	-	-
Cf, Hydrobiidae sp. juvenile			-	-	-	-	-	-	-	2	-	-	-	-	-	-	-
MARSH and WET GROUND																	
Anisus leucostoma (Millet, 1813)	Amphibious, marshlan		1	-	-	-	-	7	-		-	-	-	-	-	-	-

Appendix 3: Snails from Quoygrew, Orkney

		Sample number	**7070**	**7095**	**7119**	**7144**	**7156**	**7188**	**7317**	**7321**	**7343**	**7358**	**7372**	**7375**	**7380**	**7388**	**7390**
		Context number	**G016**	**G013**	**6013/ 6015**	**G015**	**G020**	**G022**	**G048**	**G048**	**G052**	**G052**	**G055**	**G034**	**G054**	**G056**	**G014/G019**
Button ramshorn snail	d and ditches, tolerant of seasonal drying																
cf. *Anisus leucostoma*			1	-	-	-	-	-	-		-	-	-	-	-	-	-
TERRESTRIAL																	
Discus rotundatus (Müller, 1774)	Shaded habitats, woodland to rank grassland		-	-	-	2	-	-	-		-	-	-	-	-	-	-
Oxychilus cf. *alliarius* juvenile	Shaded habitats, woodland to rank grassland		-	-	-	-	-	-	-		1	-	-	-	-	-	-

Appendix 3: Snails from Quoygrew, Orkney

		Sample number	**7070**	**7095**	**7119**	**7144**	**7156**	**7188**	**7317**	**7321**	**7343**	**7358**	**7372**	**7375**	**7380**	**7388**	**7390**
		Context number	**G016**	**G013**	**6013/ 6015**	**G015**	**G020**	**G022**	**G048**	**G048**	**G052**	**G052**	**G055**	**G034**	**G054**	**G056**	**G014/G019**
Trochulus sp. juvenile			-	-	-	-	-	-	1		-	-	-	-	-	-	-

APPENDIX 4: ANIMAL BONE FROM CEARDACH RUADH, BAILE SEAR

Appendix 4: Animal bone from Ceardach Ruadh, Baile Sear

	Context	112	112	111	111	111	110	108	108	107	107	106	106	105	104	103	102	101	101
	Sample	Hand-collected	17	Hand-collected	16	15	14	12	11	Hand-collected	10	9	8	7	6	5	4	3	2
BOS																			
Lower 1st or 2nd Molar, mid-wear				1															
Scapula		1																	
Tibia								1											
Femur or humerus									1										
Metapodial								1											
CAPRINE																			
Incisor															1				
Lower 1st or 2nd Molar, mid-wear										1									
Cranial fragment		1																	
Rib																1	1		
Humerus, juvenile																			1
Radius, gnawed																		1	
Pelvis, juvenile																	1		

Appendix 4: Animal bone from Ceardach Ruadh, Baile Sear

	Context	**112**	**112**	**111**	**111**	**111**	**110**	**108**	**108**	**107**	**107**	**106**	**106**	**105**	**104**	**103**	**102**	**101**	**101**
	Sample	**Hand-collected**	**17**	**Hand-collected**	**16**	**15**	**14**	**12**	**11**	**Hand-collected**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
Pelvis			1																
Tibia			1								1								
Tibia, gnawed																		1	
Patella												1							
LARGE MAMMAL																			
Mandible or maxilla fragment					1														
Radius				1															
MEDIUM MAMMAL																			
Ribs				2															
RATTUS																			
Radius						1													
MURID																			
Lower incisor														1					
BIRD																			
Tibiotarus											1								
Phalanx (small bird)														1					
FISH																			

Appendix 4: Animal bone from Ceardach Ruadh, Baile Sear

	Context	**112**	**112**	**111**	**111**	**111**	**110**	**108**	**108**	**107**	**107**	**106**	**106**	**105**	**104**	**103**	**102**	**101**	**101**
	Sample	**Hand-collected**	**17**	**Hand-collected**	**16**	**15**	**14**	**12**	**11**	**Hand-collected**	**10**	**9**	**8**	**7**	**6**	**5**	**4**	**3**	**2**
Vertebra												1	2	1					
Unidentified			1				3				8			10	5	5	12	5	
Unidentified, burnt			1					5			1			8			6	1	

Appendix 4: Animal bone from Ceardach Ruadh, Baile Sear