Palaeolithic and Mesolithic Scotland: ScARF Panel Report

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ScARF Summary Palaeolithic and Mesolithic Panel Document

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ScARF Summary Palaeolithic & Mesolithic Panel Report

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Executive Summary

Why research Palaeolithic and Mesolithic Scotland?

Palaeolithic and Mesolithic archaeology sheds light on the first colonisation and subsequent early inhabitation of Scotland. It is a growing and exciting field where increasing Scottish evidence has been given wider significance in the context of European prehistory. It extends over a long period, which saw great changes, including substantial environmental transformations, and the impact of, and societal response to, climate change. The period as a whole provides the foundation for the human occupation of Scotland and is crucial for understanding prehistoric society, both for Scotland and across North-West Europe.

Within the Palaeolithic and Mesolithic periods there are considerable opportunities for pioneering research. Individual projects can still have a substantial impact and there remain opportunities for pioneering discoveries including cemeteries, domestic and other structures, stratified sites, and for exploring the huge evidential potential of water-logged and underwater sites. Palaeolithic and Mesolithic archaeology also stimulates and draws upon exciting multi-disciplinary collaborations.

Panel Task and Remit

The panel remit was to review critically the current state of knowledge and consider promising areas of future research into the earliest prehistory of Scotland. This was undertaken with a view to improved understanding of all aspects of the colonization and inhabitation of the country by peoples practising a wholly hunter-fisher-gatherer way of life prior to the advent of farming. In so doing, it was recognised as particularly important that both environmental data (including vegetation, fauna, sea level, and landscape work) and cultural change during this period be evaluated.

The resultant report, outlines the different areas of research in which archaeologists interested in early prehistory work, and highlights the research topics to which they aspire. The report is structured by theme: *history of investigation*; *reconstruction of the environment*; *the nature of the archaeological record*; *methodologies for recreating the past*; and finally, the *lifestyles* of past people – the latter representing both a statement of current knowledge and the ultimate aim for archaeologists; the goal of all the former sections. The document is reinforced by material on-line which provides further detail and resources. The Palaeolithic and Mesolithic panel report of ScARF is intended as a resource to be utilised, built upon, and kept updated, hopefully by those it has helped inspire and inform as well as those who follow in their footsteps.

Future Research

The main recommendations of the panel report can be summarized under four key headings:

- **Visibility**: Due to the considerable length of time over which sites were formed, and the predominant mobility of the population, early prehistoric remains are to be found right across the landscape, although they often survive as ephemeral traces and in low densities. Therefore, *all* archaeological work should take into account the expectation of encountering early prehistoric remains. This applies equally to both commercial and research archaeology, and to amateur activity which often makes the initial discovery. This should not be seen as an obstacle, but as a benefit, and not finding such remains should be cause for question. There is no doubt that important evidence of these periods remains unrecognised in private, public, and commercial collections and there is a strong need for backlog evaluation, proper curation and analysis. The inadequate representation of Palaeolithic and Mesolithic information in existing national and local databases must be addressed.

- **Collaboration**: Multi-disciplinary, collaborative, and cross- sector approaches must be encouraged – site prospection, prediction, recognition, and contextualisation are key areas to this end. Reconstructing past environments and their chronological frameworks, and exploring submerged and buried landscapes offer existing examples of fruitful, cross-disciplinary work. Palaeolithic and Mesolithic archaeology has an important place within Quaternary science and the potential for deeply buried remains means that geoarchaeology should have a prominent role.

- **Innovation**: Research-led projects are currently making a substantial impact across all aspects of Palaeolithic and Mesolithic archaeology; a funding policy that acknowledges risk and promotes the innovation that these periods demand should be encouraged. The exploration of lesser known areas, work on different types of site, new approaches to artefacts, and the application of novel methodologies should all be promoted when engaging with the challenges of early prehistory.

- **Tackling the 'big questions'**: Archaeologists should engage with the big questions of earliest prehistory in Scotland, including the colonisation of new land, how lifestyles in past societies were organized, the effects of and the responses to environmental change, and the transitions to new modes of life. This should be done through a holistic view of the available data, encompassing all the complexities of interpretation and developing competing and testable models. Scottish data can be used to address many of the currently topical research topics in archaeology, and will provide a springboard to a better understanding of early prehistoric life in Scotland and beyond.

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1. Introduction to the Palaeolithic and Mesolithic Periods

The Palaeolithic and Mesolithic periods[1] are concerned with the fundamental developments in physical and cultural evolution which brought humanity from its very earliest hominin ancestry to a stage (the Neolithic) at which agricultural food production became the economic norm. These developments took place over an enormous extent of time – several million years – and against a backdrop of major climatic, geophysical, and ecological changes during the Pleistocene and early Holocene (Bell & Walker 2005).

There is still uncertainty about when people were first present on the land mass now known as Scotland. It is probable that inhabitation took place during the Lower Palaeolithic, of the same character as that for which there is accumulating evidence in southern Britain in the time range of as early as 700,000 to 500,000 years ago (Ashton et al 2011; Pettitt & White 2012; Stringer 2006). Yet it is equally probable that evidence for such inhabitation will continue to elude archaeology, in particular because of the effects of major climatic events and geomorphological processes which have affected Scotland between then and now. Most significant in terms of the masking, disruption, and erosion of all earlier land-surfaces has been the last major glacial cycle, the Weichselian (Devensian), during which Scotland was completely submerged beneath ice at the Last Glacial Maximum.

In a sense, it is the Last Glacial Maximum which sets the archaeological clock ticking for Scotland, because it is only with the ameliorated conditions following this event that the survival of any archaeological residues in their contemporary or near contemporary, contexts can be expected. The date by which conditions favourable to human habitation in Scotland were in place is currently taken to be *c*.14.7 ka cal BP (12,700 cal BC), and there are now positive indications that people were here during the earlier stages of the Lateglacial Interstadial, probably by 14 ka cal BP (12,000 cal BC) if not sooner.

Human presence during the Lateglacial may well not have been continuous, and it must be remembered that at this period Scotland was merely the outermost component of the north-west European peninsula, since much of what is now the southern North Sea was dry land (Doggerland). Humans, and the herds of animals on which they were primarily dependent for their livelihood, are likely to have roamed widely across this massive expanse of land and probably subsisted at quite low-level densities. Subsequently, during the rapid and extreme (but relatively brief) climatic downturn of the initial Younger Dryas (Loch Lomond Stadial) around 12.65 ka cal BP (10,700 cal BC), a possible complete depopulation episode for Scotland can be anticipated.

[1] Note that using cal BC dates for the time before the earliest reliable radiocarbon dates for lithic assemblages from Scotland [i.e. the early Later Mesolithic dates from Cramond] is fraught with various difficulties and those given here must be regarded with caution.

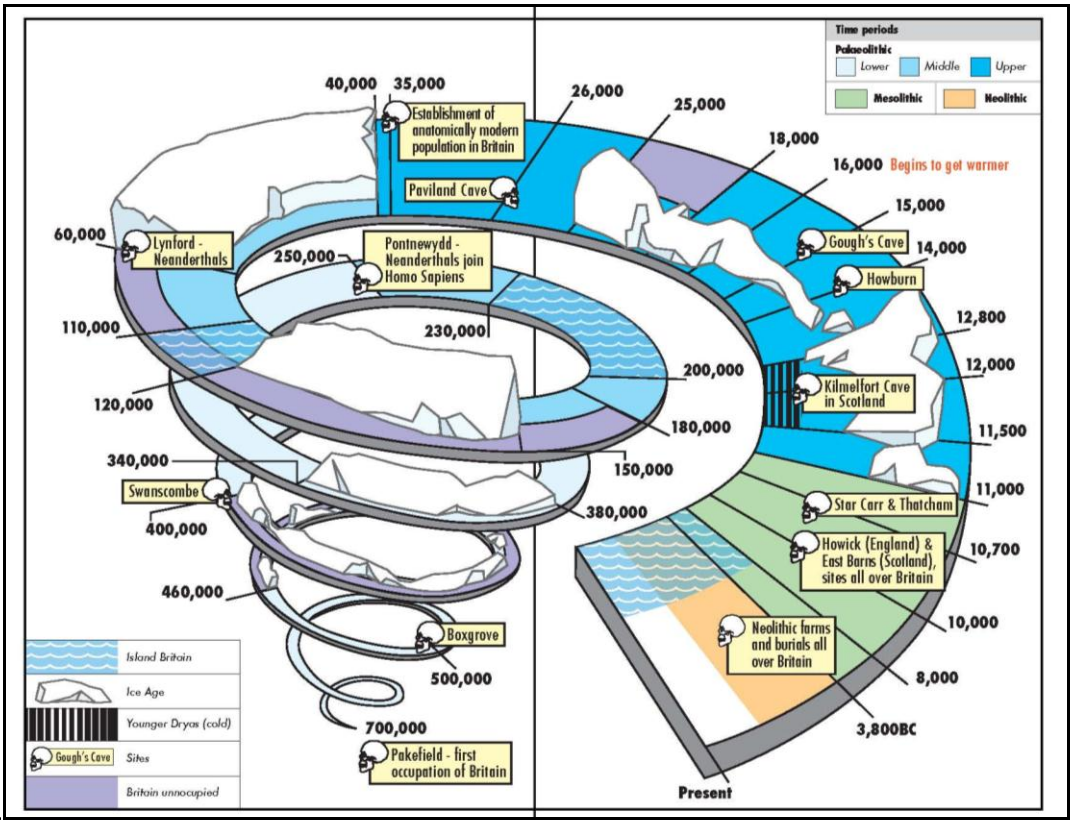

Figure 1: Time-chart: the Late Upper Palaeolithic and Mesolithic periods in Scotland occupy the time slot on the right-hand side between *c*.14,000 and *c*.4000 cal BC, © Caroline Wickham-Jones.

Thereafter, however, a continuous human presence in Scotland can be envisaged, perhaps regularly reinforced with incomings as, with the progressive rises in sea-levels, the extent of Doggerland shrank and the available hunting grounds were reduced. Long before Britain was finally separated from the Continent around 6000 cal BC Scotland's only land connection was with England, but by then Scotland had itself almost been split in two by the marine incursions in the Central Belt. In adaptive terms it is clear that 'island-hopping' was already well-developed in Scotland by the early Holocene, reflecting the increased importance of water-transport and an economic shift from reliance on large game to exploitation of seafood of all kinds.

A distinguishing feature of the Palaeolithic and Mesolithic archaeology of Scotland in contrast to that of all later periods is its low visibility – there are very few sites known by anything other than surface scatters of lithic artefacts. Palaeolithic and Mesolithic habitation evidence, apart from being relatively ephemeral in the first place, is far more vulnerable than that of any subsequent period to the vicissitudes of time and chance; such factors as glaciation, permafrost, changing sea levels and consequent inundation, coastal erosion, alluviation, peat growth, colluviation, and talus formation have all contributed to its destruction or concealment. This presents a massive challenge for researchers, but very significant advances in knowledge of these periods have occurred over the past decade or so. Hopefully, the formulation of the present research framework will lead to and underpin further increases in understanding over the coming decades

2. History and Current state of Palaeolithic and Mesolithic Studies in Scotland

Aspects of the background to studies of the Palaeolithic and Mesolithic periods in Scotland have been considered in previously published papers (Saville 1997; 1998a; 2004a), but it is appropriate here to provide an overview and to bring the story more up-to-date.

2.1 Palaeolithic

Scotland was largely immune to the excesses of eolith-mania other than those of the Revd Frederick Smith (e.g. Smith 1909), which, however, never inspired widespread credence. Finds of genuine Lower Palaeolithic handaxes have been made in Scotland, but in every case source criticism suggests these are relatively recent introductions which have been lost and rediscovered (Saville 1997; 1998b). There has never been any claim for in situ evidence of Middle Palaeolithic or Early Upper Palaeolithic activity in Scotland, and it is only in the case of the Later Upper Palaeolithic that there is any background of studies to consider.

In the 1920s there was a flurry of speculation about evidence for Palaeolithic activity at the Creag nan Uamh bone caves near Inchnadamph in Sutherland (e.g. Cree 1927). In the absence of any definitive publication of the 1926–27 excavations or the artefacts therefrom, such speculation faded until a revival of interest in the 1980s was fuelled by new studies of the extant faunal (especially reindeer) remains and their initial ^{14}C dating (e.g. Lawson and Bonsall 1986). Subsequent ^{14}C dating and re-evaluation of the reindeer antlers (Murray *et al*. 1993) and the human remains (Hedges *et al*. 1998), together with the rediscovery of the artefacts from the 1920s excavations, allowed a thorough reconsideration of the facts which concluded there was no positive evidence for any human presence at the bone caves prior to the Neolithic (Saville 2005).

A further strand of speculation began in the 1950s, following an initial suggestion that isolated finds of flint tanged points could represent Late Upper Palaeolithic activity (Livens 1956). Further similar suggestions were made on the basis of flint artefacts from Jura (Mercer 1980). This general concept was subsequently given support, amongst others by Morrison and Bonsall (1989), and elaborated upon following the identification of further possible examples of tanged points (Edwards and Mithen 1995). A review by Ballin and Saville (2003) determined that at least two of the then known tanged points – those from Shieldaig and Tiree – were identifiable as likely Late Upper Palaeolithic Ahrensburgian points, potentially datable to the later stages of the Younger Dryas Stadial (**Figure 2**).

Figure 2: Tanged point from Sheildaig ©NMS

Aside from the possibilities presented by archaeological evidence, palaeo-environmentalists have developed alternative arguments for Lateglacial human presence from the examination of cores taken through organic-bearing deposits of the period. In particular they have suggested that relatively high occurrences of microscopic charcoal from Lateglacial horizons could be a proxy for local human activity (Edwards 2004; Edwards *et al*. 2000), although this remains speculative.

However, the recent recognition of an actual early Lateglacial site in southern Scotland has changed the knowledge and perception of human presence in Scotland at this time (Ballin *et al*. 2010a; Pitts 2009; Ward 2009; Ward & Saville 2010). Fieldwork by the Biggar Archaeology Group at Howburn Farm, Elsrickle, in South Lanarkshire, recovered a large and distinctive lithic assemblage with precise parallels to late Hamburgian-type industries in southern Denmark and northern Germany, which date to the later Bølling chronozone (see **Figure 13**). The site appears to represent a hunting camp at which some retooling took place, and the lithic residues perhaps indicate several visits to the location spread over a long period. The most likely explanation for the presence of hunters at this spot is that it was close to a gathering point for herds of game animals, probably reindeer or wild horse. Howburn cannot be the only instance of a site of this period in Scotland, although to date there is just the single unusual and possibly 'Creswellian'-type flint artefact from Fairnington, near Kelso in the Borders, to suggest otherwise (Pettitt 2008; Saville 2004b).

Nevertheless, further Upper Palaeolithic evidence has come to be recognized as probably dating from a slightly later stage of the Lateglacial than that at Howburn Farm, the Allerød chronozone, when a cultural shift from Hamburgian to *Federmessergruppen* or curve-backed point tradition industries had taken place in Denmark, Germany, and other parts of what is now the adjacent European mainland. Again the evidence comes from a single site, the Kilmelfort Cave, near Oban in Argyll, where it is now clear that the best parallels for what was originally thought to be a somewhat enigmatic Mesolithic lithic assemblage lie with those from Continental *Federmessergruppen* sites (Coles 1983; Saville 2004b; Saville & Ballin 2009).

Figure 3: Fieldwalking at Howburn ©A Saville

Now that the true identities of the Howburn and Kilmelfort sites, both of which were initially thought to be of Mesolithic age, have been recognised, a perceptual barrier has been lifted. This has been assisted by the prominence given in recent years to the existence of Doggerland, which has clarified the potential for connectivity and equivalence between Scotland and lands to the east in the Lateglacial (e.g. Gaffney *et al*. 2009). It is now possible to view Scotland as fully part of the Lateglacial world of Upper Palaeolithic hunters both before and after the Younger Dryas cold event.

2.2 Mesolithic

The first use of the term Mesolithic in a specifically Scottish publication seems to have been Lacaille's (1930) article on 'Mesolithic implements from Ayrshire'. Although Lacaille's paper may have been the first appearance in print in Scotland of the designation 'Mesolithic' with reference to Scottish artefacts, many of what are now recognised as key Mesolithic sites and finds in Scotland had already been discovered in the 19th century, and most were mentioned in Lacaille's influential book *The Stone Age in*

Scotland (1954), which despite its title was principally concerned with the Mesolithic period.

Figure 4: MacArthur Cave under excavation, ©RCAHMS.

Thus Wilson (1851, 33) referred to the whale skeletons and antler implements from the draining operations in the Carse of Stirling, including the earliest recorded finding of what was probably an antler mattock in 1819 at Airthrey (Bald 1819) and another in 1824 at Blair Drummond (Drummond 1824). The best-known Mesolithic artefact from the carse clays of the upper Forth Valley, the Meiklewood antler-beam mattock, was found near a Rorqual whale skeleton in 1877 (Turner 1889; Clark 1947; Smith 1989). For Wilson the relics from the carse clays were those of the 'Primaeval or Stone Period'; clearly of considerable antiquity, but not otherwise classifiable at a time when the antiquity of human evolution and cultural development was still generally underappreciated. Turner (1889, 791) supposed the mattocks from the carse clay to be Neolithic, but made a very good guess at their age being at least 5000 to 7000 years ago.

Figure 5: Antler-beam mattock from Meiklewood ©NMS

Discoveries of highly important midden deposits in caves and rockshelters at Oban, Argyll, coincided with the expansion of that town at the end of the 19th century – MacArthur Cave was found in 1894 (Anderson 1895, 211) and Druimvargie rockshelter in 1897 (Anderson 1898, 298) – whilst exploration of the famous Oronsay shell middens started in 1881 (Grieve 1883, 480; 1885, 48; Mellars 1987, 117). Barbed points from one of the Oronsay middens were exhibited at an exhibition in London in

1883 (Anderson 1898, 307) and the biserial barbed point from the River Dee at Cumstoun, Kirkcudbrightshire, was discovered in 1895 (Munro 1908, 231). The Campbeltown flint assemblages, which were to become so important for the supposed 'Larnian' connection with Ireland, were first noted in the 1890s (Gray 1894).

Gray (1894, 271 & 274) considered his Campbeltown flints to be Palaeolithic, while Anderson perceptively related the Oban and Oronsay finds to:

> *... a horizon which has not heretofore been observed in Scotland, but corresponding with the intermediate layers in the cavern of Mas d'Azil ... described by M. Piette, and which he has seen reason to claim as filling up the hiatus ... supposed to exist between the palaeolithic and the neolithic (Anderson 1898, 313).*

Although Anderson was spot on in recognizing the true nature of the Oban and Oronsay material, his reference to the Mas d'Azil could be seen as the start of an unfortunate and misleading, but quite long lasting, trend for describing Scottish Mesolithic finds as Azilian (e.g. Macalister 1921, 516), which equated them with what is actually an Epiplaeolithic cultural tradition best known in southern France. The Azilian connection was not fully refuted until the 1950s (Lacaille 1954, 95; Thompson 1954, 206), by which time it had largely been replaced by the arguably equally confusing label of Obanian (Movius 1940; 1942).

Figure 6: Map of Key sites mentioned in the text ©RCAHMS

The Obanian

The term 'Obanian' was coined by Movius (1940; 1942) and elaborated upon by him (1953) and by Lacaille (1954), as a cultural designation for the coastal, bone- and antler-tool using, apparently non-microlithic, facies of the Scottish Mesolithic, represented at sites in and around Oban, at Risga (on Loch Sunart), and on the island of Oronsay. The Obanian was thereby conceptualized as a localized, atypical, and very late manifestation of coastal, niche-adapted foraging groups – 'strandloopers' – who did not manufacture microliths or other 'refined' tools but 'made do' with a scalar-core flake industry. For several reasons this picture has now been revised. Firstly, the direct radiocarbon determinations which have been made on Obanian bone and antler tools have revolutionized understanding of the duration of the Obanian, which now extends from at least c.8340 BP (c. 6390 cal BC) to ostensibly well beyond 5000 BP (3000cal BC). Not only does this echo almost the full known extent of the Mesolithic in Scotland, it is the Obanian dates themselves which contribute substantially to infill this timespan. Secondly, the excavation of open-air sites both at Oban and on the island of Colonsay has demonstrated the existence of conventional microlith-using Mesolithic groups in close geographical proximity to the classic Obanian sites (an association which had always seemed a possibility from the evidence at Risga). Thirdly, a rockshelter site with a midden deposit with Obanian-type bone points and bevelled tools (one dated to c.7590 BP) was found at An Corran on the north-east coast of the Isle of Skye (Saville and Miket 1994 a and b; Saville 2004d). Together with the evidence from Ulva Cave, off the island of Mull (Bonsall *et al.* 1992), and now that from the First Settlers Project in the Inner Sound region (Hardy and Wickham-Jones 2009a), this considerably extends the geographical range of the Obanian. In addition, the An Corran Obanian bonework was apparently associated with a rich lithic blade industry with microliths.

In combination, these factors now make it highly plausible to see the Obanian as distinctive from the rest of the Scottish Mesolithic only in that: a) conditions for preservation of bonework are enhanced at the shell-middens; b) the middens result from specific processing tasks only appropriate in certain coastal locations; and c) those processing tasks require a specialized toolkit, not the full artefactual repertoire. This position, which has been thoroughly examined by Bonsall (1996; 1997), reunites the Obanian with the rest of the Scottish Mesolithic; it is a time-transgressive functional variant, not a cultural offshoot, and the designation 'Obanian' is now of historical interest only.

Figure 7: View across an Oronsay shell midden to the Paps of Jura in the background, ©RCAHMS.

Mesolithic lithic tools, in particular the diagnostic microliths, had begun to be observed and recorded in Scotland early in the 20th century. The first illustrations of Scottish microliths may have been those of Scott (1895, plate 2) and Smith (1895, fig. 56), both in the final decade of the 19th century. Scott's microliths were from Craigsfordmains, Berwickshire, and he described them as 'flint implements of a peculiar type', while Smith's were from Stevenston Sands, Ayrshire, and he similarly was unable to grasp their true significance.

Microlithic implements from the west of Scotland, akin to the 'so-called "Pygmy Flints" of other countries' (Anon. 1911, 831), were exhibited in Glasgow in 1911, and Callander (1911, 177) referred to 'pigmy' flints from Culbin, Glenluce, and Shewalton Sands. Paterson (1912; 1913) noted examples from near Banchory in the Dee Valley, NE Scotland, illustrating some indisputable microliths with the caption: 'Scottish pygmy flints of Indian type' (Paterson 1913, fig.1). Corrie (1916) illustrated and described a collection of 'pigmy' flints among his finds from Dryburgh, Berwickshire. He was followed by Callander (1927a), also with finds from Berwickshire, by Lacaille (1930; 1931) with finds from Ayrshire, and by the Masons (1927; 1931) with more Tweed Valley finds.

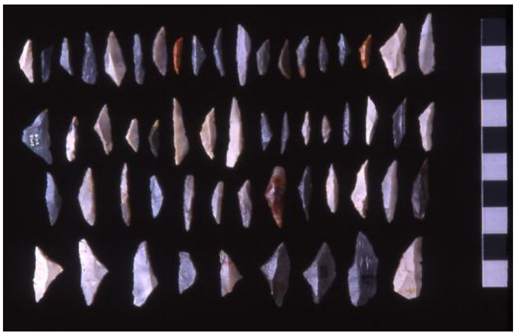

Figure 8: Dryburgh microliths ©NMS

Pygmy (or pigmy) flint was a widely accepted early designation for a microlith, still current in the 1920s (Callander 1927a; 1927b; Burkitt 1925, 19; Macalister 1921, 535; Paterson 1929). Lacaille referred both to 'pygmies' and microliths in 1930, but microlith is the preferred usage by the time of his 1937 overview of 'The microlithic industries of Scotland' and 'pygmies' do not feature in his 1954 book. Lacaille (1935; 1942) also took a lead in Scotland by realizing the significance of the microburin as a diagnostic Mesolithic waste product from microlith production, presumably following Clark (1932, 97–103; see also Childe 1942).

Most publications of these 'pygmy' flints referred to them as Tardenoisian, a term derived from the finds from the French locality of Fère-en-Tardenois, which was applied very loosely to designate all microlithic industries, though especially those with evidence for use of microburin technique. The term was widely used in general works (e.g. Burkitt 1921; Macalister 1921; Childe 1925), so that Callander (1927a) was able to feature Tardenoisian in the title of his article without explaining its origin or significance, though this appears to be the first specifically Scottish usage. It became the common term for microlithic industries in Scotland in the 1930s (e.g. Childe 1935, 20; Edgar 1939; Lacaille 1931) and 1940s (Childe 1946; Movius 1942; Simpson 1943) and was extensively employed by Lacaille in his 1954 book.

The Tardenoisian equation in Britain was reviewed by Clark in 1955, who recommended the replacement of Tardenoisian by Sauveterrian (after the finds from the French locality of Sauveterre-la-Lémance), since it had become obvious that the most diagnostic element of true Tardenoisian assemblages in France, the microlithic trapeze, was absent from British Mesolithic industries altogether. Affinities with the Sauveterrian microlithic industries (which were pre-Tardenoisian in France) were seen as far more appropriate for the British material, without necessarily implying non-indigenous origin. Although

Clark (1955, 20) specifically reclassified the Banchory and Dryburgh finds as Sauveterrian, this appellation never really caught on in Scotland, other than being discussed by Mulholland (1970, 103–10) with reference to the Tweed Valley assemblages and by Mercer (1968; 1970) in the first two publications of his Jura finds.

One of the other dominant trends during the mid-20th century in Scottish Mesolithic studies was to hypothesize links with Ireland. In his chapter on 'Man with Mesolithic culture arrives in Scotland', Lacaille (1954) proposed that the earliest Mesolithic in Scotland was a version of the Irish Larnian. Both Lacaille and Movius (1942), whose lead Lacaille followed, seem to have envisaged actual settlement taking place from NE Ireland to SW Scotland, as indeed became the generally accepted explanation for the Mesolithic in SW Scotland (e.g. Childe 1946). This proposition hinges on the significance attached to lithic finds in association with raised beach deposits at Campbeltown, first reported by Gray (1894). These finds were seized upon by the Abbé Breuil when he visited Edinburgh in 1921 as one of the few potentially pre-Neolithic lithic assemblages in the National Museum which was more 'Magdalenian' than 'Tardenoisian' (Breuil 1922), though other scholars were more cautious (Garrod 1926, 176).

A new Campbeltown location was investigated in 1935 by McCallien, and McCallien and Lacaille (1941, 88) equated the Campbeltown material with Movius's newly defined Early Larnian. Although Lacaille (1954, 311) persisted with the view that the Campbeltown material demonstrated that the Mesolithic was introduced into SW Scotland from Antrim by Early Larnian immigrants, Movius (1953, 87–9) became more cautious on this point, but it was left to Coles (1963, 92), who reassessed both the Campbeltown and Antrim material, to demonstrate conclusively the fallacy of the Larnian link and to cast doubt on any Mesolithic contact between Ireland and Scotland. Virtually no subsequent evidence for contact or even parallelism between Ireland and Scotland before the Neolithic has come to light, the very few examples of potential linkages seeming to be the exceptions to prove the rule (Saville 2003b; 2009).

Another major error in Lacaille's approach was to regard much of the best lithic evidence for the Mesolithic in Scotland as post-Mesolithic in date, assuming a culture / time-lag only credible in an era before radiocarbon dating (Saville 1996). Since the publication of Lacaille's major work on the Mesolithic, the Scottish database for this period has, slowly but surely, continued to expand, albeit very unevenly across the whole country. One particular early survey, of surface scatter sites in the Tweed Valley, was important in demonstrating the value of detailed research in specific topographic zones and in revealing the density of the evidence (Mulholland 1970). In view of this it was a major disappointment that the work of the Council for British Archaeology's Mesolithic Sub-Committee did not come to fruition in Scotland (Saville 1998b), so that the resulting gazetteer covered only England and Wales (Wymer 1977). A more recent attempt to get to grips with surface lithic scatters of all periods in Scotland has been only partially successful, and does not readily allow for the extraction of Mesolithic data (Barrowman and Stuart 1998).

Excavations of Mesolithic sites after the Second World War were low-key affairs in general, as at Low Clone and Barsalloch in the south-west (Cormack 1970; Cormack and Coles 1968), but a more ambitious approach by Coles at Morton in Fife in 1969–70 led to a seminal paper for

Scottish Mesolithic studies in which a wide range of artefactual, environmental, structural, and chronological data was presented (Coles 1971). Also in the 1960s a remarkable campaign of excavation to study the Mesolithic began on the Isle of Jura. Starting with the excavations at Lealt Bay in 1966 (Mercer 1968), this research by the Mercers and Searight continued for 16 years until John Mercer's premature death in 1982 (Searight 1984). Another concerted campaign began in 1970, with Mellars's project to reinvestigate the Oronsay Mesolithic shell-middens, and continued until 1979 (Mellars 1987). At the same time, excavations at a mainly Bronze Age site at Kilellan on the island of Islay were incidentally uncovering an underlying flint assemblage, which first indicated the potential of this island for Mesolithic research (Burgess 1976; Saville 2005). The 1970s, in retrospect a busy decade for Mesolithic excavations in Scotland – for example Walker's work at Shieldaig, Wester Ross (Ballin and Saville 2003; Walker 1973) – finished with a major fieldwork campaign in 1978–1980 at Nethermills Farm, Crathes, on the north bank of the River Dee in Aberdeenshire (Kenworthy 1981).

The end of the 1970s also saw the start of a campaign to investigate the enigmatic shell middens (comprised predominantly of oyster shells) of the Forth Valley, focusing particularly on the midden at Nether Kinneil (Sloan 1982; 1993). There are some 20 or so of these middens, mostly along the southern shore between Falkirk and Bo'ness, but with a few on the north side in Fife and Clackmannanshire (Ashmore and Hall 1996; Sloan 1989; 1993). The size of some of the middens is extraordinary. The best known are those at Inveravon (Grieve 1872; MacKie 1972), at least 27m and probably much longer; Mumrills (Bailey 1992), 43m long; Polmonthill (Stevenson 1946), possibly 155m long; and Nether Kinneil (Sloan 1982), over 150m long. There are two major problems, apart from their size, with these middens – their origin and their date – both of which have been the cause for considerable debate. Grieve (1872) was adamant they were not natural, though perhaps not much earlier than Roman in date. Support for their artificial nature has included reports of lenses of burning at Polmonthill (Stevenson 1946) and the stone-built hearths and banks and so on at Nether Kinneil (Sloan 1982). Their anthropogenic origin has continued to be suspected, however, on the basis that the traces of human activity may relate to later re-use of naturally accumulated shell banks (Jardine 1984, 4–5; Kinnes 1985, 20). The radiocarbon dates from Nether Kinneil, which has anyway produced pottery and bones of domesticated animals, lie in the 5th millennium BP (5-4000 cal BC), but there are earlier dates in the 6th millennium BP (6-5000 cal BC) from the middens at Mumrills, Inveravon, Cadger's Brae, and Braehead (Ashmore 2004b). Thus a Mesolithic date for some appears probable, though it is still the case that no Mesolithic artefacts have been recovered from any of the Forth middens.

Work on the Mesolithic in the 1980s was dominated by the important excavations at Kinloch, Isle of Rúm, from 1984 to 1986 (Wickham-Jones 1990), which demonstrated a Mesolithic presence in the country both at an earlier date and further north than was thought at the time as well as rekindling wider academic and public interest in the archaeology of the period. Much was also happening elsewhere and numerous new Mesolithic locations were reported from the SW (Edwards *et al.* 1983). Rescue excavation at Newton on Islay produced a large flint assemblage in association with possible structures (McCullagh 1989) and two newly recognized rockshelter shell-midden sites at Carding Mill Bay I and Raschoille Cave, Oban, were salvaged (Connock 1985; Connock *et al.* 1992).

Figure 9: The excavation site at Camas Daraich, Skye. Note site trench in centre foregound, in front of lorry ©Caroline Wickham-Jones

Tom Affleck excavated at several sites in the SW and on Arran (Affleck *et al*. 1988; Edwards 1996b) while a project to record and selectively to excavate caves and rockshelters in Mid Argyll ran from 1985–1991 (Tolan-Smith 2001) and excavations which still continue were started at Ulva Cave on the small island of Ulva, west of Mull, in 1987 (Bonsall *et al.* 1991; 1992; Russell *et al.* 1995). A major campaign – The Southern Hebrides Mesolithic Project – of survey and excavation on Colonsay and Islay, was launched in 1988, continued for a decade and was rapidly published in full (Mithen 2000), as was another west coast project – Scotland's First Settlers – which ran from 1998 to 2004 and looked at the area around the east coast of Skye and the facing mainland (Hardy and Wickham-Jones 2009). Other west coast sites have been excavated at Camas Daraich and An Corran, on Skye (Birch *et al*. 2000; Wickham-Jones and Hardy 2004; Saville and Miket 1994 a and b; Saville *et al*. forthcoming) and at Kilmore near Oban (Bonsall *et al*. 2009a). New projects are in progress, one – the Inner Hebrides Archaeological Project – looking at the early prehistory of Mull, Coll and Tiree (Mithen and Wicks 2008) and another intended to publish in more detail aspects of past excavations at Risga in Loch Sunart (Pollard 2000; Pollard *et al*.1996) and the material culture evidence from excavations on Oronsay (Mellars 1987), and further work on Islay as the East Islay Mesolithic Project (Mithen & Wicks 2009).

Commercial archaeology has already made a big impact on Mesolithic studies. Significant new finds have already been made in the south-west (MacGregor and Donnelly 2001; Pollard 1993; RCAHMS 1997, 96) and at Fife Ness in the East Neuk (Wickham-Jones and Dalland 1998). Shortly after the startling results of excavation at Howick on the Northumberland coast (Waddington 2007), rescue excavations by AOC

Archaeology Group in advance of quarrying at East Barns, near Dunbar in East Lothian revealed another Mesolithic 'house' (Gooder 2007; Gooder and Hatherley 2003). This was a substantial sub-circular timber structure with associated features and deposits containing masses of lithic debris and organic residues, including carbonized hazelnut seeds which were used to furnish the ^{14}C dates of 8300–7650 cal BC. Final details of further possible further timber structures at a site excavated by CFA Ltd at Elgin are awaited (Suddaby 2007), and an unexpected series of large pits have been uncovered at a National Trust for Scotland site at Crathes in Aberdeenshire (Murray *et al*. 2009).

On the other hand amateur archaeology continues to lead to new and important Mesolithic discoveries, often by accident during the exploration of sites of later periods, but in that respect it is no different from the fortuitous nature of commercial work. At Cramond, the Edinburgh Archaeological Field Society uncovered a small feature which was subsequently excavated by the Edinburgh City archaeologists and has yielded the earliest radiocarbon dates so far for the Scottish Mesolithic (Saville 2008). Important new sites have been located and excavated around Daer Reservoir in the Lowther Hills by the Biggar Archaeology Group (Ward 1995; 1997; 2000a; 2010), which has also investigated many other Mesolithic lithic scatters in South Lanarkshire. Edinburgh Archaeological Field Society has test-pitted another potential site at Dalmeny (Jones 2006) and local fieldwalking has revealed a widespread scatter of material relating to Mesolithic activity in the fields around the excavation site at Nethermills in Aberdeenshire.

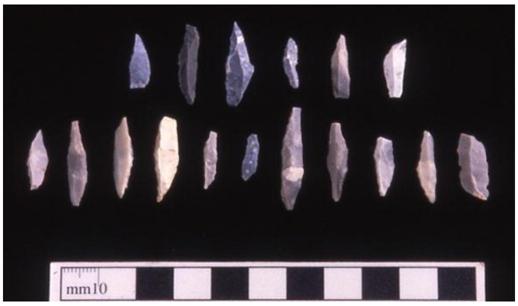

Figure 10: Microliths from Daer ©Alan Saville

Nor has all this work focused entirely on sites and artefacts, as shown by the review of early Postglacial vegetational history by Edwards and Ralston (1984) and by many other palaeoenvironment-oriented contributions by Edwards (e.g. 1989) and others, raising issues which are still subject to lively debate (Edwards 1996a; 2004; Kitchener *et al*. 2004; Tipping 1996; 2004; 2007).

Since Lacaille's book (1954) various overviews or summaries of the Mesolithic in Scotland, in varying degrees of detail and styles of approach, have been published – Piggott and Henderson (1958), Atkinson (1962), Woodman (1978, 196–8), Mountain (1979), Ritchie and Ritchie (1981), Morrison (1980; 1986), Smith (1992), Wickham-Jones (1994), Finlayson and Edwards (1997), Finlayson (1998), Mithen (2000a), Saville (2004), and Warren (2005). Some regional summaries have also appeared (e.g. Bonsall 1997; Coles 1963; Kenworthy 1975; Ritchie and Ritchie 1972; Mercer 1979; Saville 2000; Scott 1966; Wickham-Jones and Firth 2000), of which those of the south-west by Morrison (1981; 1982) have been the most substantial. The Royal Commission on the Ancient and Historical Monuments of Scotland has also included several useful summaries of the Mesolithic evidence in some of its survey volumes, in particular the surveys of Stirlingshire (RCAHMS 1963, 18–20), the southern Inner Hebrides (RCAHMS 1984, 2–5), and eastern Dumfriesshire (RCAHMS 1997, 94–6).

Direct precursors of the present framework exercise were the reviews by Peter Woodman (1989), written at the invitation of the Society of Antiquaries of Scotland, and that by Noel Fojut (2006) of Historic Scotland. In subtitling his article 'a plea for normality', Woodman was referring to the past tendency to regard the Mesolithic in Scotland as marginal, late, obscure, and somehow irregular in comparison with the rest of mainland Britain. This criticism was justified to a degree, especially following the major influence Lacaille's work had on perceptions of the Scottish Mesolithic, but perhaps overstated the case by concentrating too much on the 'Obanian' question. Nevertheless, and partly in response to Woodman's comments on the priority which should attach to the Oban area, detailed survey work was undertaken (Macklin *et al.* 1992; 2000), another newly located rockshelter (Carding Mill Bay II) has been salvaged (Bonsall pers. comm.), and open-air Mesolithic locations have been located and sampled (Bonsall and Robinson 1992; Bonsall *et al*. 1993). Since then research projects focused on the east of Scotland (Finlayson and Warren 2000; Warren 1998; 2001; 2007) and Caithness and Orkney (Pannett 2001; 2002; Pannett 2007; Pannett and Baines 2002; Wickham-Jones and Firth 2000; Woodward 2007 & 2008) have been mounted to counter the western bias in the Mesolithic database.

Fojut's (2006) review was prepared for an international symposium on early prehistoric archaeology and heritage management held in the Netherlands in 2002, but not published until 2006, and makes no mention of the advances in Mesolithic research covered by the publication of the Society's own international conference on the Mesolithic (Saville 2004a), or indeed of Woodman's (1989) review. Nevertheless, like Woodman's, this overview of trends in Mesolithic research in Scotland in the 1980s and 1990s and it's prospects contained some useful insights and alluded to many of the topics covered by the present ScARF report.

Apart from the 'Obanian', the other oft-quoted bias in Scottish Mesolithic studies towards coastal sites is being countered by numerous discoveries of inland and upland sites, as at Ben Lawers in Perthshire (Denison 2001a), Chest of Dee, Aberdeenshire (Fraser 2003), Loch Garten, Highland (Saville 2007), and the aforementioned sites around the Daer Reservoir in South Lanarkshire (Ward 1995; 1997; 2000a; 2010). And the true extent of Mesolithic inhabitation throughout the entire country is finally being resolved by new fieldwork and research in Orkney (e.g. Lee & Woodward 2009; Wickham-Jones and Downes 2007; Woodward 2007; 2008), Shetland (Melton 2005; 2008; Melton and Nicholson 2007), and the Western Isles (Edwards 2009; Edwards and Mithen 1995; Edwards and Sugden 2003; Gregory *et al*. 2005; Simpson *et al*. 2006). It may be only St Kilda that eluded people in the Mesolithic!

Raw material studies have benefitted from two recent directions of study. Detailed consideration of the occurrence of pitchstone artefacts throughout Scotland has concluded that during the Mesolithic, in contrast to the Neolithic period, the exploitation and use of this raw material was largely restricted to its immediate locality of origin on the Isle of Arran and surrounding margins (Ballin 2009). This type of restricted regional distribution seems to be typical of the Scottish Mesolithic in terms of the usage of other raw materials such as bloodstone, mudstone, and quartz (Ballin 2008; Clarke and Griffiths 1990; Saville 2003b; Wickham-Jones 1986). The other advance has been in the understanding of the acquisition of radiolarian chert in southern Scotland (Ward 2007; Warren

2007). It now appears that there was widespread small-scale quarrying to exploit seams of chert, making this Mesolithic enterprise the earliest evidence for extractive industry in Scotland.

The transition to Neolithic economy and culture in Scotland has been of particular fascination to researchers, because of the apparent evidence for Obanian persistence and the relative absence of early Neolithic activity. One view has seen the west coast evidence as reflecting the emergence of social complexity among Mesolithic people, who undergo gradual indigenous economic and social transformation (Neolithicization) whilst retaining many aspects of their Mesolithic economy and settlement mobility (Armit and Finlayson 1992; 1996; Finlayson 1995; Mithen 2000b). The evidence for any emerging complexity has, however, also been disputed (Murray 2000). Other work, exploiting the results from analyses of isotopic data from the small number of Mesolithic and early Neolithic human bones available from western Scotland has indicated a sharp contrast in dietary habits between the largely marine diet of the Mesolithic 'fish-eaters' and the almost wholly terrestrial diet of the Neolithic 'meat-eaters'. This has been taken along with other strands of evidence to suggest the alternative possibility of a complete cultural break at the end of the Mesolithic, with Neolithic culture introduced by new colonists (Schulting and Richards 2002). Another perspective on this has been taken by those suggesting that a widespread change to drier climatic conditions starting at *c*.4,100 cal BC was the catalyst for the adoption of agriculture by indigenes (Bonsall *et al*. 2002, 14).

Already by the time of Woodman's (1989) review the situation as regards the chronology of the Scottish Mesolithic was changing markedly, particularly with the sequence of radiocarbon dates from Kinloch, Rúm, and these were followed by accelerator mass spectrometry (AMS) determinations on bone and antler artefacts (Ashmore 2004a; 2004b; Bonsall and Smith 1990; Bonsall *et al*. 1995; Saville 2004d). A significant effect of these radiocarbon dates, and all the others coming on stream[2], has been to demonstrate more clearly that there is a considerable time-depth to the Mesolithic in Scotland, but has not as yet helped to clarify the earliest and latest stages of the period.

The artificial divide between the Lateglacial hunters of the Late Upper Palaeolithic and those of the Early Mesolithic is provided by the climatic transition from the Pleistocene to the Holocene epochs, now conventionally dated to around 11.7 ka cal BP (9,700 cal BC). In other words, the Early Mesolithic represents the cultural stage of hunting peoples at the beginning of the current interglacial episode in which humans live today. As indicated in the previous section, it is now considered highly probable that people were present in Scotland during the terminal phases of the Pleistocene, and therefore a relatively seamless transition between the Late Upper Palaeolithic and the Mesolithic could be envisaged, albeit with innovative responses to the changes taking place in the environment and biotope and the probable growth in population numbers, although these would never have been large. However, a continuing problem with the Scottish Mesolithic has been the

[2] Follow the links from www.scottishheritagehub.com to the Palaeolithic and Mesolithic date list. A date list of Scottish Mesolithic dates has been compiled as part of the panel's deliberations. Thanks are due to Clive Waddington for compiling this, Peter Marshall for providing an assessment, and panel members for supplying dates.

difficulty of identifying Early Mesolithic sites.

The distinction between Early and Later Mesolithic in England was defined on the basis of artefact typology in the 1970s, when an alternative nomenclature to the previous 'Maglemosian' and 'Sauveterrian' was deemed necessary. The separation date between 'Early' and 'Later' was adopted as during the first half of the 9th millennium BP (c.6750 cal BC), and the defining characteristics were, essentially, that 'Early' lithic industries had mainly simple, relatively large microlith types (especially obliquely blunted points and isosceles triangles) made on 'broad' blades, while 'Later' industries had more elaborately retouched 'narrow-blade' microliths, including small 'geometric' and other edge-blunted forms (Jacobi 1973; 1976; 1978; Mellars 1974). It remains an issue of contention whether or not this distinction is applicable across Scotland.

Chronological developments: 'Broad' and 'Narrow Blade' technologies

In Scotland, analysts found that the vast bulk of Mesolithic lithic assemblages related in form to the English Later Mesolithic, narrow blade, template. Moreover, the few sites which did produce typologically Early Mesolithic, broad blade, artefacts in English terms, such as Morton A in Fife and Lussa Bay on Jura, lacked reliable stratigraphy and contexted ^{14}C dates to confirm their supposed status (Saville 2004b). The situation was further complicated by a series of ^{14}C determinations obtained from the site at Cramond, Edinburgh, in undoubted association with a chert industry characterised by narrow blades (i.e. conventionally Later Mesolithic in English terms) , which proved to be the earliest dates in Britain for such material (Saville 2008; Waddington 2007). These dates show that people with a developed narrow-blade technology were in Scotland by *c*. 8400 cal BC (Saville 2008: 211–213), and they are backed by other, early, dates for material that would be regarded as conventionally 'later' were it to be found in England.

Figure 11: Microliths from Cramond ©NMS

This situation provokes several questions, such as: how do the broad blade sites relate to the Scottish Mesolithic? There are undoubtedly sites with conventionally 'broad blade' industries in Scotland; when were they in use; and what was the relationship between broad-blade technology and narrow blade technology. With regard to the narrow-blade microlithic technology, at what date did it arrive or develop in Scotland? In general how did lithic technology develop over the 4000 years to the end of the Mesolithic period?

The early existence of narrow-blade technology in Scotland may help to explain the relative dearth of broad blade associated Mesolithic sites, if we conclude that the actual time-span into which broad blade assemblages might have occurred is quite restricted (cf. Waddington et al. 2007, 219–223). Or it may be that the two industries have a quite different relationship in the north of the British Isles. Nevertheless, it is difficult to offer a similar explanation as to why there appear to be so few Mesolithic sites (whatever the type of industry) from the end of the period, at the time when Neolithic economy and technology were becoming established. All things being equal, one might have expected there to be an expanded population and thus significant settlement evidence after so many millennia. Had Later Mesolithic people been so profligate with their resources that population decline becomes an explanation? Or was there a change in technology (particularly lithic technology) that has as yet not been fully identified, as suggested by some (e.g. Hardy & Wickham-Jones 2009)?

Figure 12: Blades from Lussa Bay ©NMS

Current evidence suggests the incursion of peoples from several 'homelands' (in interesting similarity to current theories of the arrival of the Neolithic) and the picture will undoubtedly be refined as knowledge of the prehistoric populations of Doggerland increases. The precise incursion/s of people into Scotland in the early Holocene is still the subject of much debate, and the likely paucity of evidence for any colonisation phase represents a challenge. With regard to the end of the period, models, such as Lacaille's of a Mesolithic way of life enduring in some regions need to be tested. It is clear that chronology and typology have still to be refined.

Clarification of the position of broad blade sites is one research priority: validation and understanding of the broad blade assemblages of Scotland in general is needed. Excavation to better understand broad blade sites, in the Tweed Valley for example, would be very useful. Another priority must lie in clarification of the relationship, if any, between broad and narrow blade sites. Finally, identification and excavation of industries representative of the later, pre-Neolithic period of the Mesolithic is undoubtedly important.

2.3 Future Research Recommendations

Consideration of the story of the discovery of Palaeolithic and Mesolithic archaeology in Scotland so far suggests there is still much more research and investigation to be done, including:

- Detailed historiographic consideration of the recognition of the Palaeolithic and Mesolithic in Scotland.
- Investigation of the intellectual history of studies of these periods in Scotland, including biographical research on key figures and excavations, e.g. Symington Grieve (on Oronsay) and Lacaille.
- Examination of existing lithic artefacts in museums and private and commercial collections to isolate diagnostic types and to document provenances.
- Enhancement of national and local records to ensure proper representation of Palaeolithic and Mesolithic evidence for development control and research purposes.
- Analysis and publication of existing backlog of fieldwork assemblages known or likely to include Mesolithic (and Palaeolithic) artefacts, including some key sites/assemblages which should be prioritised.

3. Environment

3.1 Climate changes in Scotland from the Last Glacial Maximum c. 16000 yrs BP to c. 6000 BP

The current climato-stratigraphic framework or stratotype for climate change in the Late Devensian Epoch, intended to be applicable across the North Atlantic region, is described in Lowe *et al*. (2008), following re-calibration of the annually resolved NGRIP $\delta^{18}O$ ice-core record by Rasmussen *et al.* (2008). The table below (**Table 1**) presents the ages of successive climatic events, numbered from the base of the Holocene. Ages are defined from the NGRIP record, given by Rasmussen *et al.* (2008) as GICC05 age ka b2k, or years before AD2000 in the NGRIP record. There is expected to be a close relation between these ages and, for instance, calibrated ^{14}C assays (cal BP), but the imprecision of calibrations makes this not possible to establish. GS events are colder, stadial events: GI events are milder interstadial events.

Table 1: Table outlining the ages of successive climatic events, numbered from the base of the Holocene.

Event	Onset & Termination (GICC05 age b2k)	Duration (years)
Holocene	11703 to present	11203
GS-1	12896 to 11703	1193
GI-1a	13099 to 12896	203
GI-1b	13311 to 13099	212
GI-1c	13954 to 13311	843
GI-1d	14075 to 13954	121
GI-1e	14692 to 14075	617
GS-2a	Not defined to 14692	

Greenland Stadial 1 (GS-1) is roughly equivalent to the Younger Dryas Stadial; Greenland Interstadial 1 (GI-1) lasting 1996 years is roughly equivalent to the Windermere Interstadial. GI-1d and GI-1b are colder phases within GI-1; GI-1d may be equated with the 'Older Dryas' of continental NW Europe.

Temperature variations in Scotland prior to the Holocene are best defined from the Whitrig Bog chironomid record in SE Scotland (Brooks & Birks 2000), but this sequence is not dated. From biostratigraphic and tephrostratigraphic correlation (Turney *et al*. 2007), chironomid assemblages suggest that mean July temperatures were lower than *c*. 7.5ºC before the Windermere Interstadial, perhaps before *c*. 14300 GICC05 age ka b2k, and reached *c*. 12ºC after this. Coleopteran data (Coope 1987) suggest temperatures of *c*. 18ºC. Temperatures decline throughout the Windermere Interstadial in all records to around 11ºC. Evidence from chironomids suggests three falls in mean July temperature of between 0.5 and 3 ºC within the Windermere Interstadial, perhaps equated with events GI-1d and GI-1d. Perhaps around 12896 GICC05 age ka b2k, mean July temperatures plummeted to below *c*. 7.5ºC. Within the Younger Dryas, mean July temperatures rose to *c*. 9ºC. Assuming precise correlation with the NGRIP record, the Younger Dryas succeeded to the Holocene Epoch at around 11703 GICC05 age ka b2k. In Greenland this occurred in a matter of decades (Taylor *et al.* 1993; Alley 2000).

Changes in precipitation are very poorly understood from Scottish Lateglacial sequences. The greater climatic continentality of The Netherlands, and a heightened sensitivity to precipitation of sediment sequences on well-drained sand allows the suggestion of a wet early Windermere Interstadial, but increasing aridity to the Older Dryas (≈ GI-1d: 14075 to 13954 GICC05 age ka b2k) (Walker *et al.* 1994). Effective precipitation (precipitation – evapotranspiration) was variable after this until the Younger Dryas, which was again arid.

The earliest Holocene climatic amelioration was interrupted by a series of abrupt, hemispheric or global climatic events. The establishment of *Betula* (birch) woodland in the Netherlands from *c*. 11500 cal BP (Friesland Phase) was interrupted around *c*. 11400 cal BP by a dry, continental climate, the Rammelbeek Phase, correlated with the Preboreal Oscillation in the NGRIP record. Effective precipitation increased after *c*. 11250 cal BP (9300 cal BC; Bos *et al*. 2007), with the re-establishment of the North Atlantic Current (Andresen *et al*. 2007). Dense woodland was not established in The Netherlands until *c*. 10730 cal BP (8780 cal BC; Bos *et al.* 2007), at what used to be the beginning of the Boreal period. Further short-lived deteriorations in climate occurred at *c*. 10300 (8350) and *c*. 9500 cal BP (7550 cal BC), seen in some but not all proxies (Hoek & Bos 2007 and references therein). The major early Holocene climatic reversal, the 8.2 ka event (Alley *et al.* 1997), was small in comparison with Lateglacial oscillations but had widespread, hemispheric impacts and involved a temperature depression of 2–3ºC (Klitgaard-Kristensen *et al.* 1998). North-west Europe was markedly more arid. Stager & Mayewski (1997) and Debret *et al.* (2009) argue that northern hemispheric atmospheric circulation before *c*. 8200 cal BP (6250 cal BC) was probably markedly different to today because of the persistence of a Laurentide ice cover; recognisable 'Holocene' climatic patterns may have commenced only at this time.

No significant climatic reversals are recorded in NW European proxies until c. 6000 cal BP (Mayewski *et al.* 2004). The period 5400 to 4000 BC was 1–2ºC warmer than present in NW Europe (Davis *et al.* 2003). However, the period of hemispheric abrupt climate change that would later be associated with Neolithic archaeological events actually commenced in the preceeding Mesolithic, from *c*. 7000 cal BP (5050 cal BC).

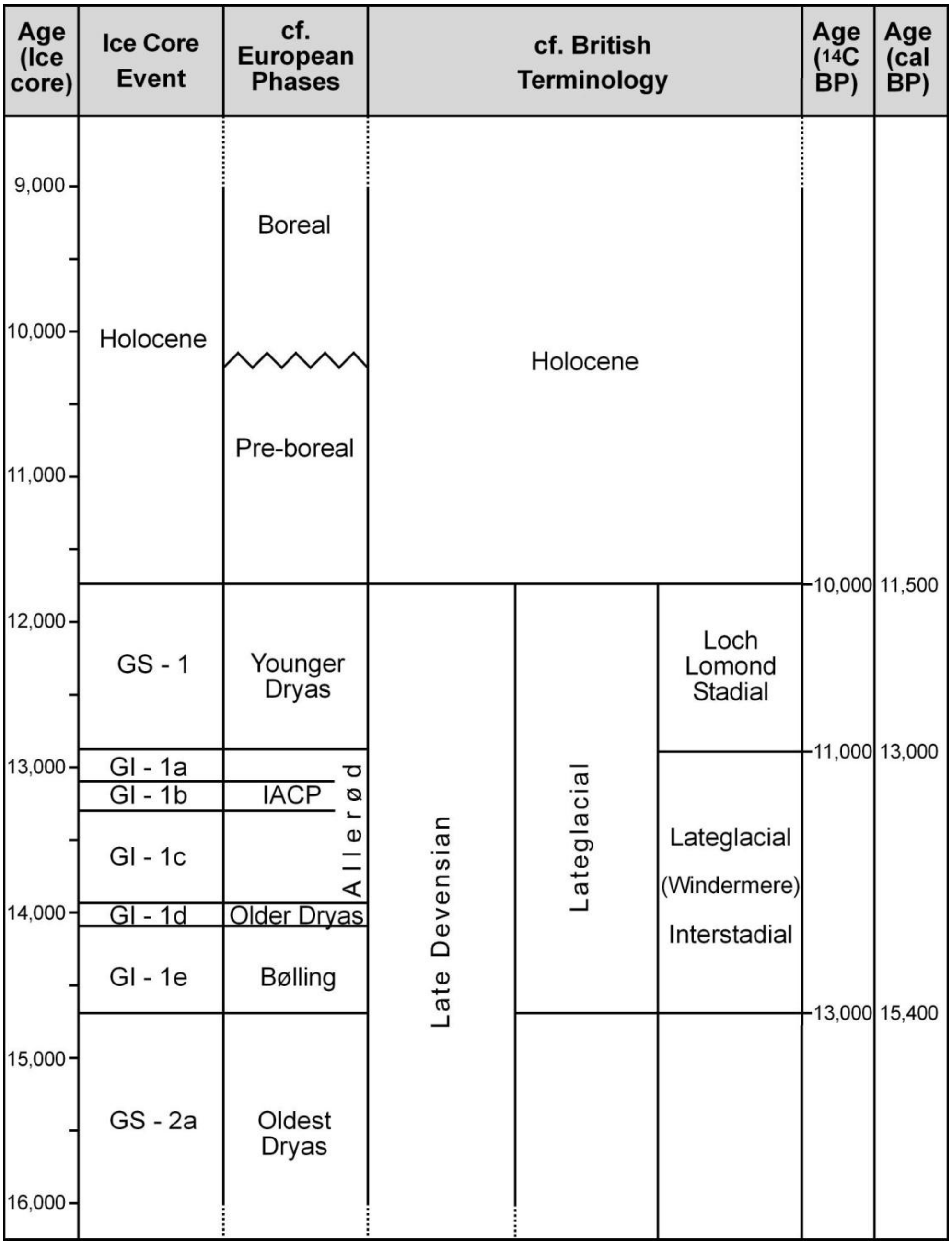

Figure 13: Table of chronostratigraphic and nomenclatural comparisons. Ice core ages (ice core years before AD 2000) and events from Lowe *et al*. (2008) and Walker *et al*. (2009). IACP = Intra Allerød Cold Period.

3.2 Vegetational and associated environmental changes during Late Devensian and early Holocene times

3.2.1 Introduction

Vegetation history during the periods covered in this document is most readily reconstructed from pollen analysis (palynology), supplemented by the evidence from other indicators such as plant macrofossils, insects and sedimentology. This survey makes no pretence at exhaustiveness and the associated literature is vast. Reviews of vegetational history, often with a specific focus, may be found in Edwards and Ralston (1984), Tipping (1995; 2004), Edwards and Whittington (1997a, b; 2000; 2001), and Walker and Lowe (1997). Area-specific contributions include Keatinge and Dickson (1979), Birks and Williams (1983), Edwards and McIntosh (1988), Edwards (2000), Edwards et al. (2000b, 2005), Tipping and Milburn (2000), Tipping (2008), and Green and Edwards (2009). The techniques of palynology are discussed exhaustively in Dimbleby (1985), Faegri and Iversen (1989), and Moore et al. (1991). For the evidence from plant macrofossils, readers are directed to Godwin (1975) and Dickson and Dickson (2000); climate change events *per se* are summarised by Tipping (see **Table 1**).

3.2.2 Lateglacial times

The Late Devensian ice sheet maximum (Dimlington Stadial) covers the period 26–13 kyr BP (24000 – 11000 cal BC) and probably reached its maximum around 20 kyr BP (18000 cal BC), although this would have varied spatially. By 13000 ^{14}C years BP (11000 cal BC) deglaciation had probably affected virtually everywhere in Scotland. The disappearance of the main ice sheets from towards the end of the Devensian ice age left northern Britain devoid of a vegetational cover and with many areas having only glacially-derived material overlying the bedrock. From this time, a vegetational recolonization occurred. Although the ensuing interstadial period was relatively warmer, it was also one of overall declining temperatures and temperature oscillations. At the end of the Lateglacial Interstadial there was a severe cooling which lasted *c*. 1000 radiocarbon years from *c*. 11 kyr BP (9000 cal BC). During this time local ice sheets were re-established and some valley glaciers reappeared (the Loch Lomond Stadial period).

The accumulation of palynological information for the Late Devensian period has been extensive. There are virtually no regions of Scotland that have not been explored. Even such areas as the Outer Hebrides and the Shetland Islands, where it was once thought that records for this period were lacking. In some areas the sedimentary records are interrupted due to the resurgence of ice during the Loch Lomond Stadial period, revealing a retrogression in the vegetational recolonization process.

The vegetational history of the Lateglacial Interstadial period may be considered from several standpoints, although it is not possible to consider all of these in depth here. The number of sites with records from this time allows a general picture of the recolonisation progress to be established. Given the latitudinal extent of Scotland, it might be asked whether, within the overall development, a north-south contrast in vegetation at any one time came into existence or was the recovery in temperature swift enough to nullify this effect? It is also feasible that an east-west contrast came into existence due to the dominance of oceanicity in western areas and greater continentality in the east. Depending upon the concentration of sample sites and the level of pollen counting resolution, it is also possible to show variation in vegetational cover on a local scale arising from differences in topography and especially of aspect. A frequent spectre in such deliberations, however, is the inadequacy of the dating evidence. The bulk of this dating for Lateglacial sites involves radiocarbon and much of this was undertaken during the 1970s, a time when dates were relatively expensive to obtain and they consisted of bulk ^{14}C dates covering considerable thicknesses of deposit rather than small samples (especially of plant macrofossils). The advent and wider availability of AMS dating has helped to change this situation, although a reduction in research related to Lateglacial palynology means that good dating frameworks are lacking. Published exceptions include Loch an T-Suidhe in Mull (Lowe and Walker 1986) and West Lomond in Fife (Edwards and Whittington 1997c).

The earliest sediments of Devensian Lateglacial limnic deposits are either devoid of or possess very few pollen grains. At this time vegetational colonization was being undertaken by liverworts and mosses and the filaments of *Drepanocladus* are frequently encountered. Throughout the interstadial period the landscape was open and the flora displays many arctic or alpine associations typical, in part, of bare or unstable soil; at the same time, the sediments of the period are not infrequently relatively organic, reflecting areas of some soil stability. Among the commonest taxa were Poaceae (grasses), Cyperaceae (sedges), *Betula nana* (dwarf birch) and *Salix herbacea* (dwarf willow). Although it is sometimes difficult to be certain of separating the pollen of these two latter taxa from their arboreal relatives, the presence of macrofossils, particularly leaves, bears witness to the species involved. Further common components of the vegetation included *Empetrum nigrum* (crowberry), *Juniperus communis* (juniper), *Artemisia* (mugworts), Asteraceae (daisy famililY), *Filipendula* (meadowsweet), *Rumex* (sorrels), Ranunculaceae (buttercup family) and Caryophyllaceae (pink family). Aquatic vegetation also developed - shallow water bodies would have allowed rapid warming – with seed dispersal undoubtedly assisted by wildfowl and migratory birds. The pollen of *Myriophyllum alterniflorum* (alternate water milfoil) does in some instances, reach values of 40% total pollen, while *Nymphaea* (white water lily) and Potamogetonaceae (pondweeds) were also found.

From the above it should not be concluded that the landscapes of the Late Devensian Interstadial in Scotland were not only very open with unstable soils, but also a dreary waste of grasses and sedges with some dwarf shrubs and heathland. This would fail to recognize that certain dominant taxa (especially Cyperaceae, Poaceae and *Betula nana*) are prolific pollen producers. Present throughout most of this period were many herbaceous taxa, many insect-pollinated, which do not need to produce abundant quantities of pollen. To the plants already mentioned may therefore be added, for example, Brassicaceae (cabbage family), Lactucaeae (dandelion group), Chenopodiaceae (goosefoot family), *Sedum* (stonecrops), *Thalictrum* (meadow rues) and even *Koenigia islandica* (Icelandic purslane) which today is only found at restricted locations in Skye and Mull.

Attention has already been drawn to the fact that the period of the Lateglacial interstadial was affected by considerable climatic oscillations. These had been shown palynologically and sedimentologically in many pollen sequences from Continental Europe (e.g. Fletcher et al. 2009; Ilyashuk et al. 2009), but Scottish ones, in general, seemed to be somewhat insensitive to such episodes. It was the availability of the record obtained from cores taken from the Greenland ice sheet which first provided proof of these oscillations, although correlating them precisely with events in the Continental pollen records has been hampered by problems of dating (Lowe *et al*. 2008; Walker *et al*. 2009). Whatever the dating precision, eastern Scotland (and perhaps sites elsewhere; Tipping 1991a, b; Edwards *et al*. 2000a) seems to provide sites which reveal sequences of many of the traditional climatic interludes, e.g. Stormont Loch (Caseldine 1980), West Lomond (Edwards *et al*. 1997c), Lundin Tower (Whittington *et al*. 1996), Pickletillem (Whittington *et al*. 1991) and Wester Cartmore (Edwards and Whittington 2010). These sites have often benefited from higher pollen counts and sampling resolution.

The Greenland ice cores show that around 11k radiocarbon years ago there was a renewed decline in temperatures. There is no doubt that this event was also experienced in Scotland. The very large number of pollen records that have data from this period all show a change from the pollen assemblage of the interstadial period. This heralded the start of the Loch Lomond Stadial period. During this time tundra conditions were experienced, but the constituent taxa of the vegetation involved apparently varied from area to area. Almost everywhere Poaceae and Cyperaceae pollen became the dominant herbaceous taxa along, variously, with *Artemisia* and *Rumex* while *Salix herbacea* and *Betula nana* frequently increase. Spore-bearing plants such as *Huperzia selago* (fir clubmoss) and *Selaginella selaginoides* (lesser clubmoss) appear to have been prevalent. Virtually all such polleniferous deposits are found within a minerogenic sediment matrix deriving from eroded soliflual soils.

Expansions in microscopic charcoal have been found in pollen samples of Loch Lomond Stadial age over many parts of Scotland, as well, to a lesser extent, in sites of Lateglacial Interstadial age (Edwards *et al*. 2000a). Although human activity might be implicated in this phenomenon, there is probably more support for a natural cause associated with climatic aridity. It would be useful if charcoal analyses were to be carried out in close proximity to any archaeological sites proven to be of Palaeolithic age.

3.2.3 The Holocene

Following the demise of corrie glacier activity at the end of the Lateglacial period there was a rapid warming of temperatures to levels probably greater than those of today (Atkinson *et al*. 1987). This climatic change, coupled with the development of soils, facilitated the spread of woodland across the existing open, herb- and shrub-dominated landscape. Mapped reconstructions portray the dominant tree types prior to major discernible human impacts *c.* 5000 BP (3780 cal BC) (McVean and Ratcliffe 1962; Bennett 1989; Tipping 1995; Edwards and Whittington 1997a), although it is probable that a woodland mosaic existed in most areas. Research in peripheral areas suggests that they were wooded for much of the first half of the Holocene (cf. Wilkins 1984; Bohncke 1988; Bennett *et al.* 1990, 1992; Edwards 1990, 1996; Brayshay and Edwards 1996; Fossitt 1996). The density of the arboreal cover may be in question and the effects of long-distance transport of pollen can be significant (Tyldesley 1973; Donaldson et al. 2008; but see Brayshay *et al*. 2000).

Radiocarbon dating shows a marked time-transgressive nature to the spread of many woodland taxa (Birks 1989). For instance, tree birch (*Betula* spp.) was established over most of Scotland by 10000 BP (8050 cal BC); oak (*Quercus*), present in southern Scotland shortly after 8500 BP (7530 cal BC) did not reach Aberdeenshire and Skye until about 6000 BP (4870 cal BC); and the principal areas colonized by *Pinus sylvestris* (Scots pine) in Scotland may have come from multiple source areas at various times (Bennett 1984; Froyd and Bennett 2006).

A common feature of pollen diagrams is the prominence of *Corylus avellana* (hazel) representation and its maintenance from around 9000 BP (8030 cal BC). This phenomenon is sometimes ascribed to hunter-gatherer impacts and possible resource manipulation (e.g. coppicing or burning to enhance woody growth and enhanced hazel nut yields, which at the same time could increase flowering and pollen production [Smith 1970]). However, for Scotland, Edwards and Ralston (1985) noted the existence of high hazel values even for areas distant from likely Mesolithic activity, while a study of microscopic charcoal at a number of sites in Scotland (Edwards 1990) revealed no correspondence between enhanced fire incidence, as inferred from charcoal, and early maxima for hazel type pollen. Huntley (1993) explored a series of hypotheses concerning the spread of hazel and concluded that climate was likely to be the primary underlying cause. This in no sense denies the usefulness of hazel nuts and hazel wood products to Mesolithic peoples, nor of the utilization of hazel in a woodland management system.

Uncertainty also surrounds the role of humans in the rise and spread of alder (*Alnus glutinosa*). Following observations by McVean (1956a, b), Smith (1984) implicated Mesolithic people in the expansion of alder pollen. This was held to be subsequent to fire and woodland disturbance, and based on the supposition that such activity promoted catchment runoff and waterlogging in habitats favoured by *Alnus.* A number of Scottish pollen profiles do display an increase in microscopic charcoal as alder expands (Edwards 1990; Bunting 1994), but not all. Like the spread of many plants, that of *Alnus* is likely to have a number of contributory causes of which human activity can be one.

Many pollen diagrams display temporary and apparently small reductions in woodland of all species. These perturbations are sometimes accompanied by expansions in charcoal values and human agency may sometimes have been responsible – indeed, lithic artefacts are sometimes known from the pollen sites themselves or their vicinity (e.g. Knox 1954; Edwards *et al*. 1991; Tipping *et al*. 1993; Edwards and Mithen 1995). It remains difficult to separate natural from human causes and equifinality could apply. Woodland has always been subject to disease, death, windthrow, and lightning strikes which could create openings, while grazing activities could have maintained clearings for many hundreds of years (Buckland and Edwards 1984). By the same token, human communities, in using woodland resources for food and shelter, would have disturbed woodland.

Studies which demonstrate plausible impacts upon woodland come from island locations. Archaeological excavations at Kinloch, Rùm have produced one of the earliest known Mesolithic occupation sites in Scotland, with dates on carbonized hazel nut shells extending back to 8590±95 BP (7700–7500 cal BC) (Wickham-Jones 1990). Palaeoecological studies from a site located 300 m from the excavation area reveal sharp and sustained changes in the pollen of alder, hazel, grasses, and willow, together with associated peaks in microscopic charcoal (Hirons & Edwards 1990). Although the interpretation of the patterns at Kinloch is very difficult, they do not seem to represent a natural vegetational succession and human involvement seems likely. At Loch an t-Sìl, South Uist, close sampling of Mesolithic age sediments reveals two phases of woodland removal, mainly involving birch and hazel, at *c* 8040 BP (7010 cal BC) and 7870 BP (6620 cal BC), lasting 130 and 70 radiocarbon years respectively (Edwards 1996a). These are associated with expansions in Poaceae, *Calluna vulgaris* (heather) and charcoal and reductions in ferns. The removal of birch and hazel may have an anthropogenic origin and the expansions in grass and heather could indicate their spread into cleared areas. Whether the extension of browse in order to attract grazing animals was the intention or a useful by-product of cropping woodland, remains unknown. The reduction of ferns is similar to features observed in the east Shetland pollen site of Dallican Water (Bennett *et al.* 1992). At Dallican Water this is taken to indicate possible grazing by red deer which may have been transported to Shetland by hunter-gatherers intent on introducing a valuable resource. In southern Shetland, a double shell midden of Mesolithic and early Neolithic age has been exposed by coastal erosion at West Voe, near Sumburgh (Melton and Nicholson 2004; Edwards *et al*. 2009). Sediments from Loch of Gards, 0.5 km to the southwest, showed vegetational and associated environmental changes for the period covered by the middens (*c.* 4200–3600 and 3500–3250 cal BC) and prior to this. Birch and hazel are both reduced in two phases from *c.* 6000 and 3910 cal BC, with concomitant increases in charcoal and mineral matter to the lake (the latter is inferred to be a consequence of soil erosion). Contrary to the situation of only a few years ago (Edwards 2009), the Outer Hebrides and Shetland have both furnished evidence, arguably, for a material Mesolithic presence (Gregory *et al*. 2005; Edwards *et al*. 2009) which extends beyond the data provided in pollen records. In both archipelagos, more Mesolithic finds are likely to be hidden beneath sea, sand or peat.

Given their speeds of occurrence, rising sea levels and the spread of peat are unlikely to have been greatly deleterious to Mesolithic lifestyles (cf. Edwards & Sugden 2003; Edwards 2004; 2009; Tipping 2008) – indeed they may have brought benefits in terms of increasing the variety of coastal habitats as new estuaries and islands formed and in the supply of peat as a fire and (albeit sub-optimal) grazing resource.

The sustained charcoal peaks found in the Western and Northern Isles, if anthropogenic (and this is an issue that has not been resolved; Edwards 1996; Tipping 1996), do not have to indicate woodland removal by fire or the driving of game, but may simply result from the burning of felled wood or peat for heating or cooking purposes, or the fire-related creation or maintenance of heaths as a grazing resource as has long been mooted for England (e.g. Dimbleby 1962; Simmons 1969; Caseldine and Hatton 1993). This process has also been conjectured for Callanish, Lewis (Bohncke 1988), and also for evidence from sites in South Uist (including Loch an t-Sìl), but only as a possibility (Edwards *et al*. 1995).

Hunter-gathering gave way wholly or in part to agriculture around the turn of the fourth millennium cal BC and many topics relevant to this period of transition can be dealt with in accounts which deal either with Mesolithic or Neolithic times. Relevant issues as pre-elm decline cereal pollen, the elm decline, simulation modelling, soil erosion, and climate change are discussed in the ScARF Neolithic report[3].

3.3 Fauna

There is no comprehensive published account of Scottish fauna through the Lateglacial and early Holocene, and it has to be admitted that the database for reconstructing any such account is inadequate on account of the relatively poor survival of skeletal remains from these periods (Kitchener & Bonsall 1997; Kitchener 1998).

Lateglacial faunal remains in particular are scanty. It is considered, however, that some of the species known as, or suspected to have been, present in Scotland during the Devensian prior to the Late Glacial Maximum did not recolonize in the Lateglacial. The so-called Pin Hole Mammal Assemblage-Zone ('Mammoth steppe') of pre-LGM OIS3 stage Britain has

[3] Follow the links from http://www.scottishheritagehub.com/content/scarf-neolithic-panel-report to the Neolithic panel report.

been defined by Currant and Jacobi (2001; 2011) and it included among the larger fauna the woolly rhinoceros (*Coelodonta antiquitatis*), the woolly mammoth (*Mammuthus primigenius*), bison (*Bison priscus*), giant deer (*Megaloceros giganteus*), lion (*Panthera leo*), reindeer (*Rangifer tarandus*), and spotted hyaena (*Crocuta crocuta*). Of these species the woolly rhinoceros importantly is documented in Scotland from finds made in glaciofluvial sand and gravel deposits in the Bishopbriggs area just north of Glasgow, and the species has a most recent direct radiocarbon date from there of 31,140±170 BP (Jacobi *et al*. 2009a). OIS3 dates for bear bones have also been obtained from Uamh nan Claonite, Assynt, Highland (Birch & Young 2009). Remains of woolly mammoth, giant deer, and the ringed seal (*Phoca hispida* – an Arctic species) have been found in Scotland (Kitchener 1998) and most probably relate to the OIS3 stage, but they have no associated radiocarbon dates.

New research is suggesting some faunal presence during parts of OIS2 and elements of a tentative Dimlington Stadial Mammal Assemblage-Zone, to include a species resisent to extreme cold – the musk ox (*Ovibos moschatus*) – has been proposed (Currant & Jacobi 2011). Thus far there are no dated specimens from this period in Scotland.

The Lateglacial post-LGM mammal fauna (the so-called Gough's Cave Mammal Assemblage-Zone) as known from Britain includes reindeer (*Rangifer tarandus*), wild horse (*Equus ferus*), aurochs (*Bos primigenius*), elk (*Alces alces*), brown bear (*Ursus arctos*), lynx (*Lynx lynx*), wolf (*Canis lupus*), arctic fox (*Vulpes lagopus*), saiga antelope (*Saiga tatarica*), and red deer (*Cervus elephas*) among the larger species (Currant & Jacobi 2001). The principal Scottish location to have produced radiocarbon-dated Lateglacial examples of any of these species is the limestone cave system of the Creag nan Uamh, Assynt, Highland, from where skeletal remains of brown bear, wild horse, and reindeer have been obtained (Murray *et al*. 1993; Birch & Young 2009). Other now extinct species known from the Creag nan Uamh caves are the arctic fox, the collared lemming (*Dicrostonyx torquatus*), the narrow-skulled vole (*Microtus gregalis*), and the northern vole (*Microtus oeconomus*), but their remains have not been directly dated (Kitchener 1998), The need for caution over assigning undated skeletal remains to early periods is shown by another example from the Creag nan Uamh caves, where a lynx bone has a radiocarbon age of 1770±80 cal BP (Kitchener & Bonsall 1997).

There is as yet insufficient evidence to speculate on possible Younger Dryas/Loch Lomond Stadial faunal presence (Currant & Jacobi 2011).

When it comes to the Postglacial period, Kitchener *et al*. (2004) have appraised the evidence for the mammal fauna in Scotland during the Mesolithic. As during the Pleistocene there is a paucity of preserved bone assemblages, although from comparative studies elsewhere in Britain the anticipated species can be more accurately predicted than for the Lateglacial. Definite evidence exists early on for three species which, apparently, then became extinct in Scotland during the Mesolithic (probably in the very early Mesolithic): giant deer, reindeer, and wild horse (Kitchener 1998; Gonzalez *et al*. 2000). This apparent time lag in vertebrate faunal changes across the Pleistocene/Holocene transition is thought possibly to reflect the complexity of the pattern of biome development in the early Holocene, which could have allowed for the persistence of Lateglacial-like refugia for flora and fauna (Coard & Chamberlain 1999). Resolution of the uncertainties of species survival across the transition will depend upon new finds and more accurate radiocarbon dating (Jacobi *et al*. 2009b, 21; cf. Street & Baales 1999).

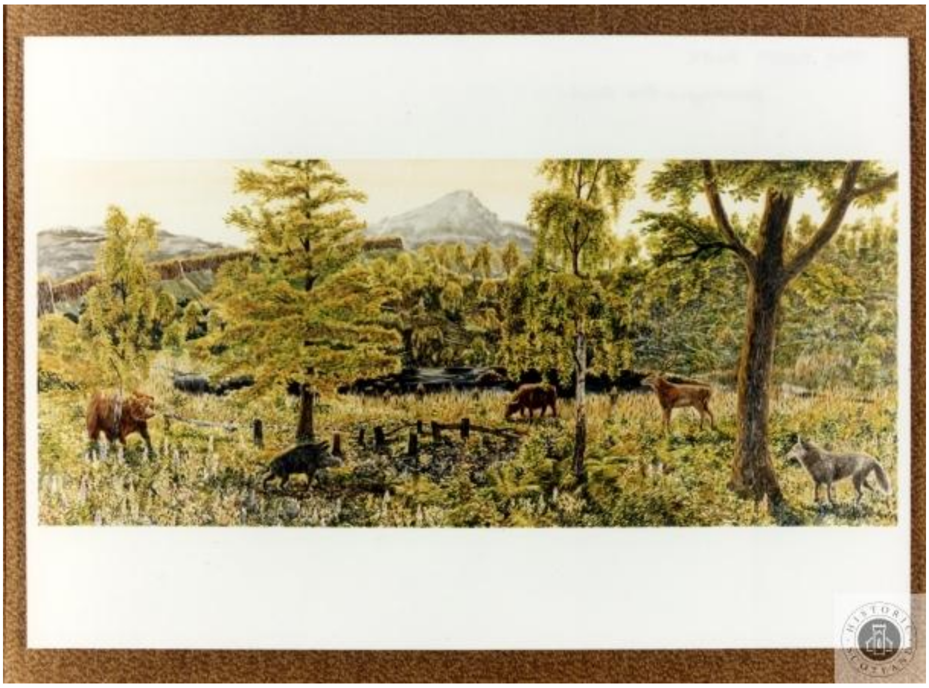

Figure 14: Reconstruction of Mesolithic fauna in Holyrood Park, Edinburgh, Crown Copyright Historic Scotland

Survivors from the Lateglacial which also then survived the Mesolithic period before becoming extinct in Scotland at later periods were the brown bear, elk, aurochs, and lynx, while the red deer, a long-term survivor which was probably present in the Lateglacial is first positively documented during the Mesolithic (Kitchener *et al*. 2004). The beaver (*Castor fiber*) and stoat (*Mustela erminea*) were present in Mesolithic Scotland, but have not been recorded from any actual Mesolithic sites (Kitchener *et al*. 2004). Kitchener *et al*. (2004, table 5.3) have listed the species recorded from various Mesolithic sites, and further discussion of individual animal bone assemblages can be found in Coles (1971; 1983b), Mellars (1987), Hardy and Wickham-Jones (2009), and Bartosiewicz (in press).

There is in fact a relatively substantial amount of information available about the various small mammals, birds, fish, molluscs, amphibians, insects, and microfauna present, or suspected to have been present, in Scotland during the Mesolithic period (see for example Coles 2010; Kenward & Whitehouse 2010; Kitchener 2007; 2010; and see section 3.3.1 below). For the most part these data have not been collated, however, so there is no Scottish equivalent, for example, for Price's work on the small mammals of SW Britain (Price 2003; also listings in Schreve 2004). Also the ability to be certain that particular faunal remains are definitely Mesolithic will normally depend upon radiocarbon dating of individual specimens, since, in the absence of securely stratified Mesolithic horizons, the danger of contamination from more recent material is always present. Furthermore, for archaeologists the evidence which does exist can be fairly obscurely or only partially published, requiring determined research to track down, for example in the case of the Mesolithic amphibia from the Creag nan Uamh caves (Gleed-Owen 1999) or the early Mesolithic ducks from Puggieston, Angus (Smith & Jones 1976).

What needs to be emphasized is the archaeozoological importance of Quaternary faunal remains, even when found in contexts with no direct human connection, because of their potential for chronology and palaeoenvironmental reconstruction (e.g. Kolfschoten 2006). It is also worth noting the wider benefits which can accrue in terms of public interest and education when significant discoveries of Pleistocene mammals occur (Ashwin & Stuart 1996; Stuart 1997).

3.3.1. Early to Mid-Holocene marine fauna Species representation in Mesolithic shell middens

Aquatic faunal remains form a significant proportion of many Early to Mid-Holocene shell midden deposits. The range of species represented in each midden is variable, reflecting factors such as local microenvironments, resource selection by humans, and archaeological preservation. For example, at Ulva Cave 36 distinct taxa of shellfish have been identified (Pickard & Bonsall 2009); at Morton the shellfish assemblage was similarly diverse with 37 taxa recorded (Coles 1971). By contrast at An Corran, Skye, 14 genera were recovered from Early to Middle Holocene deposits (Pickard & Bonsall 2009) and at Sand, Applecross, only eight taxa were recorded (Milner 2009).

Fish are reported to be abundant at all sites. Unfortunately, detailed reports of the fish bone assemblages remain scarce. With the exception of Sand (Parks & Barrett 2009) species diversity is generally limited, but this may reflect publication standards as much as prey specialization. Gadidae are recorded at all sites for which information is available, and saithe (*Pollachius virens*) dominates the ichthyofauna recovered from the Oronsay sites (Anderson 1895, 1898; Connock *et al.* 1993; Mellars & Payne 1971; Mellars & Wilkinson 1980).

Sea mammals were recorded at the Oronsay sites, Risga in Loch Sunart, and Sand (Anderson 1898; Grigson & Mellars 1987; Lacaille 1954; Parks & Barrett 2009). Finds include the very large rorqual (*Balaenoptera* spp.), and several smaller species — seals (Phocidae) and dolphin or porpoise (*Delphinus delphis/Phocaena phocaena*).

Brachyurans, or true crabs, are present in most middens. Generally, where data are available, the presence of edible, swimming and green shore crab is reported (e.g. Anderson 1898; Coles 1971; Lacaille 1954). At Ulva Cave at least six species of crab were identified (Pickard & Bonsall 2008). Lobster (*Homarus gammarus*) was recorded at the Oronsay sites (Mellars & Payne 1971). Fine sieving of midden samples from Ulva Cave also led to the recovery of fragments of sea urchin (Echinoidea) tests (Pickard & Bonsall 2008).

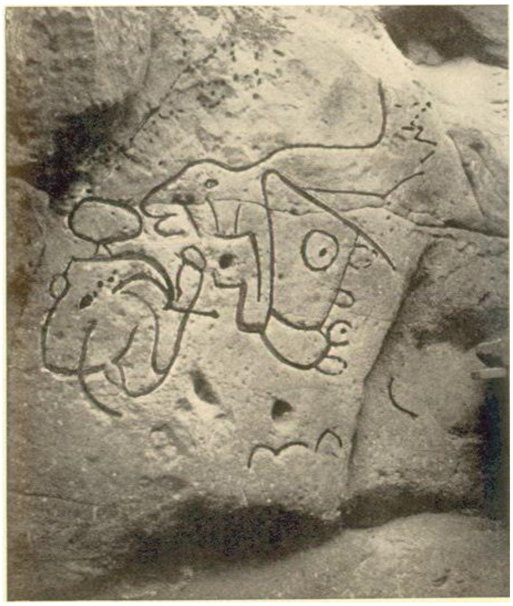

Figure 15: Retouched carving from Michael Cave, Wemyss, Fife (Edwards 1933, 173). The carving has been interpreted as a terrestrial mammal as well as a seal (Kitchener *et al.* 2004, 77).

Other resources foraged on the shore include aquatic algae, inferred from the presence of small shellfish that live on seaweed but would have little food or decorative value. The seaweeds may have been harvested as food, fuel, or for medicinal properties (e.g. Banga 2002; Turner & Clifton 2006). Such shellfish species were particularly abundant at Ulva Cave (Pickard & Bonsall 2009). This may indicate a particular emphasis on seaweed collection at this site, but more likely reflects the sampling strategy adopted (Pickard & Bonsall 2009).

A wide range of aquatic bird species were identified at Morton with sea birds such as razorbill (*Alca torda*), and cormorant (*Phalacrocorax carbo*), comprising a significant proportion of the assemblage; however the relative abundance of the remains was not quantified (Coles 1971). Similar diversity of bird species is recorded at Risga although a distinct range of seabirds, including the now extinct great auk (*Pinguinus impennis*), were documented (Lacaille 1954). The majority of the species represented are seabirds that nest on cliffs or inhabit inshore waters.

Harvesting strategies

Consideration of the behavioural ecology of the shellfish and crustacean species identified may indicate harvesting strategies. Two genera, limpet (*Patella* spp.) and periwinkle (*Littorina* spp.), dominate the west coast midden assemblages. The relative abundance of the major species identified at each of the sites generally reflects that of modern shore populations in the region (Little & Kitching 1996). However, the virtual absence of dogwhelk (*Nucella lapillus*), a common carnivorous gastropod on modern shores, at An Corran may indicate food avoidance practices (Pickard and Bonsall in press). Overall, the evidence points to the adoption of least effort harvesting strategies at most sites (Connock *et al.* 1993; Pickard & Bonsall in press). The majority of the species identified are epifaunal littoral species, i.e. species that live on the substrate surface and occupy tidal regions of the shore. They are most readily collected at low tide with little or no equipment.

Infaunal and sublittoral shellfish and crustacean species that live below low water and/or buried in the substrate are rare at midden sites on the west coast of Scotland, although a recent marine survey attests to their abundance in coastal waters (McKay 1992). Some species such as the king scallop (*Pecten maximus*) were collected not as food but as empty shells for use as raw material (Russell *et al*. 1995). Infaunal bivalves are more characteristic of Mesolithic shell middens on the east coast of Scotland, where soft shorelines are more prevalent. In traditional and commercial shellfisheries bivalves are the most highly valued shellfish in terms of palatability and quantity of flesh (e.g. Gosling 2003). In the Late Mesolithic midden at Morton in Fife one of the most abundant shellfish was Baltic tellin (*Macoma balthica*). Its presence implies foraging in low salinity coastal environments (Coles 1971) consistent with the evidence of extensive estuarine areas near the site around the time of midden accumulation (Chisholm 1971).

Few unequivocal fishing-related artefacts have been recovered from Scottish Mesolithic sites. However, fishing strategies may be inferred from the size of specimens and range of species identified. The small size of many fish recovered and the abundance of gadidae in middens is suggestive of line fishing from the shore at these sites. One of the few items of dedicated fishing gear attributed to the Scottish Mesolithic, a fish hook from Risga (see Morrison 1980: plate XIV), would, if this identification as a fish hook is correct, lend support to this suggestion. Stationary traps or weirs, which are relatively commonplace finds at Mesolithic sites elsewhere in North-West Europe, are not recorded archaeologically. Such installations represent a considerable investment of labour, both in terms of construction and maintenance, and would likely only have been set up near long-term residential camps. It is not clear if any of the known Mesolithic shell midden sites from Scotland fall into this category.

The role of sea mammals in Mesolithic subsistence is equivocal. Their remains are never numerous, but at some sites, e.g. Cnoc Coig on Oronsay, they outnumber those of land mammals. Though likely used for food, seals and other sea mammals could also have been exploited for fur, skin, and intestines, which have traditionally been used in the manufacture of waterproof clothing and vessels (e.g. Lantis 1938). Evidence from Cnoc Coig suggests that skin and blubber were extracted from very young seals, whereupon the carcasses were discarded (Grigson & Mellars 1987). Both harbour seal (*Phoca vitulina*) and grey seal (*Halichoerus grypus*), which are commonly found in near-shore waters, could have been sought on haul-outs and skerries (Grigson & Mellars 1987). By contrast, rorqual (*Balaenoptera* spp.), which was recorded at Risga (Lacaille 1954) is a generally open sea species. Fin whale (*Balaenoptera physalus*), which was tentatively identified at Caisteal nan Gillean I and Priory Midden (Grigson & Mellars 1987), is seldom encountered in inshore waters. As there is no clear evidence for subsistence fishing in open-sea waters (Pickard & Bonsall 2004) and given the size of the fin whale and other rorquals, it is likely that Mesolithic groups exploited occasional stranded animals on the shore — a practice widely documented historically (e.g. Olsen 1999). Although marine mammal remains do occur in some middens, the frequency and pattern of occurrence suggest that their exploitation was often opportunistic.

Seabirds, prized by some historically documented forager societies (e.g. Meldgaard 1988; Oakes 1991) are relatively common in the middens. While they may have been taken primarily for their feathers or skins, their meat may have been consumed and the eggs collected where and when nesting sites were accessible. An interesting but rare occurrence in Mesolithic shell middens is the now extinct great auk (*Pinguinus impennis*). Its bones have been reported only from sites on offshore islands (Oronsay, Risga; Lacaille 1954) — these birds spent their lives at sea and came ashore only to breed, and rocky islands were their preferred breeding grounds. Greenland Inuit are known to have exploited great auks intensively, consuming their meat, intestines, fat, and eggs, and using their fat as oil for lamps, and their skins for clothing and bags (Meldgaard 1988). Like penguins, the great auk is reputed to have been a powerful swimmer, but awkward on land, and their exploitation by Mesolithic people was likely a seasonal pursuit with the birds being captured at their spring breeding sites.

3.4 Relative sea level changes during the last 15,000 years

The relative sea level history of Scotland during the Lateglacial and Holocene (last 15,000 years) is complex. This is due to the overburden of ice when the last Scottish ice sheet covered the region. Ice cover was concentrated in the western Highlands with thinner areas of cover towards the peripheries of Scotland. Thus, the area around Oban in the west had greater thickness of ice than areas of the Outer Hebrides, the North coast and the Northern Isles. This leads to varying amounts of isostatic rebound and therefore, the position in the landscape where relict Shorelines can be seen today.

For the Oban area, this translates to visible shorelines dated to *c*. 10ka BP (c.8000 cal BC) yrs up to 10 metres OD. However, the same Lateglacial Shoreline is well below present sea level in the areas of Coll and Tiree, Islay and the Solway coastline. Predicted shorelines for the Outer Hebrides and the Orkney Isles suggest they are located between 20–30 metres below present.

Figure 16: Location of the Early Holocene iintertidal site at Clachan Old Harbour, Raasay © Sue Dawson

The net result of relative sea level change for Scotland is thus that there are areas where the sea bed has been dry land within the last 15,000 years. As this is the period within which Scotland has an increasing record of human presence, it is likely that these areas were inhabited. They offer the possibility that submerged archaeological sites may be preserved. Perhaps the best known area is that around the Orcadian archipelago where the sea did not reach present levels until about 4000 years ago (SEA4[4]), but another area lies to the west of the Western Isles (SEA7; Jordan *et al*. 2010), and there are small localized areas elsewhere, e.g.: around Coll, Tiree, and Islay. Although there are no specific data on relative sea level rise for these areas, it is assumed that sea level reached roughly its present level between 5000–4000 years ago meaning that any submerged archaeological sites are likely to relate to Mesolithic or early Neolithic settlement. Interestingly, both Orkney and the Western Isles stand out from the rest of Scotland in that they have relatively little evidence for Mesolithic settlement. Mesolithic sites are few and far between in Orkney and even more so in the Western Isles. Given the importance of coastal resources in the Mesolithic and the apparent concentration of sites around Scotland's coastlands this may be significant as an indication that evidence for the first 5000 years of human settlement in these areas is lying off shore. Recent fieldwork in Orkney suggests the probable preservation of stone structures relating to the Neolithic on the seabed (Wickham-Jones *et al*. 2009).

It is also worth remembering that large-scale areas of the Scottish shelf have been dry land for considerable periods over the past 700,000 years as a whole – a period during which there were episodes of human (Palaeolithic) habitation elsewhere in Britain. England and Wales have a good record of early sites (Stringer 2006), particularly in the south, but there are so far no Lower or Middle Palaeolithic sites in Scotland (Saville 1997). Environmental and osteological evidence suggests that this submerged landscape has, at times, been suitable for human occupation (Stringer 2006) and it is possible that surviving Palaeolithic sites from the

[4] Strategic Environmental Assessments (SEA) of North Sea Areas: http://www.offshoresea.org.uk/site/scripts/sea_archive.php).

'Scottish sector' of the sea bed still survive – comparable sites on land having been destroyed or buried by the actions of the last Ice Age which blanketed mainland Scotland.

Submerged archaeology is likely to comprise a considerable resource for Scotland, a resource that, unlike other parts of Britain[5], has been largely neglected to date. Increased pressures on the submarine landscape make the need to deal with this resource ever more urgent.

3.4.1 Sea-level modelling

Increased awareness and considerable research over the past few decades has resulted in the production of various models to illustrate how relative sea-level has changed in the northern North Sea area and around Scotland throughout the Holocene. It will be noted from the following maps (**Figure 17**), however, that there is considerable discrepancy in detail from map to map. This has arisen because of the inexact nature of modelling as a tool. Accurate models depend on using accurate data. While individual models could be refined by the addition of more data, any one model is quickly outdated by new work. It is also true that data localised to Scotland is necessary in order for any model to be of specific use for Scottish archaeology. At present, some parts of Scotland are well represented in the data, while other stretches of coast have little, if any, data. Differential crustal rebound means that extrapolation from one part of Scotland to another will always be inexact. For these reasons, modelling is at present a weak tool with which to manage archaeological information relating to submerged landscapes around Scotland. The maps do, nevertheless, give an impression of the extent of coastal change with which the Palaeolithic and Mesolithic population of Scotland had to contend. The following models are neither 'right' nor 'wrong', they are based on different data.

Suffice it to say, however, that sea-level change during the Lateglacial and early Holocene had profound physical effects on Scotland, which undoubtedly had significant impacts on human inhabitation; sea-level change over this period was sufficiently marked for it to be intimately associated with cultural change (Smith *et al*. 2011).

3.4.2 Storegga tsunami

One of the world's largest submarine slides with a total volume of c. 5,600 km^3 occurred on the continental slope west of Norway. Part of the sediment complex, with a volume of c. 1700 km^3 is believed to have moved as an underwater landslide approximately 7300–7200 radiocarbon years ago (i.e. at *c*. 8110 ± 100 calendar years BP/6160 ± 100 cal BC; Dawson *et al*. 2011). This occurred 'near the end of a period of extreme cold climate' resulting from the 8.2 ka event mentioned in section 3.1 above (Dawson *et al*. 2011, 1170). The sudden movement of sediment across the Norwegian continental slope

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[5] Work on submarine archaeology and landscapes around Britain to date, includes: http://www.st-andrews.ac.uk/~crb/website/website13_4_10/; http://www.arch.soton.ac.uk/Research/Aggregates//shelve-intro.htm; http://www.hwtma.org.uk/projects/bouldnor/index.htm; http://www.iaa.bham.ac.uk/research/fieldwork_research_themes/projects/North_Sea_Palaeolandscapes/index.htm; http://www.wessexarch.co.uk/projects/marine/alsf/seabed_prehistory/2004-2007/map.html; http://www.bmapa.org/archaeology.htm; http://www.science.ulster.ac.uk/cma/slan/ (Wessex 4min video: www.youtube.com/watch?v=TcGBnVI0gM0)

and onto the abyssal plain of the Norwegian Sea generated a large tsunami that was propagated across the North Atlantic and Norwegian Sea regions (Dawson *et al*. 1988). The tsunami affected an area of coastline over 600 km long and deposits have been discovered at numerous coastal locations in western Norway, Greenland, Scotland (including Shetland and Orkney), the Faeroe Isles, and as far south as eastern England (Dawson & Smith, 2001; Bondevik *et al*. 2003; 2005; Smith *et al*. 2004).

Isobase models estimate contemporary sea surface level offshore at c. 14 m below the present day mean high water spring tides. Geological studies of coastal deposits in Scotland and Norway attributable to the tsunami indicate that the tsunami runup exhibits strong local and regional variability. In parts of the Shetland Isles, the runup at the coast may have been as much as between +25/+30m above sea level. The tsunami sediments identified in coastal localities are considered particularly valuable as a synchronous marker horizon.

Given the prevalence for exploitation of the coastal zone at the time this event is likely to have been catastrophic for the human population in part of Scotland.

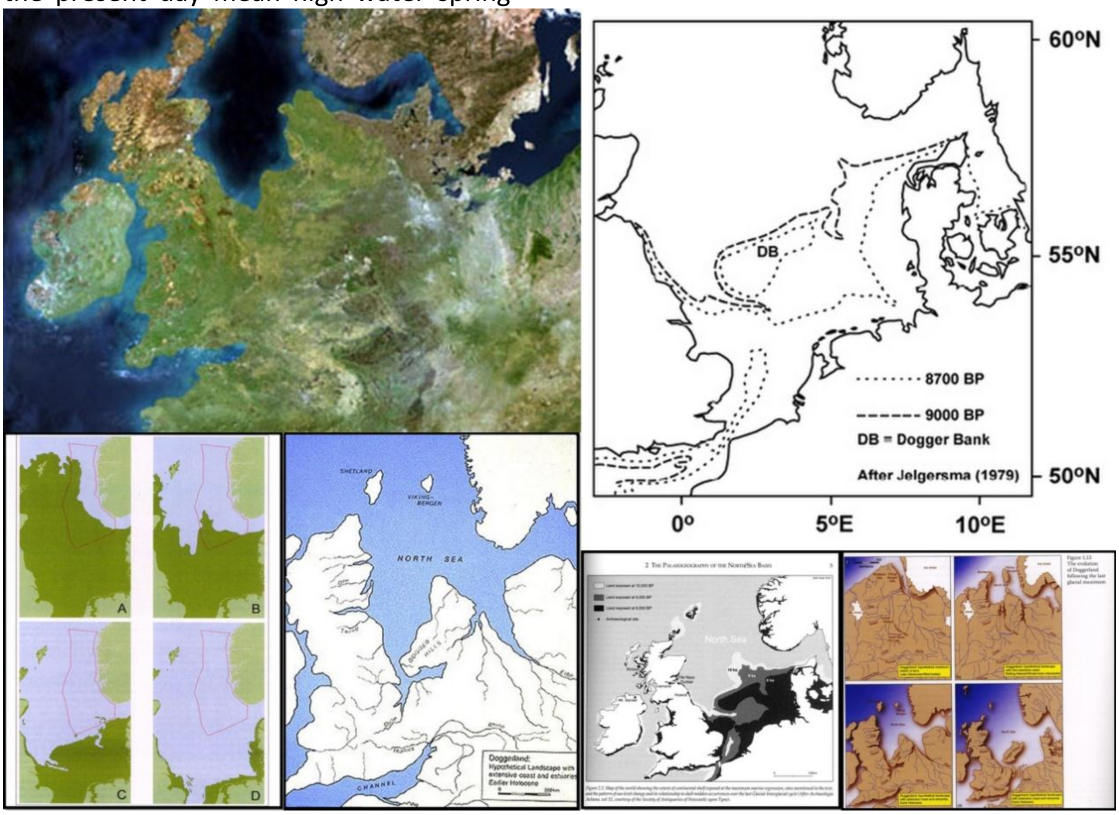

Figure 17: These maps highlight the variety in current models of past sea-level. In order to improve upon these and to help develop predictive models of site survival more high precision data is required. This can be achieved in partnership with other sectors (particularly the energy and aggregate industries) and as part of international projects, such as current work on Doggerland (Gaffney, Thomson and Fitch 2007)[6].

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[6] Follow the Marine and Maritime report links at http://www.scottishheritagehub.com/ to 'submerged landscapes'

3.5 Future research recommendations

Key areas for future work include:

- The effect of the environment on past communities, including both long-term processes and events such as the tsunami, as well as considering the impact of the human presence upon Scotland's environment, vegetation, and animal population.
- Comprehensive surveys of the data available for all aspects of the environment and biotope through the Lateglacial and early Holocene.
- Exploring the development of Scotland's coastline over time based on point data, considering the impact of sea-level change on contemporary populations, and integrating this with established projects including work on Doggerland.
- Development of predictive modelling for submerged site survival, and focused survey for submerged sites in likely locations.
- Liaison with Quaternary scientists over the reconstruction of the North Sea plain and its transgression through the Lateglacial and early Holocene.

4. The Archaeological Record

4.1 Material Culture

Material culture refers to all humanly created or modified physical materials, ranging in size from a tiny bead to a large structure, associated with any person or group. From the Palaeolithic and Mesolithic periods the principal aspect of material culture which survives for recovery by archaeology is that composed of lithic materials which are resistant to decay. Items of non-lithic material culture survive by chance depending on their inherent properties and the nature of the context or contexts in which they have been deposited or re-deposited. This is particularly the case with the Palaeolithic and Mesolithic given the time which has elapsed, as the processes of decay inevitably increase with age. In certain cases it may only be the fugitive traces which survive rather than the items themselves; e.g. when archaeologists record postholes representing the uprights of a former structure or charcoal spreads representing former fireplaces. Material culture is of course critical for the archaeological study of all periods, but becomes of paramount importance for the reconstruction of Palaeolithic and Mesolithic lifeways.

4.1.1 Artefacts

Archaeologically, material culture is most obviously expressed in the form of surviving artefacts. In some cases these will be so specific that they are in themselves diagnostic as to period, which is to say they are typo-chronological markers. In many other cases artefacts may be of multi-period type (such as most flint scrapers) or so generic (e.g. a plain bone pin) that they cannot be dated without being in a context which is otherwise datable, or by being associated with other more chronologically sensitive items, or by being capable of being sampled themselves for radiocarbon dating. In the case of these, earliest expressions of human activity in Scotland the biases of material preservation have over-emphasised the importance to archaeology of lithic artefacts. While stone tools were undoubtedly important it is necessary to remember that they were but part of a rich suite of material goods made of many materials, including wood, bone and antler, and many parts of which have not survived, or not survived in great quantity. The picture to be obtained from stone alone is therefore biased.

This section makes no attempt to give a detailed account of individual artefact types or assemblages, but provides a summary of the artefact types involved, together with key references, which themselves contain the detailed further references to relevant publications and research.

Other than isolated finds of Lower Palaeolithic handaxes introduced in modern times (Saville 1977), the only genuine Palaeolithic archaeological residues so far detected in Scotland consist of Late Upper Palaeolithic artefacts of flint, chert, and quartz. These can be characterized very broadly as comprising the following types and attributes indicative of successive phases of the Lateglacial. (Note that using cal BC dates for the time before the earliest reliable radiocarbon dates for archaeological assemblages from Scotland [i.e. the early Later Mesolithic dates from Cramond] is fraught with various difficulties and those given here must be regarded with caution)

13,000–12,000 cal BC

To this period pertain tanged points, angle-backed points, *Zinken*-type piercers, *becs*, end-of-blade scrapers, double end-of-blade scrapers, burins, *en éperon* preparation technique, large, platform-struck bipolar blade cores, imported flint & chert (Creswellian / Hamburgian (Havelte) / Magdalenian traditions) (Ballin *et al*. 2010a).

11,800–10,700 cal BC

This period exhibits curve-backed points, straight-backed points, short scrapers, microliths, local flint and other local raw materials, e.g. quartz (*Federmesser* / Curved-Backed Point traditions; Saville & Ballin 2009).

10,200–9,800 cal BC

Elsewhere in Britain this period is characterised by 'small', gracile tanged points and long blades but is as yet unconfirmed in Scotland ('Ahrensburgian' tradition; Ballin & Saville 2003)

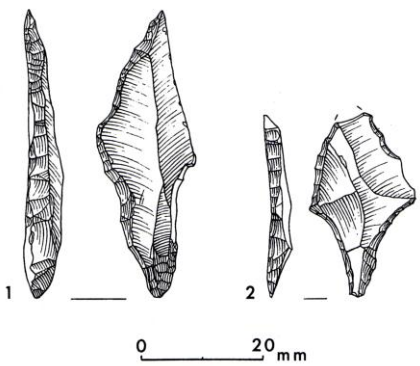

Figure 18: Lithics from Sheildaig and Balevullin ©Alan Saville

Mesolithic material culture remains are still dominated by struck lithic artefacts as in the Palaeolithic, but in a wider range of silicious raw materials. Tool types represented include: microliths, scrapers, burins, piercers (incl. *meches de fôret*), and with microburins an important waste element. Insofar as these are indicators of phases within the Mesolithic some diagnostic types point to Early and Later horizons as follows:

9,800–8,500 cal BC

This period exhibits predominantly broad blade production: obliquely blunted point microliths, 'large' isosceles and equilateral triangle microliths, microburin technology ('Early Mesolithic' tradition; Saville 2004c).

8,500–4,500/4,000 cal BC

This period exhibits predominantly narrow blade production, though also broad blade forms: small geometric microliths, especially scalene triangles and crescents, platform-struck cores and bipolar anvil-struck cores, obliquely blunted point microliths, microburin technology, blade technology, conical and cylindrical blade cores, scalar (bipolar) cores, scrapers of various forms, hammerstones of various types including bevel ended pieces, pyramidal bladelet cores, often very small ('Later Mesolithic' tradition; Mithen 2000; Saville 2004c; Wickham-Jones 1990).

It should be noted that some production techniques previously thought to be in themselves indicative of period, such as Levallois reduction and bipolar anvil flaking can be of multi-period occurrence. There is a possibility that microlith production is less common towards the end of the period and that there is a potential increase of bipolar technology towards the later Mesolithic.

Figure 19: Barbed points ©NMS

Significant residues of other categories of stone tools and artefacts of organic materials survive from the Mesolithic period in Scotland, including those listed below. Many of these types of artefacts may also have been made and used in the Late Upper Palaeolithic, but so far none have been recovered.

- ‘Coarse’ stone tools: hammers, anvils, bevel-ended tools, waisted pebbles, countersunk pebbles, hourglass perforated ‘maceheads’, pebble axeheads, abraders (pumice) (Clarke 2009; Saville 2009).

- Bone tools: points, knives, bevel-ended tools, chopping blocks (Mellars 1987; Saville 2004c).

- Antler tools: barbed points, bevel-ended tools, beam ‘mattocks’ (axeheads?); Direct AMS dating so far suggests dates at around 5000 cal BC for the ‘mattocks’, between *c*. 7000 to 4600 cal BC for the barbed points, and *c*. 7500 cal BC to beyond the Mesolithic for the bevel-ended artefacts (Saville 2004c; Smith 1989).

- Teeth: boar’s tusk ‘chisels’ (probably used as blades inserted into antler, bone, or wooden sleeves).

- Shell: ornaments (‘beads’), scoops, scrapers, containers (Hardy & Wickham-Jones 2009; Mellars 1987; Saville 2004c).

- Ochre: ‘pencils’ (Coles 1971; possibly also used in the Late Upper Palaeolithic; see Saville & Ballin 2009, 38-39).

Figure 20: Oronsay beads from a midden: © SCRAN/NMS

Types of artefact currently missing from the record, but presumably existing in the past (and evidenced from other parts of Europe and the UK), include: fish-hooks (unless the barbed point fragment from Risga was one of these [Morrison 1980, plate XIV, far right]); baskets; nets; rope / string, antler frontlets; stone / shale beads (Saville 2009); anything made from hide or skin, including clothing; amber pendants / figurines; bone / tooth / tusk beads; any artefacts of wood – including bows and arrows, paddles, logboats, fish-traps, and bark containers; and any items combining different raw materials, such as skin-covered wooden boats/canoes and hide-covered timber structures.

Raw materials

For flaked stone artefacts in Palaeolithic and Mesolithic Scotland a wide variety of types of silicious rock was exploited. In the case of the earliest Late Upper Palaeolithic, types of flint and chert not otherwise known from Scotland were brought in by hunting groups, probably in the main as preforms or finished tools (Ballin *et al*. 2010a). In the later Late Upper Palaeolithic and all through the Mesolithic it would appear that only locally available raw materials were exploited. Apart from the more readily available flint, to be found in redepoited form in beaches, rivers, and gravels, the southern Scottish chert, and the near ubiquitous but hugely variable quartz, Mesolithic people were adept at seeking out usable materials such as baked mudstone, bloodstone, chalcedony, pitchstone, and jasper (Coles 1971; Saville 1994a; 2003; Wickham-Jones 1986). There is a strong possibility in the case of chert exploitation from the Southern Scottish Uplands that Mesolithic people were the first to use quarrying as a technique to obtain fresh raw material (Warren 2001; 2007b; Ward 2007).

Water-worn cobbles from beach, river and gravel sources are the dominant tool blank for Mesolithic coarse stone tools (Clarke 1990; 2009; Mithen 2000). No specific source for the exploitation of naturally occurring ochre clay has been identified in Scotland, but ochre is available quite widely. Pumice was collected from beaches and would also have been widely available, though in restricted quantity in any one location. Shells similarly were collected from beaches, no doubt in most cases as a 'secondary product' following the harvesting of shellfish for food or bait.

Deer antler could be collected after being shed naturally, but was also on occasion taken from hunted animals, as of course was the bone, sinew, and skin of deer and other animals for use in artefact manufacture.

4.1.2 Structures

Upper Palaeolithic

None have been found, but temporary tent-like structures are assumed to have been present at open-air camp sites of any duration, as must have been the case at Howburn (Ballin *et al*. 2010a), and there is likely to have been use of any suitably available rock-shelters and caves, as at Kilmelfort (Saville & Ballin 2009).

Mesolithic

The evidence for the, admittedly rather ephemeral, structural remains known prior to 2000 was listed and discussed by Wickham-Jones (2004). It comprised a variety of stone, posthole, and stakehole settings, hearths, depressions, and other vague traces inferred from charcoal and artefact spreads, though there was also the suggestion of a circular post-built structure having been found at Nether Mills, Aberdeenshire, which has not yet been published fully (Kenworthy 1981) . Since then it has become clear that some much more substantial hut-like structures with sunken floors were being constructed by Mesolithic people (Waddington 2007), and a Scottish example has been excavated at East Barns in East Lothian (Gooder 2007; Gooder & Hatherley 2003). The large circular pit at Staosnaig, Colonsay, may also have been the base for a hut (Mithen 2000, 432), and possible further round huts are reported from Elgin (Suddaby 2007). Mesolithic people also appear to have dug pits for various purposes, some of which may be associated with above-ground structures for which no evidence survives (Murray *et al*. 2009).

Mesolithic use of caves and rockshelters in Scotland has long been documented (e.g. Lacaille 1954; Tolan-Smith 2001; Hardy & Wickham-Jones 2009; and see section 4.2.2 below).

4.2 Site Types and Character of Archaeology

Figure 21: Reconstruction of the Mesolithic settlement at Sand, Applecross in Wester Ross, by Phil Austin. Thanks to the Society of Antiquaries of Scotland for permission to reproduce. This image is part of the Scotland's First Settlers Project, available for free download as a SAIR: www.sair.org.uk/

4.2.1 Cave and Rock-shelter Sites

As shelters, depots, landmarks, and tombs, caves have provided a focal point for human ritual and subsistence activities over a significant time period. Caves also preserve a record of past faunas and environments, as well as documenting , as natural geological structures, the geomorphological history of the wider landscapes and littoral zones. Due to their relatively stable microclimates and natural protection from the more usual external taphonomic threats which impact on archaeological deposits on the surface, cave sites generally provide enhanced preservation including organic materials. As such, archaeological evidence from caves allows a glimpse of past societies' cultural understanding of natural places in the landscape. The inaccessibility of some caves also suggests that specialised knowledge and equipment would have been essential prerequisites for their utilisation, rather than simple opportunism.

While Scotland has a record of cave archaeology, most of this work was undertaken during the late 19th and early 20th centuries, at a time when archaeological techniques and fieldwork publication were not comparable with those today. There has also been a profound coastal bias, e.g. the cave and rock shelters around Oban (Anderson 1895; 1898; Turner 1895; Bonsall & Robinson 1992; Bonsall *et al.* 1993; Bonsall & Sutherland 1992; Bonsall 1996; Saville & Hallen 1994). The coastal bias is replicated in many wider landscape survey projects investigating the earliest settlement of Scotland. The geomorphology of natural caves and rock shelters has also received limited research, a major gap in knowledge that will have to be addressed if sites where potentially Mesolithic and more specifically Palaeolithic archaeological deposits exist, are to be targeted. It is widely accepted that the major glacial events of the Devensian and the Loch Lomond Readvance are responsible for the destruction of sites on the surface relating to the earliest settlement of

Scotland. Therefore, the potential preservation of Palaeolithic and Mesolithic deposits in caves is significant, including sites submerged through the effects of deglaciation and changing sea-levels.

One promising non-coastal cave complex that has witnessed much attention is at Creag nan Uamh, Assynt, Highland, originally interpreted as a likely site of Upper Palaeolithic activity on the basis of a rich faunal assemblage including reindeer (Peach & Horne 1917; Callander *et al.* 1927; Cree 1927), the deposits have since been reinterpreted (Murray *et al*. 1993; Birch & Young 2009; Saville 2005; Kitchener 1998; Kitchener & Bonsall 1997). The Pleistocene and early Holocene faunal assemblages from the Creag nan Uamh caves are of significant importance to Quaternary studies in Scotland, while subsequent analysis and documentary research (Lawson 1981), artefactual analysis and radiocarbon dating of human remains (Saville 2005) have proved that the recovered archaeological material relates to post-Mesolithic activity.

Figure 22: Alt nan Uamh Cave (Creag nan Uamh), Assynt © RCAHMS

Recent archaeological fieldwork projects investigating cave sites have included Ulva Cave, Mull (Bonsall *et al.* 1989; Bonsall *et al.* 1994), the caves and rock-shelters of Argyll (Smith 2001), and the Scotland's First Settlers Project (Hardy & Wickham-Jones 2009) that investigated the seascapes of the Inner Sound between Skye and the adjacent west coast Mainland. Results of this work indicate the widespread human use of caves and rock-shelters during the Mesolithic and through subsequent periods of time. The prolonged use of sites evidenced in these projects is generally typical of cave occupation in Scotland (Leitch 1987; Martin 1984: 122-7) and elsewhere in Britain (Branigan & Dearne 1992) and Ireland (Drew 2006). Little new fieldwork is currently being undertaken in cave sites in Scotland today and as a result there are significant gaps in knowledge of cave use from the Palaeolithic and Mesolithic periods. It is here that re-evaluation of existing material, offers most potential. One example of this is the reassessment of the lithic assemblage from Kilmelfort Cave, Argyll (Coles 1983) where a late Upper Palaeolithic date is now proposed on typological grounds (Saville 2004a, 210; Saville & Ballin 2009).

As repositories of archaeological deposits and information through time it is important that the contents of caves are investigated in an all-embracing way including the varied inputs of material into the site, the study and analysis of all materials and their relationships (whether deposited by humans or other agencies). Only in such a way can researchers expect to understand the complex taphonomic variables that exist in such sites. Caves also act as good natural sediment traps and are significant for their potential to preserve deposits pre-dating the last glacial maximum, as evidenced in the recent work in caverns at Uamh an Claonaite, Assynt, Highland (Birch & Young 2009).

Studies that quantify and evaluate the value and conservation status of archaeological cave deposits (e.g. Holderness *et al.* 2007; Chamberlain & Williams 2000; Drew 2006) and promote more integrated research networks[7] offer some successful models that could be further developed in Scotland. Working with caving groups to help identify archaeological deposits and avoid disturbance can yield worthwhile results, as at High Pasture Cave[8] and the Grampian Speleological Group is now setting a good example of this with its recent work in the Assynt caves.

The extensive investigation of cave sites elsewhere in Britain and Ireland has revealed a wealth of information relating to their use. The discovery of 'Cheddar Man' in Gough's Cave (Jacobi 1985; Stringer 1985; Cook 1986) and the only early postglacial cemetery at Aveline's Hole in the Mendip Hills (Garrod 1926; Schulting 2005), have shown the potential of caves to inform knowledge of funerary practices. Rock art has also been more recently identified at Aveline's Hole and at Creswell (Pettitt *et al*. 2008). Using sound heuristic methodological approaches it may be possible to produce new and important information from cave sites pertaining to the earliest settlement of Scotland although the time-consuming and long-term commitment required for new field work campaigns (and the potential for negative returns) also needs to be acknowledged.

4.2.2 Middens

Middens have always loomed large in the study of Mesolithic Europe (Milner *et al*. 2007). The historical legacy of the 'Obanian' (see the boxed example on the Obanian), has exerted a powerful influence on perceptions of coastal habitation and the significance of shell midden deposits in Scotland; so much so that midden sites have been considered a defining characteristic of the Scottish Mesolithic, often viewed as part of a putatively mobile life-cycle. Yet they are rare in the Scottish Mesolithic and new Mesolithic sites are rarely middens; e.g. in 2004/5 six new Mesolithic sites were found in Scotland and none were midden sites. Existing midden sites display little consistency in size and content, some contain evidence for internal structures; some appear to result from specialised activities. Middens occur in a variety of locations from rock-shelters and caves to open-air shorelines and there is considerable chronological variation. Some go on to be used in later periods, and are often associated with Neolithic and Bronze Age activity, including burial (Pollard 1996; Saville *et al*. in press).

The rich organic preservation, as found within a midden, is unusual by Scottish standards so that midden sites have been well studied. Nevertheless, research has tended to lump the remains together as if they represent a uniform phenomenon, despite the fact that in many cases all that they have in common is the presence of marine shells within a coastal location.

Midden sites vary greatly in size. Scottish middens rarely occur as upstanding monuments. The large mounded middens of Oronsay are almost unique; only Risga, Loch Sunart, Highland, is also an upstanding midden and it is much smaller. The Forth Valley middens comprise visible mounds but they are composite sites stretching over a considerable period of time and have proved hard to interpret. There are Mesolithic dates (generally 4th millennium BC; Ashmore 2004a; 2004b) from the lower levels of Inveravon, Mumrills, and Nether Kinneil, and these are backed up by the discovery of a series of Mesolithic bone and antler tools from the same area, but there has been no detailed work of the scale carried out on the west coast sites, and that which has taken place shows that some of these

[7] see http://www.uplandcavesnetwork.org/
[8] http://www.high-pasture-cave.org/

middens continue inuse into the Iron Age (Sloan 1982; 1984; 1989; 1993).

Other Scottish middens are much smaller. At Loch a Sguirr, Skye, little more than a vestige of midden survives inside a rock-shelter (Hardy & Wickham-Jones, 2009). Perhaps this is closer to the norm for Mesolithic sites generally. Even where conditions are favourable it is the presence of shells rather than bone that gives the Mesolithic midden its characteristic form. All sites must have contained some organic material, but most of it has decomposed over the millennia to leave only a black sticky deposit. Between Oronsay and Loch a Sguirr a series of sites completes the size range. The recently excavated midden at Sand, Applecross, measures roughly 8 x 8m (no more than 50 cu m), and could have built up over one or two intensive episodes of shellfish exploitation (Hardy & Wickham-Jones 2009). That at An Corran, Skye, on the other side of the Inner Sound, is larger and has Neolithic and later activity in the upper levels (Saville & Miket 1994a; 1994b; Saville *et al.* in press).

Figure 23: Midden remains from Morton Farm, Tentsmuir, Fife ©SCRAN

The middens of the well known Oban Cave sites are difficult to estimate in terms of size due to the early date of excavation and the fact that they were often disturbed before archaeological work took place. This latter factor also applies to those Oban sites discovered in recent times such as Raschoille (Connock 1985) and Carding Mill Bay (Connock *et al.* 1992). In the east of Scotland there are fewer surviving middens, but the best known, at Morton, was neither upstanding nor large, though upstanding middens may have existed along the mouths of the River Tay (e.g. Broughty Ferry; Lacaille 1954), and around the Moray Firth (e.g. Milltown of Culloden; Wordsworth 1992).

Many midden sites date to the later part of the Mesolithic: Oronsay, Morton, and the Forth valley sites all have dates in the fourth and fifth millennia BC (Ashmore 2004a; 2004b). There are other midden sites with earlier dates: Sand, Druimvargie (Oban), and Ulva all have dates that relate to the sixth and seventh millennia BC (Ashmore 2004a; 2004b). Ashmore's list, and the more comprehensive list of Mesolithic dates[9] serve as a reminder that middens can occur at any point in the Mesolithic (see **Table 2**).

Published accounts of midden sites vary greatly in quality, but it is often possible to extract some interesting information, notably the great variety of material that makes up the bulk of the midden. Some middens are limpet dominated, some dominated by cockle, and some by oyster. Recent work at Sand has highlighted the importance of crab (Milner 2008) and this is supported at both Oronsay (Mellars 2004) and Morton (Coles 1971) while some sites contain deposits of fish bones (Parks & Barrett 2009). Animal bone may be of less importance in the make-up of most sites, but some have significant assemblages of bird bone, most notably at An Corran (puffin; Bartosiewicz in press). Resources such as seaweed, samphire, birds' eggs, and sea urchins, all of which are less likely to survive in the

[9] Available to download at http://www.scottishheritagehub.com/content/scarf-downloads-0

archaeological record, are often overlooked as a likely resource exploited by early peoples. The value of midden sites as indicators of terrestrial fauna and exploitation is also worthy of emphasis.

The differences in midden make-up are not confined to food remains. There is evidence for internal structures at Oronsay and Morton, but not at Sand or An Corran. There is also variation in the artefactual component, though this is more difficult to quantify due to the differing standards of excavation. Some middens contain microliths (Sand), others do not (Oronsay). The lithic assemblages often lack formal 'retouched' tool types, such as scrapers. Few midden excavations have considered remains lying outwith but adjacent to the midden. The recent work at Risga, however, yielded large quantities of lithic artefacts including knapping debris, microliths, and scrapers from an area to the side of the midden (Pollard *et al.* 1996), and these were also present at Morton (Coles 1971). Midden data are essentially incomplete until the adjacent non-midden areas that relate to each site have been excavated. At Sand, for example, large quantities of heat-fractured stone were found on the slope below the midden. In other (later) circumstances this might have been considered more akin to the remains from a burnt mound, but at Sand it was regarded integrally as evidence of the broader spectrum of activities that had taken place (Hardy & Wickham-Jones 2009). Bone and antler artefacts such as bevel-ended tools are present on many sites, as is a range of cobble tools including hammerstones and bevelled pebbles.

In summary, midden sites are by no means common in the Scottish Mesolithic record, but because of the rich environmental and artefactual remains they produce they play a dominant role in accounts of the period. The wide range of material recovered from midden sites has made comprehensive analysis and publication difficult, and this has hindered interpretation of the way in which these sites should be fitted into the picture of Mesolithic Scotland as a whole.

Table 2: Date spans for midden sites in Scotland (information from Ashmore 2004a & 2004b). NB: these dates are based on a variety of raw materials, and some were taken several years ago. The dates from Morton A have not been included because of uncertainties over the (mixed) sample

Site Years BC	7500-7000	7000-6500	6500-6000	6000-5500	5500-5000	5000-4500	4500-4000	4000-3500
Druimvargie, Oban	X	X	x					
Sand		X	x		x			
An Corran		X	x		x			x
Raschoille		X	x	X	x			x
Ulva		X	x			x		x
Castle Street, Inverness		X	x	X				
Loch a Sguirr			x					
Lon Mor			x		x		x	
Morton B				X	x	x	x	x
MacArthur Cave, Oban				X				
Risga					x	x		
Caisteal nan Gillean, Oronsay					x	x	x	

Forth Valley sites	x	x	x	x
Cnoc Sligeach, Oronsay		x	x	x
Cnoc Coig, Oronsay		x	x	x
Priory Midden, Oronsay		x	x	
Muirtown, Inverness		x	x	
Carding Mill Bay			x	x
Caisteal nan Gillean 2, Oronsay			x	x

4.2.3 Lithic Scatters

One of the defining archaeological signatures of Palaeolithic and Mesolithic activity is the presence of characteristic lithic artefacts which are often found in some quantity depending on the nature of the site. Stone artefacts are the most durable component of the prehistoric toolkit from these early periods and the transformation of the original raw material into usable tools can generate a significant amount of debris, several hundred in less than an hours knapping. Many of the Mesolithic Scottish scatter sites, like Bolsay Farm, Islay (Mithen 2000) and Rink Farm on the river Tweed (Mulholland 1970) constitute large and often spatially extensive assemblages comprising many hundreds of thousands of individual pieces. These persistent places in the landscape were also often the foci of occupation and stoneworking activity in later periods and, consequently, it can be difficult to differentiate elements of these assemblages and different events at these sites which have often subsequently been subject to intensive agricultural activity. Nevertheless, scatter sites of all kinds are an especially important resource for the Palaeolithic and Mesolithic periods (cf. Barton 2006; Veil 2006).

Of considerable interest are more discrete smaller scatter sites where more temporally defined activities can be discerned. Such sites have been found through the monitoring of upland forestry ploughed landscapes in South Lanarkshire at sites such as Daer Valley Site 84 (Ward 2005; Wright in prep.). These sites offer a more intimate view on hunter-gatherer behaviour and are often associated with firespots and other features. The identification and excavation of these types of sites are a priority in order to enhance the understanding of human action and changes in lithic technology through time, for they offer tighter chronological controls than are often possible at the larger more extensive lithic scatters.

Archaeological investigation at scatter sites has tended to focus on the excavation of the area of greatest density in order to recover representative samples of the lithic artefacts for analysis. Yet, lithic scatter sites often comprise other structural remains and features (Wickham-Jones 2004a), although this will depend on the extent of plough damage. Here the application of geophysical techniques and wider investigation in the vicinity of the scatter itself can enhance the recovery of associated features. The Historic Scotland funded Scottish Lithic Scatters Project was an attempt to collate information on all lithic scatters in Scotland (Barrowman & Stuart 1998; Barrowman 2003; Stuart 2003) and much work still remains to be undertaken to fully understand the character and value of all types of lithic scatters as a resource. Scatter sites are vulnerable to a number of threats primarily through development and landuse practices but also from archaeological practices such as the over-zealous and selective collection of artefacts which can destroy the spatial integrity of the deposits and ultimately remove the site itself before it has been properly investigated.

Figure 24: Mesolithic lithic scatter site in sand dunes at Inver Naver © Caroline Wickham-Jones

4.2.4 Museum resources and re-evaluating the known resource

Re-evaluation of museum collections and existing site archives and assemblages also offers considerable potential to yield significant new insights into the period. In addition to enhancing understandings of the historiography of archaeological research in Scotland as a subject in its own right.

Many lithic collections currently held in museums relate to antiquarian and early 20th century collectors. Most have not been subject to specialist evaluation and many offer an opportunity to examine sites and landscapes which are now destroyed or no longer as accessible due to land use changes (for example see Woodman *et al*. 2006). This applies equally, of course, to assemblages obtained from earlier archaeological investigations. Another important area of research that has produced encouraging results is the re-examination of assemblages from cave sites housed in museums and private collections (Saville & Ballin 2009; Walker 2003). Such an evaluation should also include faunal assemblages where available as well as artefacts to consider key species relating to potential settlement during the Palaeolithic and Mesolithic periods. The consequent AMS dating of bone and antler implements from across Scotland has produced important results (Saville 2004c, table 10.2).

Earlier prehistoric artefacts and occupation evidence is commonly encountered via archaeological fieldwork taking place on chronologically later sites spanning the Neolithic to post-Medieval periods. There is a high potential for any archaeological intervention to encounter earlier prehistoric material, particularly for the Mesolithic, but often current evaluation strategies – such as mechanical topsoil stripping often militate against the identification and recovery of diagnostic material. This is unfortunate for often the only evidence that survives are lithic artefacts in these superficial contexts.

Of known Mesolithic sites in Scotland, most have initially been identified through local collectors and the endeavours of a number of highly dedicated non-professionals. The location of several important collections is currently unknown, for example the late Tom Affleck's Loch Doon material (Kevin Edwards & Dene Wright pers comms). The archaeological community also needs to develop procedures for 'best practice' to assist private individuals to manage and to retrospectively audit and integrate this vunerable unaccessioned resource in order to contribute to national understanding of Palaeolithic and Mesolithic occupation.

The often protracted post-excavation analysis involved in sites of this period means that several significant sites have only seen interim or incomplete publication. This has had a clearly detrimental impact on the understanding of the period and development of regional models. Notable in this respect are the still-outstanding publication of aspects of the Oronsay sites (Mellars 1987) and the results of the important excavations at Nether Mills, Crathes, Aberdeenshire (Kenworthy 1981).

The specialist re-evaluation of early collections as well as excavated assemblages still offers the potential to uncover diagnostic material originally overlooked or mis-identified at the time. Further typological, technological,and other analyses of existing assemblages also has a key role to play but rarely takes precedence, as it should, over new fieldwork campaigns.

4.3 Future research recommendations

Key areas for future work include:

- Detailed work on reconstructing conditions during the Lateglacial period and their implications for site location and survival.
- Systematic mapping and recording of cave potential for early sites, re-examination of existing cave assemblages, and targeted examination of new sites where appropriate.
- Synthesis of existing information on tool types and site locations, re-examination of existing assemblages, development of extensive dating strategies, and a focus on the publication of excavated sites.
- The excavations of the areas beyond the midden itself, especially the margins.
- Recognizing the combined archaeological and palaeoenvironmental potential of lateglacial kettle-holes and postglacial waterlogged deposits along river valleys.

5. Methodologies

5.1 The Challenge of Fieldwork

5.1.1 Introduction

The Mesolithic of Scotland has generally been characterized by lithic scatters, distinctive bone and antler artefacts, and shell middens, especially in coastal locations, while the only evidence so far for Upper Palaeolithic presence consists of two lithic assemblages (see section 2.1 above). Few *in situ* features survive on many sites, while organic or faunal material is usually absent on open-air lithic scatter sites. However, a wealth of faunal evidence is preserved in the alkaline conditions of some of the shell middens and within caves and rock shelters.

Because of the rarity of cut features, it is difficult to locate Mesolithic sites through many of the more usual methods of archaeological prospection. Stone tools, many of which come from surface contexts, dominate the material. Evidence and variability in the raw materials used to manufacture stone tools, along with their size and primacy, often create significant problems in identification of Mesolithic and potentially earlier sites (Phillips & Bradley 2004). In spite of the challenging environmental constraints and other difficulties including site visibility, there has been a long tradition of Mesolithic studies in Scotland (Mithen 2000, 9-12; Saville 2004b; Hardy & Wickham-Jones 2009). One of the most characteristic features of Mesolithic archaeology is the importance of local archaeologists and archaeology groups (non-institutional archaeologists) in enriching the database. A major factor, especially with local archaeologists and other interested parties, is that they recurrently examine their local area throughout the year, while institutional archaeologists work in areas for restricted time spans.

Sites are usually found where and when the ground is disturbed, for example by ploughing; by drainage ditches, roads, and tracks; by the preparation of ground for new tree planting schemes; by erosion features caused by animal disturbance, including rabbit burrows and mole hills; by more natural types of erosion features, such as the banks of streams and rivers; by commercial developments; and by the constant erosion and modification of much of the coastline. The continuing presence of the non-institutional eye in the locality is therefore a vital resource in the search for new evidence.

Figure 25: Coring as part of the environmental analysis around the Bay of Firth, Orkney © Rising Tide Project

5.1.2 Prospecting for Sites in a Dynamic Landscape

Generally, fieldwork to investigate Mesolithic and Palaeolithic archaeology in Scotland will be undertaken in a wide range of landscapes where complex geomorphological processes have had a profound influence on the surviving archaeological and palaeoenvironmental remains. These processes provide a unique challenge to the researcher prospecting for hunter-gatherer sites and it is necessary to provide brief overviews here of the landscape forms in which fieldwork will take place.

The Coastal Zone

Changes in sea level in Scotland have serious implications for trying to understand the influence of the coast upon previous settlement patterns and their survival (see section 3.4 above). This is especially significant given that local manifestations of these processes can be complex. The consequences of sea-level change are dramatic; a substantial portion of the late Pleistocene and early Holocene coastline has been lost owing to the final transgression of the sea (Smith *et al*. 2011). Coastal sites have been revealed by erosion, but here the pattern and distribution of sites is skewed, providing a bias in the archaeological record. Present and fossil shorelines, including raised beaches, abandoned sea caves and rock shelters have, however, provided a rich and varied Mesolithic settlement record for Scotland. Submerged forests and offshore peat deposits offer valuable palaeoenvironmental data and may also yield direct archaeological evidence (see for example Bell 2007; Bell *et al*. 2006).

Figure 26: Coring to sample submerged peat deposits at Mill Bay, Hoy ©Rising Tide

Rivers

Much of the evidence for the inland Mesolithic is riverine, frequently being recovered from ploughed areas along valley bottoms or on lower terraces immediately above these. It can be assumed that a better understanding of the patterns of evidence presently known regarding the use of river systems during the Palaeolithic and Mesolithic will depend on a wider understanding of geomorphological data. River systems are inherently dynamic (Brown 1997), and river profiles have changed considerably during the Holocene. The local depositional and erosional sequence associated with river systems is especially significant in upland areas while to further complicate matters, river systems, because of their importance to settlement of all periods have often been extensively managed and transformed by agricultural and other anthropogenic activities, especially in recent centuries. Nevertheless, the opportunites for important discoveries along tidal rivers and in estuarine contexts have been highlighted by recent work in south-west Britain (e.g. Bell *et al*. 2000; 2006).

Ploughsoil Contexts

The majority of evidence for Mesolithic settlement in the east of Scotland, along with the extensive surveys undertaken by Mithen on the islands of Islay and Colonsay (Mithen 2000), comes from ploughsoil contexts. Most arable land occurs within river valleys or on wider coastal plains, while the occasionally ploughed and improved pasture may extend the distribution of such land into the higher parts of the landscape in the Scottish uplands. However, in places, the extent of soil movement associated with arable agriculture can be extensive. Also, where modern ploughed soils have been affected by fluvial deposition processes, the Mesolithic surfaces may be deeply buried below these accumulations of deposits. The Upper Palaeolithic site at Howburn, South Lanarkshire, would not have been found had ploughing not revealed a surface artefact scatter (Ballin *et al*. 2010a).

Figure 27: Excavating in the ploughsoil, Kinloch, Rum © Caroline Wickham-Jones

Permanent Pasture and Heather Moorland

Large areas of upland Scotland are in permanent pasture, whether improved or rough, or are covered by heath communities. In all such cases the vegetation is rarely entirely removed, or the soil surface disturbed other than very locally by livestock, or through developments of some kind. Mesolithic sites in such areas have generally only been located at the margins of water courses or more extensive water bodies where the vegetation cover has been removed or at times of low water when an exposed horizontal surface is available for examination, by targeted test-pitting, or by chance during other archaeological operations. Although extensive in area, and potentially containing many relatively undisturbed sites, these zones are amongst the most intransigent in terms of standard survey approaches (Finlayson *et al* 2004).

Peat Landscapes

Away from the coast, valley bottoms and neighbouring terraces, the presence of extensive peat cover creates a further barrier to the discovery of archaeological material relating to the Palaeolithic and Mesolithic. The timing of the onset of peat coverage in eastern Scottish upland landscapes is variable. In places such as Carn Dubh, Perthshire (Tipping 1995), peat was already established during the Mesolithic period, but the large-scale development of this phenomenon post-dates that period, and therefore now masks many areas of the Mesolithic landscape that would previously have been more attractive for a range of uses. Whilst blanket peat now covers some 1.1 million hectares of the Scottish landscape, the distribution of peat is not even and its presence severely limits archaeologists' ability to locate sites within such upland landscapes (Finlayson *et al.* 2004). The early removal of peat for agricultural reclamation in some parts of Scotland, particularly areas liable to have been foci for Mesolithic movement and exploitation such as the Carse of Gowrie and the Carse of Stirling, will undoubtedly have destroyed valuable Mesolithic evidence, now only represented by a few surviving organic remains (Lacaille 1954).

Wetland Areas

One further zone of high potential, especially given the early dates noted for some peat formation, is wetland areas, which may preserve particularly good data. Although difficult in prospection terms, this particular problem is not unique to Palaeolithic and Mesolithic site recovery, but is one shared in considerable measure with at least all prehistoric periods (see papers in Coles & Olivier 2001). The potential value of these locations is widely appreciated and there seems no reason to advance specific recommendations for hunter-gatherer wetland archaeology, as a result of the heightened levels of preservation anticipated (Finlayson *et al.* 2004).

Mountain Environments

The mountain uplands of Scotland comprise a major part of the country's land mass that have been, and are still, subjected to severe and variable climactic conditions. It therefore comes as no surprise that these areas have received little attention from archaeologists researching the Palaeolithic and Mesolithic periods. In the past, these upland areas would have supported a rich and diverse fauna and flora, including tree cover during the more favorable conditions that endured during the early Holocene (Roberts 1998, 99–101). Many of these upland areas would have supported large populations of ungulates, such as reindeer and red deer, and would have provided good hunting grounds for people during the summer months. Bang-Andersen has produced evidence from Norway to suggest that people were utilizing these upland landscapes in Norway during the Mesolithic (Bang-Andersen 1987) and there is increasing (if still sparse) evidence for this in Scotland (at sites such as Chest of Dee or Ben Lawers).

5.1.3 Addressing the Fieldwork Challenges

The following sections will briefly review the various types of fieldwork methodologies that have been utilized to recover Mesolithic sites in Scotland, while for Palaeolithic sites methods used in England and Wales will be discussed.

Desk-Based Assessments

There are significant challenges accessing raw data in SMRs/HERs, on both a national and local level, for known Mesolithic sites[10]. Because they often exist only as artefact scatters, even if those have been securely identified as Mesolithic, sites are not always recorded as such. Valuable information relating to individual sites is often only available within larger reports (relating to major fieldwork projects) and in the 'grey literature' pertaining to developer-funded archaeological fieldwork. There is also a problem of misidentified Mesolithic sites in the records, as when, particularly in the older literature, artefacts have been incorrectly described as 'microliths'. Generally speaking, most of the evidence for the Mesolithic period available from museum and private collections is not recorded in SMR/HER databases.

Aerial Photography

The identification of Mesolithic sites using oblique aerial photography has not been adequately addressed. There has been the occasional instance where coherent Mesolithic remains have been found in cropmarked landscapes such as Newton on Islay (McCullagh 1989), at Dunbar Cement Works (Gooder & Hatherley 2003), and at Crathes, near Banchory (Murray *et al.* 2009). This indicates that with optimum conditions early prehistoric sites may be visible as cropmarks on the aerial photographic record of Scotland and it may now be possible to begin to see whether there are any diagnostic features in the relevant cropmark records that can be recognised as potentially diagnostic of Mesolithic activities. New developments in aerial reconnaissance, for example using LIDAR, may have

[10] Available to download at http://www.scottishheritagehub.com/content/scarf-downloads-0

implications for Palaeolithic and Mesolithic research (see papers in Cowley 2011).

Geophysics

Geophysics is currently rarely used in Mesolithic and Palaeolithic research. However, pilot studies have been undertaken at several sites in Scotland (Finlay & McAllen 2004) to investigate the extent of shell-midden sites, while some encouraging results were obtained at Howick, Northumberland, where the remains of a large structure of Mesolithic date had been identified (Waddington 2007). A similar roundhouse structure was also revealed using geophysical survey and excavation at East Dunbar (Gooder & Hatherley 2003). The application of geophysical survey techniques for the identification of Mesolithic features is generally an untested method in the British Isles, but has great potential and significant implications for future investigations of such sites (see papers in Cowley 2011).

Pollen Analysis

There have been many instances where pollen analysis has suggested the presence of hunter-gatherers in the landscape, but where no archaeological evidence has as yet been recovered in the vicinity to underpin this interpretation (Edwards 1990; 1995; 1996b; Whittington *et al.* 1990). Unfortunately, this type of data is not readily available to the curators of SMRs and HERs, making it difficult to identify areas where they might wish to request a Mesolithic dimension to any archaeological investigation should development be proposed. Pollen data can also be difficult to interpret, e.g. to what extent the locations of such data indicate a settlement pattern that is topographically coherent and which can then be used to suggest areas for curatorial intervention. Such indicators are probably only going to reveal traces that could be satisfactorily tested by a large-scale project that would require a systematic test-pitting regime (Finlayson *et al.* 2004).

Fieldwalking

Fieldwalking of ploughed areas remains a relatively economical way of locating sites and has been one of the main methods of finding Mesolithic sites (and one Palaeolithic site) in Scotland, but this is constrained in some regions of the country by the availability of cultivated, or otherwise unvegetated, land. This is particularly the case along the west coast and within large areas of the hinterland and mountainous regions that comprise large tracts of peat-covered land, which has covered much of the early prehistoric landscape.

Ideal fieldwalking conditions include a combination of surface weathering, good light, and sympathetic weather, and without long-term access to an area it is difficult to optimise these variables at short notice. Furthermore, in many areas, fieldwalking opportunities are limited in time due to the requirements of intense sowing and crop-rotation schemes. Difficulties also surround the identification of sites through fieldwalking, where one visit is often insufficient to locate meaningful samples of lithic material. This is an effect of both the low density of material on some sites, and – it may be postulated – the small quantities of material that might be churned up by the plough to appear on the surface on any less damaged site. The value of repeat visits to walked fields has been confirmed by several large landscape-based projects (Mithen 2000, 157–62; Hardy & Wickham-Jones 2009; Ballin *et al*. 2010a; Ward 2010; Passmore & Waddington 2009).

The location of Mesolithic sites on high-quality agricultural land is sometimes a mixed blessing. Historically, ploughing and associated activities will have increased the chances of sites being identified, but these processes will also have contributed significantly to their likely degradation/destruction. Where sites are preserved, they may only survive within the ploughsoil in a significantly transformed condition. In such cases a range of lithic evidence can be described, but often with little or no reference to other surviving features; nor is any stratigraphic integrity preserved. An indication of the duration of a particular site versus its scale of occupation is thus rendered problematic. Furthermore, the reliance on fieldwalking of tilled fields as the main detection method for hunter-gatherer sites immediately creates a significant bias in the revealed distribution pattern.

One particular problem with the identification of hunter-gatherer sites within ploughsoil contexts, especially in valley bottoms adjacent to major river courses, is widespread soil displacement – either through natural erosion or the displacement of soils during the subsequent use and working of the land. In such circumstances, the chances of finding structural remains may well be minimal, even if the occasional artefact is discovered during fieldwalking.

Landscape Survey and the Upland Landscape

Traditional survey methods, including fieldwalking are hardly applicable in the upland zone at all; Mesolithic sites are simply not going to be revealed in general ground-perspective survey. At the same time, identifying Mesolithic sites in these zones remains a very important goal (cf. Donahue & Lovis 2006; Fojut 2006). Bang-Andersen's approach for prospecting in similar environmental contexts in Norway (Bang-Andersen 1987) involved the excavation of vast numbers of shovel-pits (small test-pits) to locate artefacts. A similar approach was adopted in the Southern Hebrides Mesolithic Project and the Scotland's First Settlers Project, although on a smaller scale, in areas where ploughing was absent. With this mode of survey it is important to understand the chronology of landscape formation in order to manage the survey effectively as well as interpret the results. This requires a battery of investigative techniques and an integrated approach in which the results of test-pit survey are assessed with a wider consideration of landscape history.

Forest planting, especially within the upland zones, has radically altered the landscape of Scotland (Foot 2003). Afforestation offers a series of archaeological potentials and problems (see papers in *Trow et al*. 2010). Woodland Grant Schemes and Environmental Assessments mean that forestry ploughing represents one of the few contexts in which large upland areas can be examined. The success of the exercises undertaken by amateur groups in South Lanakshire (Johnston 1997; www.biggararchaeology.org.uk) and recent discoveries in Caithness (Pannet & Baines 2006) demonstrate clearly the gains to be made from a more general examination of these areas, especially using systematic post-ploughing fieldwalking to recover lithic assemblages.

In the Pennines and the North York Moors of England, the examination of eroding peat hags has been important for locating Mesolithic artefacts in the upland zone (Spikins 1999). Spikins outlines potential influences on peat erosion in England, including pollution resulting from the presence of major industrial cities, while another is erosion caused by sheep sheltering from the wind; these latter scrapes creating an apparent preference in the distribution of Mesolithic sites for sheltered locations (Finlayson *et al.* 2004). Sub-peat Mesolithic sites have been successfully located in upland Scotland, in particular where lowered water levels in reservoirs and natural lakes have exposed archaeological material and old ground surfaces from which peat cover has been eroded (Affleck 1986; Ward 1995).

Coastal Survey

Within the coastal areas of Scotland, especially along the west coast, Mesolithic sites have been recovered along eroding shorelines, on raised beach terraces, within abandoned sea caves and rock shelters, and within the inter-tidal zone. Generally, these sites have been recovered by dedicated non-institutional archaeologists with a particular interest in the area where they live, and through the larger academic-led research projects. Local individuals and archaeological organisations may identify sites from small-scale erosional contexts for example, during repeated visits over a relatively long period of time.

Given the long-term nature of successful fieldwalking, it may also be appropriate to encourage such activities within the coastal zone, and not simply predominantly on arable land, as is presently the case. Shorewatch groups, for example, might agree to collect lithic artefacts in the course of their activities, including surveying eroding shorelines. This could significantly enhance the record in a potentially very significant zone, such as resulted from the surveys undertaken by the Scotland's First Settlers Project (Hardy & Wickham-Jones 2009).

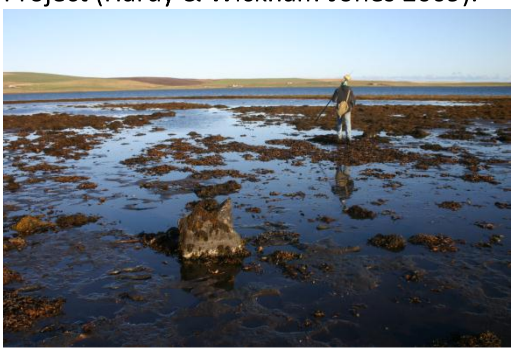

Figure 28: Multiperiod survey in the intertidal zone, Bay of Firth, Orkney © Rising Tide

Intertidal and Underwater Survey

It is important to note that around some of the Scottish coast relative sea-level rise since the early Holocene means that coastal settlement will have been submerged. The location and investigation of submerged Mesolithic sites brings its own suite of issues, addressed by Flemming *et al.* (in prep).

The exploration of the seabed has recently become a focus of research projects in the British Isles, looking at submerged archaeological sites and drowned landscapes (Dawson & Wickham-Jones 2009; Dawson 2009; Ballin 2008; Momber 2000: Gaffney *et al.* 2009; Bell & Neumann 1997; Bailey & Flemming 2008; Momber *et al*. 2011; Fleming 2004; Benjamin *et al*. 2011). This area of research and survey is still at an early stage in Scotland, although inter-tidal sites containing peat deposits and flint tools have been identified (Dawson 2009; Ballin 2008). Fieldwork undertaken elsewhere around the coast of the British Isles, some of which is taking place in advance of off-shore developments, is revealing significant results. In particular, geophysical surveys along with a wide range of finds lifted from the seabed by fishing and dredging activities are providing a better understanding of the settlement of the North Sea Plain prior to transgression by the sea (Gaffney *et al.* 2009). Work to focus on areas of preserved sediment as well as stony seabed is recommended.

Caves and Rock Shelters

A systematic examination of caves and rock shelters should be encouraged (Bonsall *et al*. 1991; 1992; 1994; Tolan-Smith 2001). Recent survey and excavation work by the Scotland's First Settlers Project has provided a wealth of evidence to suggest that these natural features in the west of Scotland have a high incidence of use in many periods (Hardy & Wickham-Jones 2009), and although later activity may mask, or have destroyed Mesolithic use, survey of these sites has to be accorded a high priority. With regard to Palaeolithic settlement in Scotland, the investigation of caves, in particular deep caves and caves sealed with glacial sediments provide one of the best opportunities for recovering evidence pertaining to these early periods of Scotland's past. Opportunities for exploring such cave and rockshelter sites have often been lost because their presence has only been revealed in the course of development, the sites being previously masked by scree etc., as at Kilmelfort Cave, Argyll (Saville & Ballin 2009). Advantage should be taken of new ground-penetrating techniques for scanning and probing hillslopes where caves and rockshelters may lie hidden, and closer links with the cave exploration community in Scotland should be established and maintained. Survey in particular areas, such as in north-east Scotland (Fojut 2006, 71), could be prioritized.

Research Excavations

The investigation of early prehistoric sites poses unique problems and possibilities, and requires the adaptation of standard methods of excavation. Although a consistent approach to excavation in the field needs to be adhered to, methodologies often have to be tailored to suit specific site requirements. This is certainly the case when working on Mesolithic sites within the varied landscapes of Scotland where unique problems have to be addressed to answer specific research criteria. The need for consistency in recovery and recording methods should always be considered during any excavation, a factor that should be carried through to the post-excavation stages of any project. A range of methodologies can then be applied to understand complex site formation processes.

Test-pit surveys, trial trenches and open-area excavations are all methods through which Mesolithic sites have been investigated in Scotland (Hardy & Wickham-Jones 2009; Mithen 2000; Finlayson *et al.* 2004). Usually, with the investigation of unknown and newly-discovered lithic scatter sites, whether revealed through fieldwalking or other means of identification, a series of test pits can be opened to plan artefact distributions and to assess the character of the site with regard to potential of trial trenching and / or area excavation – especially in light of potential *in situ* remains and features. However, there are two critical decisions that need to be made with a test-pit survey of this type, including the size of the individual test-pits and their distance apart (Mithen 2000). The great benefit of undertaking a test-pit survey of a site is the spatial control over the recovered data, allowing the production of artefact distribution maps, which can then be used for planning the resulting excavation strategies – if this is deemed necessary.

Problems arising from test-pit excavation of sites include the overall difficulties in recording soil/sediment profiles due to the potential depth and size constraints of the excavated area, the labour–intensive costs of recording all recovered artefacts in 3D, and making a decision as to whether wet or dry-sieving of all of the recovered deposits is feasible.

Figure 29: Test pitting at the Tanged point site, Millfield, Stronsay © Caroline Wickham-Jones

Depending on the results of the test-pit evaluation of a given site, it should then be possible to make informed decisions on how to proceed with further excavations – whether through trial-trench excavation or using open-area excavation. At sites with deep sediment profiles, trial trenching can be used successfully to expose long continuous stratigraphic sections that were difficult to record using test-pits, while also allowing the exposure of larger areas of relevant archaeological contexts with the help of locating features. A 100% wet-sieving strategy should be used where possible during trial-trench excavations in order to provide an unbiased sample of lithic assemblages from exposed contexts. A 3mm wire-mesh sieve should be used to recover this material (or using a smaller mesh sieve and flotation unit, especially if plant remains and other environmental data are expected to survive). Using a high-pressure hose may be required if the sediment is expected to clog the sieve, but alternative sampling strategies may have to be employed for more delicate remains due to the potential damage that could result from the high-pressure water supply to the hose. Where possible, flots and wet-sieve residues should be air-dried prior to sorting. This has been shown to assist significantly with recovery of materials from the residues (Mithen 2000, 59; Hardy & Wickham-Jones 2009).

Figure 30: Wet sieving at Kinloch Rum © Caroline Wickham-Jones

If the results of test-pit and / or trial-trench excavation reveal dense artefact scatters or areas of known *foci* within a site, then open-area excavation may be a method to evaluate the site further. This often involves the exposure of a substantial area of archaeologically relevant contexts followed by a detailed and systematic excavation strategy. The individual recording of artefacts can be undertaken using 3D-plotting in relation to quadrates and either stratigraphic context or a specific spit within a context. However, if time constraints have to be taken into consideration, then recovery by 0.5m squares and by stratigraphic context or spit within a context can be used. Both forms of recovery allow accurate spatial analysis that can be used to provide a computerised database of the results. However, on complex sites that display areas of *in situ* settlement remains and multiple features, it may be necessary to use smaller quadrate sizes in order to control the resulting data-set.

Developer-Funded Archaeology

The triggers that produce a planning response are generally based on pre-existing known sites, the vast majority of which are not Mesolithic. Therefore, although curators may be able to identify areas of high archaeological potential for more recent periods, their ability to identify areas of potential importance to hunter-gatherers is unavoidably limited; and the current understanding of the environmental locations used by hunter-gatherers is too generalised to use as a strong argument for an archaeological intervention in the absence of any more positive data. One consequence is that, in the applied sector, Mesolithic remains rarely trigger a curatorial response to development plans. An added difficulty is that the standard range of responses deployed by the applied companies may not locate them, since these necessarily privilege structural remains.

Where an archaeological intervention does occur, the techniques and methods stipulated by the curator are normally designed primarily with the evidence produced during later periods in mind. The flexibility of a response may therefore be seriously limited as methods may be part of a planning condition, and will normally be financially constrained by the tendering process. Because the demands of Mesolithic archaeology are specific, methodologies designed to deal with the surviving field archaeological remains of other periods in many cases may not be appropriate for the recovery of Mesolithic material. It is certainly possible that Mesolithic sites have been missed or underestimated in such circumstances because of inappropriate methodologies. Given the poor nature of the understanding of the character and extent of Mesolithic archaeology in some areas of Scotland, this situation is of real concern as it is possible that archaeologists are systematically misinterpreting, and therefore mismanaging, these landscapes as a result of the application of inappropriate methodologies, or an insufficient range of recovery methodologies, in such projects.

A major problem with undertaking a watching brief on a developer-funded site, in particular during the removal of the topsoil by machine excavator, is that in most cases the density of lithic artefacts is such that they will not be readily apparent on the ground. Consequently if a site survives mostly within the topsoil it will generally escape detection unless some form of test pitting is undertaken in advance of the major development of the site. Clearly sites that only survive in the topsoil have been substantially disturbed and while this may be the case, useful information can still be obtained by simply collecting a sample of the lithics and accurately recording these within the position of the site. If possible, where a curator has reason to suspect the presence of a Mesolithic site, it would be ideal if hand-dug test-pits were excavated as part of the initial evaluation, before large-scale machine topsoiling takes place.

Test-pitting by hand, accompanied by routine sieving of spoil, has been adopted in a number of research projects as one of the best ways of recovering Mesolithic data. The standard practice is to excavate 1m by 0.5m test pits and to dry or wet-sieve spoil on site through a 3mm gauge sieve. If lithic artefacts are found, then this initial evaluation should be followed up by a more extensive intervention to test whether the 'find-spot' is related to any surviving features within the subsoil. Where evidence survives below the topsoil it is important to note that, as any negative features are likely to be small compared to those representing later sites, and that they may form less obviously coherent patterns, they may be harder to identify. Mesolithic pits may often be amorphous in character, making them harder to observe, and tempting to avoid in cases where only a sample of features is being excavated in conditions of urgency.

Elsewhere in the British Isles, Palaeolithic sites are rarely affected by the more usual development proposals and as a result new sites and new data are only occasionally emerging from the development control system. Recent exciting exceptions in south-east England have resulted fortuitously from major road and railway construction schemes (Wenban-Smith *et al*. 2006; Wenban-Smith 2010). However, there has also been a long tradition of the recovery of Palaeolithic material from commercial sand- and gravel-extraction sites, although the activities of companies exploiting these resources in Scotland are rarely, if ever, monitored through the planning process.

However, the significance of deposits that could theoretically contain Palaeolithic archaeology, particularly the sites that just have palaeoenvironmental data, are not always recognised as potentially important (Hosfield & Chambers 2004), while developer-funded archaeology is not pre-disposed favourably towards the investigation of such contexts. There is currently an increase in activity offshore (Wenban-Smith 2002). Both aggregate extraction and plans for offshore wind farms can threaten the survival of Pleistocene deposits with the potential to provide new Palaeolithic and palaeoenvironmental data. It is important that archaeologists working in planning control are made more aware of such threats and wherever possible the companies engaged in such work should be educated to appreciate the nature and fragility of the resource they may be destroying. The potential for the blind destruction of this unknown and untapped archaeological resource is great and given the potential it holds it is one that requires further investigation.

Research frameworks for the British Palaeolithic are addressing some of these concerns. In particular, the frameworks are promoting developer-friendly approaches to all types of development (including but not confined to quarrying) with an impact on Palaeolithic/Pleistocene resources (see for example Howard & Knight 2004; Bridgland *et al.* 2006; Buteux *et al*. 2009; Pettitt *et al*. 2008; Gamble 1999); while in the offshore sector the existence of the Aggregates Levy Sustainability Fund has supported a wide range of projects (Pettitt *et al.* 2008). Continued work with the aggregates extraction industry is important for discovering and understanding the earliest human presence in and around Scotland.

Prospection for Palaeolithic Sites

Recently, lithic artefacts datable by typology to the Upper Palaeolithic have been recovered from a ploughsoil context at Howburn in the Southern Uplands of Scotland (Ballin *et al*. 2010a), while material also dating to this period has been found through the re-assessment of a lithic assemblage from Kilmelfort Cave in Argyll (Saville & Ballin 2009). Faunal remains and other palaeoenvironmental material have also been recovered relating to the Late Pleistocene from central Scotland in drift deposits (Lacaille 1954, 15–23; Jacobi *et al*. 2009a), from the Creag nan Uamh caves, Assynt, Highland (Lawson 1981; Lawson *et al.* 1993; Lawson & Bonsall 1986b; Saville 2005) and more recently from Uamh an Claonaite at the same location (Birch & Young 2009). Deep caves and caves sealed with glacial deposits, possibly provide one of the most important types of site for the potential preservation of evidence for Palaeolithic settlement and Pleistocene palaeoevnvornmental deposits in Scotland. In key areas the examination of information from boreholes in order to reconstruct palaeolandscapes and areas of likely preservation and human activity should be recommended (cf. Raemaekers *et al*. 2006).

The impact of the last major glacial events in Scotland has helped to obscure potential material relating to human activity during the Palaeolithic period. If methods for recovering such potential material are to be improved, then work in England, Wales, and in offshore waters must be learned from. Extraction of aggregates have revealed many Palaeolithic artefacts and sites; the gravel deposits often representing the former river courses and shorelines where people hunted, butchered, and sought raw materials for the manufacture of stone tools. Archaeological fieldwork in collaboration with the aggregates industry has provided many of the opportunities for the investigation of Palaeolithic sites in England and Wales, while research into the continental shelves including the English Channel and North Sea/Doggerland continue to improve understanding of the nature of the connection between the British Isles and the adjacent regions of Europe at this time (Pettitt *et al.* 2008; Wenban-Smith 2002). The continuing investigation of old collections and records, including 'dormant' museum and private collections, has also had a profound impact on knowledge of this period of the distant past (e.g. Jacobi 2004).

5.1.4 Conclusions

The recovery of sites relating to early prehistoric hunting-fishing-gathering peoples poses unique problems for archaeological fieldwork. Potentially low population densities, high mobility, and ephemeral material culture, generally create low-visibilty sites in the landscape that are difficult to recover using established prospection techniques. Complex geomorphological processes also hinder the archaeologist's attempts to discover new sites during these early periods of Scotland's past, especially when considering settlement and the associated environmental evidence of the Upper Palaeolithic. However, new fieldwork methodologies and a better understanding of past environments (cf. Rensinck & Peeters 2006; Peeters 2007), along with an increasing amount of discoveries through the commercial sector, are revealing the diverse and often rich data relating to people in Scotland at this time and their relationship with their wider environment.

5.2 Science-based archaeology and the Scottish Palaeolithic and Mesolithic

Scientific methods have been, or could in future be, applied to a number of distinct areas of archaeological investigation into the Scottish Palaeolithic and Mesolithic, including:

- Dating (isotopic and non-isotopic methods);
- Tephra
- Artefact studies (use-wear analysis, trace element analysis, residue analysis);
- Dietary reconstruction and population movements (stable isotopes);
- Archaeogenetics (modern and ancient DNA);
- Environmental reconstruction (palynology, stable isotopes, palaeobotany, zooarchaeology, geoarchaeology);
- Site investigation (remote sensing and geophysical prospecting);
- Conservation.

The boundaries between archaeological science and some other branches of archaeology, such as environmental archaeology and bioarchaeology, are somewhat blurred. For example, studies involving pollen analysis (palynology) figure prominently in archaeological science journals, but most palynological research is not done on archaeological materials or deposits *per se* but 'off site', directed at answering questions about past environments and human–environment interactions. Similarly, DNA studies and isotopic studies of human diet may be considered as core elements within the sub-field of bioarchaeology.

5.2.1 Dating

The principal applications of archaeological science techniques in Scottish Mesolithic studies have been in the area of dating. Radiocarbon (^{14}C) dating has been routinely applied to Scottish Mesolithic sites since the 1960s. The majority of samples analysed prior to the mid-1990s were dated by radiometric methods (gas proportional counting or liquid scintillation counting). Typically, these were bulk samples of wood charcoal, or occasionally of animal bones or marine shells. Where the sample material was limited in quantity error terms were often large. Moreover, charcoal samples were not always identified to species and hence the ^{14}C age measurements carry the possibility of an old wood effect. Similarly, shells have a marine reservoir effect, the magnitude of which is still not well established for the Mesolithic time range. The introduction of the AMS technique in the early 1980s allowed the dating of much smaller samples, thereby opening the possibility of single-entity dating of artefacts and ecofacts. However, error terms associated with dates produced by first generation accelerator mass spectrometers were often large (±80–100 ^{14}C yr), although the current generation is capable of routine precision measurements of ±25–40 ^{14}C years. With the use of the AMS technique, dating of bone collagen has become much more routine. With the older radiometric methods a large amount of bone was required (equivalent to an entire major limb bone, e.g. humerus). Currently, 0.5–1g of compact bone is normally sufficient for reliable dating. In terms of collagen extraction there is no single preferred technique, with some laboratories favouring a modified Longin method, and others favouring this method combined with ultrafiltration.

Also relevant to understading the changes taking place in the Lateglacial landscape of Scotland is cosmogenic isotope (^{10}Be & ^{36}Cl) dating of the exposure of rock surfaces (e.g. Ballantyne 2010; Everest & Kubik 2006).

The principal non-isotopic dating technique applicable to the Mesolithic time-range is luminescence dating, of which there are various forms (TL, OSL, IRSL, etc.). The advantage of the luminescence technique is that it can be used to date directly certain non-carbon containing materials, e.g. burnt flint. In practice, however, errors associated with single measurements are large; an accuracy of 5–10% of age will be routinely obtained, while for selected samples with appropriate external dosimetry and suitable luminescence properties it may be possible to achieve a precision of 3–5%. With replication, precision may be improved to 2–3%, but with obvious cost implications. Consequently, there have been very few applications of this technique in the Scottish Mesolithic (Mithen *et al*. 1992; Melton & Nicholson 2004).

Tephra

Tephra is volcanic ash which can be found within sediments in western Scotland. Such ash will have predominantly originated from volcanic eruptions in Iceland and it is important to Mesolithic archaeology because the specific geochemical characteristics of each tephra horizon can link it to a very specific volcanic event (see Lowe 2011 for a recent review of tephrochronology). As such this provides a means of additional absolute dating for sediments, which enables the verification of radiocarbon dating and contributes towards constraining chronologies for palaeoenvironmental reconstructions. Tephra analysis involves the extraction of tephra from sediments and their characterisation by using a variety of methods including SEM WDX and microprobe analysis. As yet tephra dating has had limited direct application within Palaeolithic and Mesolithic Scotland but the potential is substantial as demonstrated by the discovery of the Hoy tephra on Orkney dating to *c*. 5500 BP and Lairg A and B tephras in Sutherland dating to *c*. 6000 BP (Dugmore *et al.* 1995), and this is an active research area with numerous recent advances (e.g. Davies *et al*. 2001; Matthews *et al*. 2011; Pyne-O'Donnell 2007).

Mesolithic Radiocarbon Assessment

Radiocarbon dating has undergone radical change in recent years with the introduction of new techniques such as AMS dating, ultra-filtration pre-treatment of samples, and the application of statistical modelling including, amongst others, Bayesian modelling. One of the results of these new applications is that more precise, and more accurate, chronological control is being afforded to archaeological contexts and this is having a profound effect on understanding of the timing and duration of hunter-gather, and indeed later, activity (see for example the results for the Howick settlement: Waddington 2007).

Of course, the accuracy of the chronological control also depends fundamentally on the calibration procedure that converts ^{14}C ages into calendar age ranges. Accurate conversion is easily accomplished for short-lived, terrestrially derived Mesolithic samples (e.g. round wood charcoal, ungulate bones, etc) using one of the freely available calibration programs such as OxCal or Calib. However, marine samples such as fish bone and shell are more problematic. They derive their carbon from the marine environment which is depleted in ^{14}C relative to the contemporaneous atmosphere/terrestrial biosphere. This is the so-called marine reservoir effect (MRE). If the effect were constant, it would be a relatively simple task to allow for this depletion in the age calculation, however it is well established that the MRE varies both temporally and spatially (e.g. Ascough *et al*. 2004; 2006). The current global average surface water MRE is 400 years and deviations from this value are designated by a ΔR value. Thus, a ΔR value that is negative is indicative of a reduced MRE while a positive value indicates an increased MRE. Therefore, prior knowledge of the ΔR value for a site and period is required in order to achieve the most accurate calibration of marine samples. In the absence of an appropriate ΔR value, a value of zero is typically assumed. Ascough *et al*. (2007) have derived two ΔR values for the Mesolithic, from Sand and Northton, both of which are positive (64 ± 19 and 79 ± 32, respectively).

The calibration process is further complicated for human remains when there has been consumption of a significant quantity of marine-derived resources. Not only is an appropriate value for ΔR required for accurate calibration but also, it is important to have an accurate estimate of the proportion of marine resources contained in the diet. This estimate is typically made by reference to the $\delta^{13}C$ value of the collagen (e.g. Arneborg *et al*. 1999).

The date list[11] compiled for this assessment consists of a list of raw dates that have not been edited or checked for their accuracy, the usefulness of the sample, or the reliability of the sample and the context from which it came. Therefore, the date list must be used with care as some of the dates would not be considered scientifically acceptable. The calibrations were undertaken in November 2009 using the program Oxcal 4.1 and the calibration curve INTCAL04.

[11] Follow the link at www.scottishheritagehub.com to the Palaeolithic and Mesolithic downloads

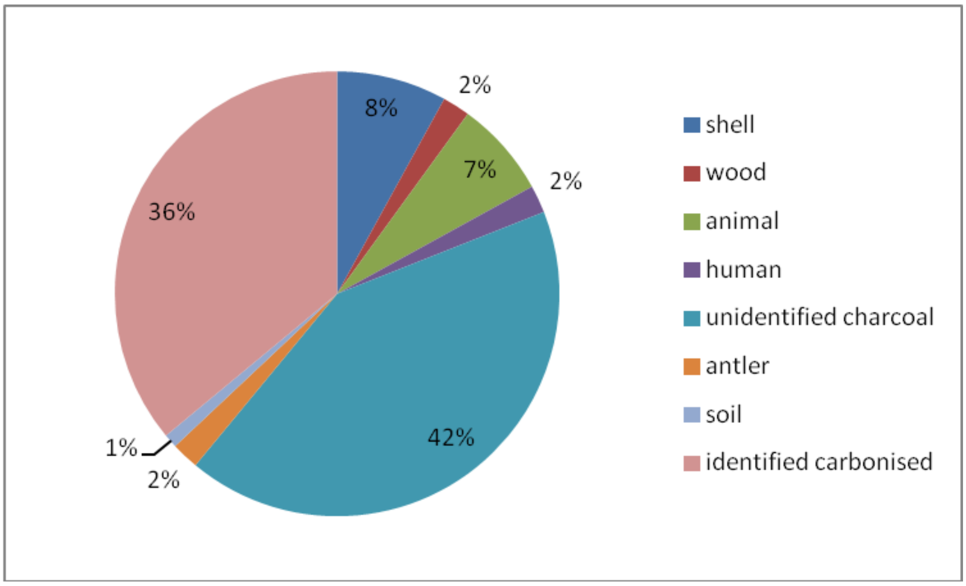

Figure 31: Percentage of 'Mesolithic' radiocarbon measurements from Scotland by material dated

Figure 31 shows that the about 50% of radiocarbon measurements for the list as it stood in November 2009 at best provide *terminus post quems* for their contexts and this is probably being generous given that no assessment of the taphonomy of most samples has been undertaken.

A very brief assessment highlights the following:

Unidentified charcoal & **wood**: can have an unknown age-at-death offset (Bowman 1990); unless identifications are given the dates on these materials only provide *tpq*s.

Identified carbonised: material – some of this is short-lived, however, a number of samples contain bulked material and may contain material of different ages (Ashmore 1999).

Shell: this needs to be calibrated using the appropriate calibration data (marine offset; see Ascough *et al.* 2007). This has not been undertaken because it requires some work to identify appropriate regional values from published data.

Animal: unless these are identified as articulated (and this *in situ*) they only provide *tpq*s for their context.

Human: these need stable isotope measurements to correct for dietary offsets (marine diet, etc).

Soil: of little value due to uncertainty over precise contextual associations (though interestingly microfossils in sediment are much used by geoscientists to get dates from sediment cores).

Antler: without an indication of the taphonomic relationship to the context they only provide a *tpq*.

Further Work

The problems identified above do not only relate to the Mesolithic but all periods that use radiocarbon. A proper assessment for all periods as undertaken above would highlight why most dates are at best only *tpq*s and could be used to produce some generic recommendations on how to approach the use of radiocarbon. This should be undertaken as a minimum before any chronological research questions are formulated.

A study is required to review the date list, removing dates that cannot be demonstrated to be reliable. The resultant dates can then be used for modelling and related purposes to provide a wide variety of useful chronological data that can be used to assist in understanding questions relating to settlement, artefact chronology and environmental change/impacts as well as contributing to the production of historical narrative for the period.

It is also recommended that the current Excel spreadsheet format for the date list is retained, or a variant of it, as this is a simple format that allows for rapid calibration of all dates using the Oxcal program, as well as for easy combining and so forth of dates for statistical modelling. It also means that the date register can be easily updated by non-specialists whilst also not being too onerous for researchers who may produce fairly large numbers of dates for any given project.

5.2.2 Artefact studies

Since the 1960s *micro-wear analysis* has been the standard technique for investigating the ways in which tools made from stone, bone, and shell were used in the past. However, after an initial burst of interest (e.g. Hope 1981), archaeologists and funding bodies in Scotland have been slow to adopt this technique, which is all the more surprising given that lithic artefacts are all that survive on many Mesolithic sites, and the few recorded Mesolithic shell middens provide some of the best evidence of bone tool manufacturing and use from this period in the British Isles. Bill Finlayson's pioneering studies of lithic assemblages from SW Scotland and Islay were aimed primarily at inferring the uses of microliths, and remain the most extensive published microwear studies of chipped stone artefacts from Scottish Mesolithic sites (Finlayson 1990; Finlayson & Mithen 2000; see also Hardy 2004). Only two studies of microwear traces on Mesolithic bone tools have been published to date (Griffitts & Bonsall 2001; Hardy 2009). Both studies focused on bevel-ended tools from shell middens on the west coast and were informed by experimental work, but reached somewhat different conclusions. The study by Hardy is notable for its use of scanning electron microscopy (SEM).

Figure 32: Experimental work under way to examine the processing of hide and associated wear on tools © Caroline Wickham-Jones

Experimental approaches have also been used to analyse the macro-wear patterns on coarse stone tools. Barlow and Mithen (2000) used elongated pebble tools for flint knapping, hide preparation, and limpet removal and compared the fracture and macro-wear patterns to those coming from Mesolithic coarse stone tools from Bolsay (Islay) and Staosnaig (Colonsay). From this they concluded that 'limpet hammers' had indeed most likely been used for removing limpets, although wear patterns relating to hide preparation were also evident on artefacts from Staosnaig.

A complementary method of functional analysis involves the study of physical (organic and/or mineral) residues on the surfaces of tools. So far, only one such study has been published for the Scottish Mesolithic, that by Hardy (2009) who examined bevel-ended tools from Sand and Loch a'Sguirr using SEM, although the results for both mineral and organic residues proved difficult to interpret.

Figure 33: Collecting nodules of Rum Bloodstone ©Caroline Wickham-Jones

Another important aspect of the study of stone tools is the sourcing (provenancing or characterization) of the materials used in their manufacture. A variety of archaeometric techniques are available to study the procurement of lithic materials, including geochemical 'fingerprinting'. Williams Thorpe and Thorpe (1984) used this technique to investigate the sources of pitchstone exploited during the Mesolithic to Bronze Age in Scotland and northern England. Successful characterisation of pitchstone artefacts is possible because there are relatively restricted sources (Ballin 2009). The challenge for archaeologists/geologists will be to extend this research to other lithic materials (e.g. flint, chert, bloodstone, baked mudstone, chalcedony, etc.), some of which were used more widely than pitchstone during the Mesolithic.

5.2.3 Dietary Reconstruction and Population Movements

Stable isotopes

Stable isotopes have a number of uses in archaeology. The concentrations of C-, N- and S-isotopes in human bone collagen can provide basic information on diet, such as the relative importance of terrestrial versus aquatic food sources. In practice, however, applications of dietary tracing using stable isotopes in the Scottish Mesolithic have been severely limited by the scarcity of human remains. No formal burials are known from Mesolithic sites, and the only dietary stable isotope results available are for disarticulated human remains from shell middens on the Isle of Oronsay (Richards & Mellars 1998; Richards & Sheridan 2000; Milner & Craig 2009). Sr- and O-isotopes in human bone/teeth can be used as tracers of population movement, but again Mesolithic applications in Scotland are constrained by the lack of human remains. O-isotope analysis can also be used to investigate the season of exploitation of fish and shellfish found in archaeological sites. While there have been some notable applications at Mesolithic sites around the Atlantic and Mediterranean coasts of Europe (e.g. Mannino *et al*. 2003; Colonese *et al*. 2009), the technique has hardly been used at all in Scotland (in spite of the abundance of suitable material); instead seasonality studies have relied on growth-line analysis of cockle shells (Deith 1983) or metrical analysis of fish otoliths (Mellars & Wilkinson 1980).

5.2.4 DNA and the Mesolithic in Scotland

The last decade has seen a significant increase in the use of genetic analysis in order to reconstruct past population movements. This includes analyses based on both modern and ancient DNA. aDNA (ancient DNA) work is very unusual in Mesolithic contexts in Britain, Brian Sykes' work with Cheddar Man is the most widely known but the recent reconstruction of the complete genome of a Mesolithic auroch from Derbyshire should be noted (Edwards *et al*. 2010). In the absence of aDNA the use of genetic analyses of modern populations is used in order to reconstruct past histories. This can include some very specific claims about the Mesolithic past and about the Mesolithic-Neolithic transition in the British Isles. For example, on the basis of modern population samples Sykes argues that 'the Y-chronosonal evidence suggests that Mesolithic immigrants from Iberia went mainly to the western and southern British Isles, contributing initially about 24% of modern lines, which is rather similar to the maternal figure' (Oppenheimer 2006, 152). Sykes argues for a clear distinction on genetic grounds for colonisation routes into eastern and western Scotland – the former ultimately deriving from the Balkans and the later from Iberia. Sykes reports that the Hebridean islands include high proportions of 'clans' (groups of related genetic sequences) 'Jasmine and Tara' that directly relate to the Neolithic expansion of agriculture, with these sequences in Scotland indicating population movement along the Atlantic fringes of Europe (Sykes 2006, 212). Whilst the frequencies of the Katrine 'clan', ultimately deriving from northern Italy *c*. 15000 years ago (an Alpine LGM refugia) are higher in Lewis than anywhere else in Scotland. Recent claims about the Mesolithic-Neolithic transition in Ireland are even more specific: 'About 13% of Irish mtDNAs belong to putative Neolithic clusters … there is an even distribution of putatively Neolithic haplogroups around the island, suggesting that females who arrived after the initial settlement were not restricted to east-facing regions. By contrast, however, Y-chromosome lineages of putative Near Eastern Neolithic origin … appear to be virtually absent from the west of Ireland' (McEvoy *et al*. 2004, 695).

The use of modern populations to reconstruct past histories has been criticised on a number of grounds, including sample sizes and a failure to consider more recent histories of migration (for discussions of the relationships between archaeology and genetics in the specific context of early Holocene history see Pluciennik 2006; Thomas 2006). However, academic critiques have not significantly held back sales of popular books which offer a sense of antiquity and ancestry (for discussion see Nash 2007). The popular presentation of Cheddar Man's supposed direct descendant, a school teacher from Cheddar, is indicative of the ways in which ancestry and senses of belonging are entangled with the reconstruction of genetic family trees.

The incorporation of genetics into anthropology and archaeology in general has been transformative (Pálsson 2007) and creates new possibilities. The resulting narratives sometimes feel unfamiliar and challenging. There can be a significant disconnect between those who use genetic data and those who do not, and at times, a sense that archaeologists feel that if they ignore the genetic interpretations the latter will fade away. Integrating the two sets of data is not straightforward but it is essential that Scottish archaeological research into the Mesolithic period actively engages with the interpretations offered by genetic research. Recent genetic and isotopic work offers much more than straightforward detail of past migrations and will, it is to be hoped, be integrated into studies of early Prehistory in Scotland.

5.2.5 Environmental reconstruction

A wide variety of scientific methods to reconstruct local and regional environments for Mesolithic sites are now available for use by archaeologists concerned with Mesolithic settlement in Scotland. These include the following:

Palynology and microscopic charcoal
Pollen analysis is the most widespread method for palaeoenvironmental reconstruction in Mesolithic Scotland applied to both off-site deposits and those from within culturally-rich sediments. The methods of palynology are well established and do not require any description in this report (the reader is recommended to consult Moore *et al.* 1991). Pollen analysis is most ideally undertaken in the context of a multi-proxy analysis of a sediment core in which the following are also examined: testate amoeba (which provide a measurement of wetness of bog surfaces); coleoptera (beetle remains used to reconstruct ecology and climate); chironimids (head capsules of aquatic larvae which are sensitive to environmental change); tephra (see above) and microscopic charcoal (which provides a measure of either human activity or natural fire events). Important applications of such methods relating to Early to Late-Mesolithic settlement can be found in Edwards *et al.* (2007) and Anderson (1998).

Plant macros
Plant macroscopic remains can be extracted either from off-site sediments cores or from culturally-rich deposits on archaeological sites. This term covers a wide range of remains including seeds, fruits, buds, scales, parenchymatous tissue, and wood charcoal. Where preserved on sites, macro remains can be hugely informative and help to offer a potential corrective to the view of Palaeolithic and Mesolithic people as primarily hunters and fishers (see papers in Mason & Hather 2002). The analysis of such remains from archaeological deposits often poses a considerable taphonomic question as to whether such remains derive from human activity or are naturally present within the deposits. Ideally they can provide a profile of the types of vegetation that have been growing locally and in some circumstances indicate the seasonality of occupation. The most abundant type of plant macro remains are fragments of charred hazelnut shell, as found in substantial quantities at Staosnaig, Colonsay, along with the remains of apple, lesser celandine, and a wide range of parenchymatous tissue. Wood charcoal can be indentified in some cases to species by identifying anatomical characteristics such as cell and tissue structure and vessel arrangement. The comparison between a vegetation profile produced from on-site wood charcoal assemblage with that from off-site pollen analysis facilitates the interpretation of each source of data, as undertaken at Bolsay and the adjacent Loch a'Bhogaidh, Islay (Kaminski in Mithen *et al.* 2000; Sugden & Edwards 2000).

Phytoliths
Phytoliths are siliceous precipitates that form within plant cells. Their morphology can be indicative of the type of cell and in some cases the type of plant within which they have formed. Because they are made of silica they are prone to survive under the right environmental pH conditions within sediments after the organic plant material has decayed. Phytoliths are not preserved under extremes of pH and are subject to post-depositional taphonomic

processes that can lead to fragmentation and constrain identification. Although phytolith studies have now become widespread in environmental archaeology and have considerable potential in the study of hunter-gatherer plant use, especially in regions where organic material rarely survives, there have as yet been no significant applications in the Mesolithic of Scotland.

Diatoms

Diatoms are a type of algae with cell walls made of silica. They are especially useful for archaeologists interested in past sea-level change because of three characteristics. First, each species of diatom has an ecological preference: some live in salt water, some in brackish water and some in fresh water. Second, each species has a unique type of cell wall and hence can be readily identified microscopically. Third, because the cell walls are made of silica they are relatively durable. Diatoms can be extracted from either off-site sediments being analysed to reconstruct sea-level change e.g. Dawson and Dawson (2000) or from on-site sediments when exploring local environments and post-depositional history.

Fauna[12]

As with pollen the techniques involved in archaeological faunal analysis (encompassing terrestrial and marine fauna including fish) are well covered elsehwere and do not need to be rehearsed here (see Lyman 1994; Hillson 1998; Yalden 1999). With regards to Palaeolithic and Mesolithic Scotland the key questions that need to be addressed concerning the composition of the fauna through time, the range of wild animals being hunted and their relative importance, the seasons in which they are being exploited, patterns of butchery and carcass discard, and utilization with regard to food and raw materials. Symbolic associations with animals need to be taken into account but the manner in which these may influence a faunal assemblage will inevitably remain unclear. The key constraint for Mesolithic Scotland is simply the availability of fauna to analyse with the only significant published assemblages coming from the Oronsay middens and Sand. As with the study of plant remains the analysis of on-site animal fauna can inform about the Mesolithic economy and the environment within which the hunting and gathering were taking place.

Mollusc analysis

This is another area of environmental reconstruction in which methodology is already well-established (Claassen 1998; Evans 1972). The analysis of molluscs and crustacea, and other materials often found in association such as sea-weed, can inform amongst other things about the dietary preferences of Mesolithic people along with their particular patterns of coastal exploitation e.g. Deith (1983; 1986). Attention is paid to the species diversity found within an assemblage of shells together with the morphology of shells such as limpets and growth-line analysis, which can indicate the season of exploitation. It is also possible to analyse the oxygen isotopes within mollusc shells to gain an estimate of past sea temperatures. Cowrie shells in particular were used by Mesolithic peoples for beads (Mellars 1987; Simpson 1996), but it can on occasion be difficult to distinguish deliberate rather than natural perforations on shells (Saville 2004c, n.6).

Sediment analysis

A wide range of physical and geochemical techniques are available to analyse sediments coming from Mesolithic

[12] Microfauna including chironomids and other insects can also play an important part in environmental reconstruction. See discussion in the ScARF Science report (follow the links at www.scottishheritagehub.com)

archaeological sites. Micromorphological analysis is now routinely used in a wide range of periods (Courty *et al*. 1989), but is yet to receive appropriate application in Mesolithic Scotland even though this could address pervasive problems of site formation. Particle size analysis, loss-on-ignition, magnetic susceptibility, and x-ray techniques are all routine methods for characterising archaeological sediments and should be widely applied for studying Mesolithic sites in Scotland.

5.2.6 Site investigation

Until recently, geophysical survey and remote sensing were not used routinely for the detection and investigation of Mesolithic sites and features (but see Marshall in Mithen 2000 for use of resistivity at Staosnaig Mesolithic site). The *Scottish Mesolithic Geophysical Survey Project* was established in 2002 by the Department of Archaeology at Glasgow University, in order to research the application of geophysical survey techniques to Mesolithic archaeology, and sites with different topographic and pedological characteristics were used as case studies. Geophysical survey has also been used as a general prospecting tool as part of the *Inner Hebrides Mesolithic Project* led by Steven Mithen. With the exception of Sand, Applecross, Highland, the results of these surveys have not yet been published in detail. At Sand a fluxgate gradiometer survey was undertaken of an area *c*. 500m^2 directly in front of the rockshelter, with the primary objective of exploring the geophysical response of the shell midden deposit and establishing its extent. A sampling interval of 0.25m was adopted and the instrumentation was set to detect features up to 1m below the ground surface. The magnetic anomalies detected could be linked mainly to geological features, metal objects in the soil, or recent disturbances of the site, but no clear magnetic response was obtained from the midden deposit (Finlay 2009).

Archaeological geoprospection has seen limited application in Scotland, but has proved useful elsewhere (Carey *et al*. 2007).

Table 3 lists some common science-based techniques and the extent of their use in Scottish Mesolithic studies. With the exception of radiocarbon dating, there have been relatively few applications of these techniques. This is further highlighted by a survey of papers with a specific focus on the Scottish Mesolithic published in the *Journal of Archaeological Science* between 1975 and 2010 (**Table 4**). If archaeobotanical, archaeozoological, geoarchaeological, and palynological studies are excluded, which fall more within the realm of environmental archaeology, only three papers published in the *Journal of Archaeological Science* over the past 35 years are concerned with the scientific analysis of archaeological materials from Scottish Mesolithic sites. While the *Journal of Archaeological Science* does not represent the total picture, it is probably a fair reflection of past and present trends in Scottish Mesolithic research and highlights both the paucity of science-based research and the imbalance between environmental archaeology and archaeometry in what little research has been undertaken. While the lack of human remains from Mesolithic sites in Scotland probably accounts for the dearth of archaeogenetic research and stable isotope studies of diet and population movements, it is more difficult to explain why there have been so few applications of archaeometric techniques to the study of artefacts and ecofacts. One reason perhaps is the lack of specialist degrees in archaeological science at postgraduate (Master and PhD) level in Scottish Universities. Therein lie objectives and opportunities for the future.

Table 3: Applications of archaeometric techniques in Scottish Mesolithic studies

Area of Investigation	Technique	Applications
ISOTOPIC DATING	Radiocarbon	Numerous
NON-ISOTOPIC DATING	Luminescence	Bolsay Farm (Islay), West Voe (Shetland)
STABLE ISOTOPES	Dietary tracing	Oronsay
	Population movements	–
	Seasonality (molluscs, fish)	–
ARCHAEOGENETICS	aDNA	–
ARTEFACT STUDIES	Lithic use-wear	Bolsay Farm, Gleann Mor (Islay), Smittons, Starr (Dumfries and Galloway)
	Bone use-wear	'Obanian' shell middens – bevel-ended tools
	Residue analysis	Sand (Applecross) – bevel-ended tools
	Trace element provenancing	Pitchstone sources (Arran)
SITE INVESTIGATIONS	Remote sensing and geophysical survey	Sand (Applecross), Newton (Islay), Port Lobh (Colonsay), Tiree, East Barns (East Lothian)

Table 4: Articles with a focus on the Scottish Mesolithic, published in the *Journal of Archaeological Science* between 1975 and 2010

Methodological emphasis	∑ articles	*J Arch Sci* reference
Archaeobotany	1	vol 28(3), 2001: 223-34 (S Mithen et al.)
Archaeozoology	1	vol 34(3), 2007: 463-84 (E.H. Fairnell, J. Barrett)
Geoarchaeology	1	vol 17(5), 1990: 509-12 (A.G. Dawson et al.)
Geochemical fingerprinting	1	vol 11(1), 1984: 1-34 (O. Williams Thorpe, R.S. Thorpe)
Growth-line analysis of shells	1	vol 10(5), 1983: 423-40 (M.R. Deith)
Palynology	4	vol 11(1), 1984: 71-80 (K. Edwards, K. Hirons); vol 16(1), 1989: 27-45 (A.H. Powers et al.); vol 32(3), 2005: 435-49 (K. Edwards et al.); vol 32(12), 2005: 1741-56 (K. Edwards et al.)
Radiocarbon	1	vol 37(4), 2010: 866-70 (M. Collard et al.)
Stable isotopes	2	vol 13(1), 1986: 61-78 (M. Deith); vol 26(6), 1999: 717-22 (M.P. Richards, R.E.M. Hedges)
∑	12	

5.2.7 Conservation

It has not been perceived as within the main remit of the ScARF Palaeolithic/Mesolithic report to investigate matters of conservation. It will have to suffice to mention, with regards to artefact conservation, that scientific techniques for investigating and preserving organic remains, such as freeze-drying, have advanced considerably. In the event of a major new discovery of waterlogged Palaeolithic or Mesolithic artefacts, however, there could be resource and capacity issues requiring recourse to facilities outwith Scotland, since institutions and commercial concerns within Scotland probably lack sufficient equipment, personnel, and expertise. Otherwise, because Palaeolithic and Mesolithic artefactual remains from Scotland are for the most part lithic and to all intents and purposes inert, preservation in a museum context is not normally problematic (Holgate 1994), although there are continuing discussions about the most appropriate way in which such artefacts should be cleaned, marked, bagged, boxed, and stored. These discussions revolve in particular around the question of not compromising potential microwear and residue traces, and it has to be admitted that no single best practice has yet been established because of the different preferences held by the various interested parties. As with archaeological finds of all periods, there are issues concerning storage capacity since the residues from Mesolithic excavations can be prolific; for example the recent Scotland's First Settlers Project (Hardy & Wickham-Jones 2009) produced, after post-excavation, some 80 large boxes of shells requiring museum storage.

As for conservation of Palaeolithic and Mesolithic sites, there are very few in Scotland which have any statutory protection. The relevant scheduled ancient monuments comprise (with their AM no. in brackets):

- Caves, Creag nan Uamh, Assynt, Highland (606)
- Garleffin standing stones and Mesolithic settlement, Ballantrae, South Ayrshire (5379)
- Middens (two) 350m WSW of Seal Cottage, Oronsay, Argyll (6288)
- Midden 250m NW of Seal Cottage, Oronsay, Argyll (6289)
- Nether Kinneil shell middens 400m ENE of Inveravon, Bo'ness, Falkirk (6917)
- Shell midden 350m W of Kinneil House, Bo'ness, Falkirk (6918)
- Morton Mesolithic settlement, Forgan, Fife (7641)
- Risga, shell midden and related structures on SE side of island, Ardnamurchan, Highland (7829)
- Shell midden 1050m NNE of Staffin House, Skye, Highland (7848)

Of these sites, the Creag nan Uamh caves have not, strictly speaking, produced archaeological evidence earlier than the Neolithic period, but they are a very important repository of Quaternary fauna with a bearing on the environment for Lateglacial human inhabitation. The scheduled shell middens have all been mentioned at various points earlier in this report, and their key importance for Mesolithic studies needs no further emphasis (but their over-representation is obvious). Morton is a key Mesolithic site, known from fieldwalking and excavation to have both earlier and later Mesolithic settlement evidence, including a shell midden. The Garleffin site is the only one on this list to have been included on the basis of surface finds of Mesolithic artefacts, but probably has only been so because this is the same location as the standing stones.

Otherwise all known Palaeolithic and Mesolithic sites in Scotland, almost all of which are primarily represented by lithic artefact findspots / concentrations / scatters, are in the normal course of events without protection other than having the possiblilty of archaeological conditions being imposed if threatened by development. This would depend upon their existence being known and their value appreciated, which is dependent in the first place upon their representation in local HERs and the RCAHMS database. The experience of ScARF Panel members with national and local records suggests that this representation is low[13]. Since by definition the existence of a lithic artefact scatter means that it either is or has been on arable land, such sites are very vulnerable to continued plough damage. It cannot be expected that all, or indeed many, Mesolithic sites known in this way should receive full statutory protection, but there is a strong case for very rare and important occurrences, for example of Upper Palaeolithic and Early Mesolithic sites, becoming scheduled ancient monuments, or in some other way actively being managed to protect them. The addition and consolidation within the existing national and local records of known information about all Palaeolithic and Mesolithic sites should be a matter of priority, as should a much more informed appreciation of the potential of artefact scatter sites (e.g. see Smit 2010).

5.3 Experimental archaeology

Experimental archaeology has a respectable history from the early work documented by Coles (1973) to the present day[14]. It is a useful tool that may be used to assist interpretation at various levels from the analysis of the practicalities of building structures to studies of tool manufacture and use. Experiment also has a valuable role in studies of site formation such as the decay and taphonomy of structures, and post-depositional movement and wear of artefacts. Experiment can never show precisely how things were done in the past, but it can help archaeologists to understand how they might have taken place. As with the study of ethnographic paralells it helps the archaeologists of the 21st century to step back and broaden their understanding of the range of possibilities in which the archaeological record has come about.

A particularly valuable facet of experimental archaeology is the potential that it offers to broaden the archaeological experience to include the wider community. Some experiments involve many people, others involve just a few individuals, but the value of experiment is that it brings different specialisms and skills to bear upon archaeological interpretation. Builders, flintknappers, boatmen, fishermen, and hunters have all potentially vital rôles in archaeological experiments relevant to studies of Mesolithic Scotland and the list of potential skills is almost endless.

The value of experiment lies not just in its use of related expertise but also in its use as an interpretive tool. Archaeological sites and finds, particularly those of the Mesolithic, can be difficult to relate to the everyday life of the past. Nothing can beat the practical demonstration of ancient skills, the actual experience of entering a reconstructed building, or the fun of trying something out for oneself. Experiment, in the form of experience, is particularly valuable for children, but also, of course, of great interest to the adult community. It is worth noting that, for experiment to be archaeologically valuable it has to be carefully controlled. This means that very often public interpretation exercises have to take place separately, in a less controlled, experiential environment; they are, nevertheless, valuable.

Recent experiments relevant to Mesolithic Scotland include work on bevel-ended tools by Birch (2003; Birch and Hardy 2009), the reconstruction of a Mesolithic round house by Waddington (2007), the knapping and burning of quartz by Ballin (2008a) and Driscoll (2010), and general experiential, replication, and

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13 Follow the link at www.scottishheritagehub.com to Palaeolithic and Mesolithic downloads

14 See http://www.abdn.ac.uk/experimental-archaeology/

reconstruction work at the former Archaeolink Prehistory Park in Aberdeenshire, which closed in 2011. The full value of experiment as an archaeological tool has yet to be fully embraced in Scotland and recommendations for future work would include increased emphasis on this.

Some 'experimental' work to replicate the wear patterns on bevelled pebbles has been done in the past e.g. Mithen (2000), but this has never been carried out with great scientific rigour and have resulted in more questions than answers.

5.4 Lithic Identification and Analysis

While the actual attributes to be recorded in any one analysis depend on both the assemblage and on the questions to be asked, lithic analysis typically includes measuring a number of fields including the length, width and thickness of an artefact as well as sometimes recording its weight (metrical analysis), in order to produce a series of statistics that describe any given piece[15]. On unbroken pieces the length-width ratio, for example, gives an indication of how long a flake is in relation to its width. Flakes with a length-width ratio of 2:1 or greater and where there are other indications of the use of blade technology, such as the presence of blade cores, are usually assumed to be blades and if it is less than 2:1 then they are categorized as flakes; however, these proportions should be used only as a guide as blades can be more squat with a lower length-width ratio while flakes can be blade-like. If an assemblage is dominated by flakes with a length-width ratio of 2:1 or more it would be classified as belonging to a blade-based industry. However, blades do not necessarily have to be twice as long as they are wide as it is the intentional flaking of a linear detachment, often with parallel sides, that creates a blade form.

The classification of flints can be hampered by the widespread plough damage that is common on lithic artefacts recovered from arable fields. Identification can be obscured by parts of the piece being missing or by edge damage appearing similar to intentional retouch, and statistical characterisation hampered by high incidence of breakage (whether ancient or modern) so it is important to be able to distinguish between breaks resulting from modern plough damage and intentional chipping (see Mallouf 1982). Useful explanations of how to get started in measuring, describing, analysing and classifying lithic artefacts can be found in Andrefsky (1998), Saville (1980), and also Watson (1968).

The illustration of flint artefacts requires a thorough understanding of how flints have been struck and how such characteristics are then portrayed using appropriate conventions. The key manuals that help unlock the door to lithic illustration are those by Martingell and Saville (1988), Addington (1986), and the more general work by Griffiths *et al.* (1990). A number of universities provide classes within Continuing Education Departments in archaeological illustration, while membership of the Institute for Archaeologists (Archaeological Illustrators Section) brings the benefits of seminars, conferences, publications, and the opportunity to seek advice from professional illustrators.

Presenting lithic scatter data from fieldwalking and test pit projects can usefully be made more compatible so projects can be compared.

[15] Follow the link at www.scottishheritagehub.com to Palaeolithic and Mesolithic downloads

Follow the link at www.scottishheritagehub.com to Palaeolithic and Mesolithic downloads for an example of summarising information from fields walked as part of one project as a single chart and used to produce lithic density per hectare counts.

Strategies for Lithic Artefact Analysis and Classification

The excavation of Mesolithic sites in Scotland often yields substantial lithic assemblages, potentially numbering in excess of 2000 pieces per metre square (including micro-debitage), and yielding over 250,000 pieces as excavated assemblages (Mithen 2000, 302). Even smaller scale sites or investigations can produce total assemblages in the region of 1500 pieces (Wickham-Jones & Dalland 1998). The recovery of diagnostic microliths, cores, or debitage pieces from deposits of more recent date also requires due consideration and specialist evaluation. The presence of such large quantities of stone-working debris has consequences for excavation and field-recovery methodologies especially the impact of topsoil striping and the use of wet sieving (see Wickham-Jones 1990, 103 for discussion of the effect of recovery method on assemblage profile, and section 5.1.3 above). The large volume of material frequently generated from Mesolithic excavations also represents a substantial post-excavation commitment in terms of both time and resources and raises longer term storage, curation, and access issues.

The excavations at Kinloch, Rùm introduced the first rapid, basic computerised classification system for large lithic assemblages in Scotland (Wickham-Jones 1990). Prior to this, individual researchers often used their own idiosyncratic typologies (e.g. Mercer 1971) or applied imported schema (Cormack 1970). The Rùm system provided basic categorisation by raw material (e.g. flint, quartz), blank type (e.g. flake, core, chunk), presence of cortex (using a tripartite division), regularity (at least 10mm of acute edge), presence or absence of retouch and/or edge damage, metric dimensions, and condition (e.g. fresh, abraded, corticated) for all pieces greater than 10mm in size. While this schema has since undergone development, lithic analysts working on Scottish assemblages often base their categorisation upon it, or on that subsequently elaborated from it by the SHMP (Southern Hebrides Mesolithic Project; Finlayson *et al*. 1996; 2000). The utility of the routine recording of some of these categories has been questioned (Ballin 2000; Saville 2002; Saville *et al*. 2007; Saville & Ballin 2009) and there is still divergence in approaches to small size debitage (<10mm max. size) and the treatment of cores and retouched pieces (e.g. MacGregor & Donnelly 2001; Ballin & Johnson 2005). In the main, however, a broad consensus in approaches to the treatment and classification of Mesolithic lithic assemblages is emerging between many analysts. This offers considerable potential for cross-comparison and to elucidate genuine temporal and regional differences in stone-working traditions.

The use of a rapid basic classification method in combination with sub-sampling to provide a detailed technological and typological profile of the assemblage has proven particularly effective when dealing with large 'palimpsest', potentially multi-period, assemblages. A more biographical approach to cores in conjunction with detailed debitage studies has also proved informative in defining the dynamic process of lithic reduction. This has enabled some parameters of lithic skill to be defined and led to the identification of novice knappers – most likely children – in at least one assemblage (Finlay 2008; Mithen & Finlay 2000a). While there has been a traditional bias towards retouched pieces such as microliths, it is the mainstay of the unmodified component of the assemblage that often yields detailed understandings of stone-working techniques and can be used to address issues of tradition, mobility, materiality, and identity.

The adoption of detailed attribute based schema for microliths and other retouched pieces initiated by the SHMP (Finlayson *et al*. 2000) as well as schemes to classify microlith fragments (Finlay 2009) seeks to address the problem of idiosyncratic and unsystematic classification schemes and to foster greater consistency in classification, particularly between different analysts. These schemes still use basic microlith type categories (e.g. scalene triangle) but attempt to explore the nature of variation. Such approaches have proved particularly fruitful in combination with usewear studies (see below), for example at some of the sites on Islay usewear was found to be more likely to occur on those microliths with more angular forms (Finlayson & Mithen 1997, 2000). The use of an integrated *chaîne-opèratoire* approach has also elucidated different routines of production and subtle manufacturing differences in microlith creation (Finlay 2000; 2003).

The recognition of Palaeolithic and Mesolithic material requires a broad and detailed knowledge of British and European assemblages and highlights the importance of the specialist evaluation of excavated assemblages, including older collections as well as a detailed understanding of local raw material to resolve issues of provenance. The identification of the Upper Palaeolithic artefacts in the Late Hamburgian (Havelte) assemblage at Howburn, South Lanarkshire (Ballin *et al*. 2010) and the *Federmessergruppen* assemblage at Kilmelfort Cave, Argyll (Saville & Ballin 2009) are based solely on typological association, in the absence of *in situ* deposits and any organic material for radiocarbon dating. Collaboration with colleagues in mainland Europe and especially those in northern Europe is helping to fully appreciate the nuances of shared and disparate traditions of stone-working during this period and enhance approaches to, and understandings of, local variation in stone tool use as well as raw material constraints.

The diversity of lithic raw materials used in prehistoric Scotland creates challenges for the analyst and studies have augmented understanding of the Mesolithic use of beach pebble flint (Mithen 2000), quartz (Ballin 2009) chert (Ballin & Johnson 2005; Wright nd), bloodstone (Wickham-Jones 1990) and baked mudstone and chalcedonic silica (Saville *et al*. in press). An important aspect is the local availability of resources which can be highly variable (Wickham-Jones & Collins 1978; Wickham-Jones 1986) but there may be other selection criteria involved, for example colour, texture, and aesthetic preferences to consider. The variability of conchoidal fracture properties in some of these raw materials also necessitates greater flexibility in terms of analysis and impacts on recovery and site comparison. Condition is also a factor, for heavy surface patination (cortication) and burning often restricts identification even to raw material type, although condition itself can reveal much about artefact post-depositional histories, site formation processes, and identify the reworking of earlier artefacts. More analytical and experimental research needs to be undertaken to fully understand fully the particular properties of the suite of raw materials exploited in Scotland.

Integral to understanding Mesolithic lithic technology in Scotland has been the use of experimental replication (e.g. Mithen *et al*. 2000; Finlay 2003; 2008). This has proved helpful in understanding raw material constraints and technological signatures which have mainly been identified by using technological attribute analysis rather than refitting. The presence of so many large palimpsest sites has often precluded refitting as a routine strategy. Refitting has been more successful in relation to particular raw materials (Mithen & Finlay 2000b) and at smaller more discrete sites, such as Kilellan Farm, Islay (Saville 2005), although studies that link pieces between different sites in the landscape (e.g. Conneller 2005; Schaller-Åhrberg 1990) have yet to be attempted in Scotland.

A suite of microwear studies has been undertaken on Scottish microliths and other artefact and debitage classes using both low-power (Bradley 1985; Finlayson 1990; Finlayson & Mithen 1997, Finlayson & Mithen 2000) and high-power microscopy (e.g. Hardy 2004). These studies reveal the complexity of microlith function and the flexibility of composite implements and the role of unmodified pieces and as such offer strong caveats against uniform interpretations of artefact function.

Coarse stone and pebble tools, such as the distinctive so-called limpet hammers and limpet scoops were among the earliest forms identified from shell midden sites (Anderson 1898). There is considerable variety in the types and forms of coarse stone implements (hammerstones, anvils, pebble tools, etc.) recovered from sites and these have suffered from lack of field recognition and unsystematic analysis (Clarke 1990; 2009; section 4.1.1 above). A number of waisted pebbles found as surface finds in the Tweed Valley and interpreted as net sinkers have also traditionally been attributed to the period (Saville 2004c; Warren 2005). The question of whether pebble stone axeheads are an element of pre-Neolithic assemblages in Scotland is still debated (Saville 1994a; 2009). Other distinctive forms of coarse stone implements such as hollowed stone palettes have been recognised at a couple of sites (Finlay *et al*. 2003) and limited residue analysis has also been undertaken with mixed results (Finlay & Whitehead 2000). No decorated or incised pieces are as yet known from Scotland although these have been found elsewhere in the British Isles, for example at Rhuddlan, north Wales (Berridge with Roberts 1994) or the incised flint pebbles at Hengistbury Head, Dorset (Barton 1992).

Though the study of Mesolithic coarse stone tools has not flourished in the same way as that of flaked lithic assemblages it holds considerable potential, highlighted by the work of Clarke (2009). There has been no overall consistent methodological approach, nor has there been consensus regarding terminology, or approach in the recording of wear traces. The consequence is that stone tool catalogues which have been produced by various researchers over decades cannot be easily interrogated for intra-site comparisons.

Experimental approaches to pebble tools and associated bone and antler forms have also formed an important part of archaeological investigations, from the experimental use of concrete limpet hammers to knock limpets off rocks (Clark 1956) to more recent studies involving hide working (Griffitts & Bonsall 2001; Barlow & Mithen 2000; Birch 2009).

Other categories of stone finds include fire-cracked rocks and pieces of pumice. While not deliberately modified, fire-cracked rocks have tended to be overlooked and more systematic recovery and analysis of these pieces would be likely to yield enhanced understandings of Mesolithic pyrotechnologies. Pieces of modified and unmodified pumice are also infrequent finds (mostly on coastal west coast sites). Several of those that have been analysed are dated to particular volcanic eruptions which provide a useful dating control (Newton 1999).

5.5 Raw material studies

Due to the fact that the bulk of evidence from Scottish Upper Palaeolithic and Mesolithic sites is in the form of lithic artefacts, lithic raw material studies form an essential part of research into Scotland's earliest prehistory. Scottish geology offered a wide variety of lithic raw materials (listed below), and the study of these raw materials permits the lithic specialist to discuss a number of issues. The most important of these are:

- Typo-technological issues;
- Territorial structures;
- Exchange within and between territories;
- Procurement sites.

5.5.1 Raw materials identified in Scottish Upper Palaeolithic/Mesolithic assemblages

General references for raw material studies in Scotland include: Smith 1880; Wickham-Jones & Collins 1978; Wickham-Jones 1986; Saville 1994a. Although jasper is present in some parts of Scotland, it does not form a notable proportion of Scottish Upper Palaeolithic/Mesolithic assemblages (Saville 1994a, 59). The principal raw materials identified in Scottish Upper Palaeolithic or Mesolithic assemblages are set out in **Table 5**.

Table 5: The principal raw materials identified in Scottish Upper Palaeolithic or Mesolithic assemblages

Pebble flint	**Found on most Scottish beaches and, to a lesser extent, till deposits (e.g. Marshall 2000a; 2000b)**
'Yorkshire' flint	E.g. Upper Palaeolithic Howburn in South Lanarkshire (Ballin *et al.* 2010a)
Quartz, various forms	Mainly in north, west and Highland Scotland (Ballin 2008)
Rùm bloodstone	E.g. Kinloch on Rùm, and surrounding islands and mainland (Clarke & Griffiths 1990)
Staffin baked mudstone	E.g. An Corran and surrounding islands and mainland (Saville *et al*. in press)
Other mudstones	E.g. Shiants, Western Isles, and Woodend Loch, near Glasgow (Wickham-Jones pers. comm.; Davidson *et al.* 1949)
Skye tuffs	E.g. Clachan Harbour (Ballin *et al.* 2010b)
Chalcedonic silica	E.g. Skye (Saville *et al*. in press)
Chert	Mainly in southern and, to a lesser degree, central Scotland (e.g. Ballin & Johnson 2005)
Agate and other silicious rocks	Occasional use, but with higher frequencies in Fife and Angus, e.g. Morton, Fife (Coles 1971)
Pitchstone	This material was used on Mesolithic Arran but, apparently, the inter-territorial exchange in pitchstone is largely limited to the first half of the Early Neolithic period (Affleck *et al*. 1988; Ballin 2009)
Various minority raw materials	E.g. silicified limestone, basalt (Lacaille 1938)

Most commonly, the preferential use of one specific raw material led to the production of characteristic core forms, as the properties of that particular raw material determined the use of specific technological approaches or operational schemas. Pitchstone (Ballin 2009), for example, is characterized by a number of different properties, each of which resulted in the ubiquity or scarcity of certain core forms: 1) the tendency to break into tabular pieces led to the formation of many small squat or cubic cores, frequently with a flat 'back-side' (this also characterizes chert); 2) the exaggerated tendency of pitchstone blades to curve along their long axes led to the formation of small discoidal cores; and 3) its brittleness made this raw material less suitable for hammer-and-anvil production, resulting in low numbers of bipolar cores.

Quartz (Ballin 2008a) is generally considered a 'difficult' raw material, defined by intricate fracture patterns, which lead to many cores being rather chunky, and with quartz operational schemas being less sophisticated than contemporary schemas in other raw materials. One consequence of this was that, in many parts of north and west Scotland, bipolar approaches were preferred (eg, Lussa River on Jura; Mercer 1971 ('chisels'); also Ballin 2002), although some pure or fine-grained quartzes (e.g., Shieldaig, Wester Ross; Ballin 2008a) allowed more traditional platform techniques to be applied.

Figure 34: Blades from the Burnetland Hill chert quarry pit near Biggar, South Lanarkshire. This picture shows how the presence of internal fault planes in chert to a degree determines the final shape of chert artefacts (courtesy of Tam Ward, Biggar Archaeology Group).

Where more than one raw material was available to prehistoric people, certain raw materials were commonly preferred for certain tasks or tool forms. Although ideology (like group identity and religion) may occasionally have played a role in connection with these choices, many of those preferences may simply express functionality, in the sense that specific raw materials produced particularly sharp cutting-edges (knives), or they may have been valued for their durability (scrapers). At Upper Palaeolithic Howburn in South Lanarkshire, certain raw materials were clearly preferred for certain tool forms, and those preferences may represent a complex mixture of ideological and functional choices (Ballin *et al.* 2010a and b).

5.5.2 Territorial structures

Raw material studies may allow the definition of several higher levels of territories, such as techno-complexes or social territories (cf. Ballin 2009). Techno-complexes may be a group of social territories, which simply share a common raw material basis, which then determines specific technological approaches (e.g. the Scottish 'quartz province' in the north and west and the 'chert province' in the south).

Social territories have been suggested via their use of style. Wiessner (1983, 256), defines style as '...formal variation in material culture that transmits information about personal and social identity', and she distinguishes between two forms of style, one relating to personal identity (assertive style), and the other to group identity (emblemic style) (Wiessner 1983, 257). Assertive style is of no relevance to the present case. Wiessner defines emblemic style as '...formal variation in material culture that has a distinct referent and transmits a clear message to a defined target population (cf. Wobst 1977, 323) about conscious affiliation or identity' (Wiessner 1983, 257). In the following, the term 'style' refers exclusively to emblemic style.

In some cases, raw materials represent style, in the sense that they are markers of prehistoric group identity, and thereby also markers of social territories. If a decision to use or not use a certain raw-material is based entirely on the presence or absence of this raw-material the expression is functional, whereas a decision to give preference to a rare raw-material, or a decision to disregard a suitable abundant raw-material, are stylistic expressions (exchange of social information).

The almost total dominance of quartz in some parts of northern and western Scotland, as well as the almost total dominance of chert in southern Scotland, may be examples of the former, as in those cases few other suitable raw materials were available in the volumes needed. The use of Rùm bloodstone and Staffin baked mudstone in one specific part of the west coast of Scotland, on the other hand, may be examples of the latter, with the overlapping distribution patterns (Clarke & Griffiths 1990, ill. 94, table 29) of these two visibly distinctive raw materials probably defining one social territory.

Raw-material preference as an expression of function usually results in a gradually declining *fall-off curve* (Renfrew 1977, 73) with growing distance to the outcrop, whereas raw-material preference as an expression of style results in a marked drop in frequency at the borders of the social territory in question (Hodder 1979, 447), or possibly a stepped decline (O'Shea & Milner 2002, 220).

5.5.3 Raw material exchange[16]

Once a territorial structure has been defined, it is possible via raw material studies to examine communication forms within and between these territories. This is usually carried out in the form of distribution analyses and with the production of fall-off curves as an important aid. The shape of fall-off curves may, for example, indicate whether exchange took place in the form of down-the-line exchange (gradually declining curve) or as directional exchange (multi-peaked curve; Renfrew 1977).

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[16] Exchange is here defined as in Renfrew (1977, 72), that is '... in the case of some distributions it is not established that the goods changed hands at all; [exchange] in this case implies procurement of materials from a distance, by whatever mechanism'.

Analysis of artefact size and degree of repair and recycling with growing distance to the raw material sources may also shed light on this issue, as down-the-line exchange has a tendency to see artefacts shrink in size with growing distance. Indicators of raw material value within an exchange network are: numerical presence (a raw materials numerical presence in relation to distance to source); artefact size; artefact types (i.e. was a raw material mainly used for mundane tasks or as prestige objects); tool ratios; use-wear; and depositional patterns.

The finds from Upper Palaeolithic Howburn (Ballin *et al.* 2010a) are still in the process of analysis, but this case study of the site's raw materials (dominated by exotic flints and cherts) is expected to shed light on early prehistoric exchange.

5.5.4 Procurement sites

Procurement sites, where raw material was either collected or quarried, represent a particular complex set of issues. To a degree, procurement sites form part of raw material exchange *sensu largo*, representing one end of the chain from source to end-user (see above), but they also need to be examined and analysed in their own right, where the technologies applied to extract the raw material, as well as the socio-economical organization behind the actual collection or quarrying processes are discussed.

Figure 35: The Burnetland Hill chert quarry pit under excavation by Biggar Archaeology Group 2007. Prior to excavation, the quarry pit was visible as a faint oval depression (courtesy of Tam Ward, Biggar Archaeology Group).

At present, few Upper Palaeolithic or Mesolithic procurement sites are known from Scotland. An undated, but probably post Mesolithic, quartz quarry from Lewis has been discussed in the archaeological literature (Ballin 2004). Chert quarry pits are known from southern Scotland (Warren 2007b, 146), but these features are often undated. However, the fact that some are associated with relatively narrow blades suggests that they were operational by in the Late Mesolithic or Early Neolithic periods. At Early Mesolithic An Corran, baked mudstone may have been procured from an exposure immediately above the site (A. Saville, K. Hardy & S. Birch pers. comms.). Rùm bloodstone was probably procured from the scree or beach at the foot of Bloodstone Hill (Wickham-Jones 1990); prehistoric quarries (even in the simple form of quarry pits) have not yet been located on Rùm (Clarke & Griffiths 1990).

5.5.5 General considerations

All lithic artefact specialists should have a basic geological knowledge of the raw materials used in Scottish prehistory – where they occur and in which periods they were used. However, the acquisition of relevant information for many less common raw materials can be problematic and, in those cases, it is essential that the lithic analyst works with a geologist. It is for example difficult to distinguish between fresh Staffin baked mudstone and the tuffs of eastern Skye (such as, for example, the form recovered from Clachan Harbour on Raasay; Ballin *et al.* 2010b). The chalcedonic silicas of the Inner Hebrides and west coast (e.g. An Corran and Camas Daraich; Wickham-Jones & Hardy 2004, 20; Saville *et al*. in press) may also be difficult to deal with, and the striped lithic raw materials (mostly meta-sediments) recovered from the the Southern Hebrides and the Western Isles are notorious (in some of these cases, even the geologists seem to disagree, defining these types of rock as variously either mylonite, baked mudstone, or hornfels).

An expert geological input is also relevant in connection with acquiring an understanding of the appearances and properties of lithic raw materials. Staffin baked mudstone and Lewisian mylonite were probably both more or less unpatterned in their fresh states, and they may have acquired their striking appearances (marked dark-light banding) as part of the weathering process. It is also likely that the appearance of some raw materials (e.g. meta-sediments) as, for example, loose-textured and apparently ill-suited for flaking, is a result of weathering since deposition. It is worth noting, however, that in many cases the size of outcrop which will spark archaeological interest may be well below that which would register as significant to a geologist. Issues of scale in fieldwork may have to be resolved.

In cases where geological consultation does not deal with a problem in a satisfactory manner, such as the case of mylonite/baked mudstone/hornfels (above), fieldwork may provide a solution. In this instance, the possibility of the raw material being mylonite could be tested by attempting to find primary outcrops, or even quarries, along the main faultline of eastern Lewis, where mylonite occurrences have been reported (Smith & Fettes 1979, 78).

5.6 Future research recommendations

The appropriate use of scientific techniques is an important factor for any archaeological project. Specific recommendations include:

- Examination of archaeological assemblages to gauge whether the procurement sites may be primary or secondary sources, and whether the raw material may represent any form of selection (flaking properties, colours and patterns, etc.);
- Comparison of archaeological samples with geological samples, in collaboration with geologists and in the field, as well as the lab, where possible;
- Field work to inspect potential source locations/quarries.
- Development of work on use-wear/residue analysis for lithic assemblages and more frequent application to excavated material.
- Understanding the dynamics of the formation of occupation deposits as well as identifying specific craft or processing activities within sites through the application of a range of methodologies to artefactual analyses, including use wear and contextual analysis.
- Experimental replication of artefactual and site processes.

6. Lifestyles

6.1 Palaeolithic/ Mesolithic lifestyles

‘Subsistence’ – what people ate in the past and how they acquired their food – has long been a primary concern of Palaeolithic and Mesolithic archaeology. This is sometimes mistakenly taken to imply that archaeologists have limited interest in issues about social organisation and ideology. That is not the case; subsistence behaviour is intimately connected to all aspects of lifestyle in past communities, especially those of hunter-gatherers. Its prioritisation is primarily one of methodological pragmatism rather than of theoretical persuasion. Indeed, it is important to recall that ‘subsistence’, ‘technology’, ‘social organisation’ and so forth constitute modern categories that are imposed onto past communities rather than these having any meaningful distinction in their own lives. A concern with what people ate simply provides a pathway into the holistic character of past behaviour and thought.

By definition, Mesolithic communities in Scotland relied on wild resources. The direct evidence for what specific plants were gathered and animals hunted is often sparse and in some areas non-existent. As a consequence, archaeologists frequently draw on comparative studies from contemporaneous cultures in regions with better preservation in Europe, such as Mesolithic southern Scandinavia, and with analogies from the ethnographic records of recently living and witnessed hunter-gatherers. In this work it is necessary to recognise that considerable diversity in diet is likely to have existed (for many reasons) across Europe in Mesolithic times just as in the present day.

It is easy to be sceptical about the value of ethnographic analogies because many of the recently documented hunter-gatherers were living in highly marginal areas, such as the San of the Kalahari (Lee & Devore 1976) and Central Desert Aborigines (Gould 1980), or were heavily influenced by contact with state societies and were using ‘modern’ technology, such as the Nunamiut (Binford 1978). Hence their relevance to Mesolithic communities in Scotland can appear at best tangential if not simply irrelevant. Nevertheless, ethnographic studies can provide an invaluable frame of reference for the study of prehistoric hunter-gatherers (Binford 2001). They must be used cautiously, but it is foolish to reject, a priori, any source of potential information and ideas when the challenge of reconstructing Mesolithic lifestyles is so demanding.

One of the main ethnographic contributions simply regards the scale of hunter-gatherer mobility. Most studies whether of San Bushmen in the Kalahari or the Inuit of the Arctic demonstrate one pervasive characteristic of hunter-gatherer lifestyles, that – with extremely few exceptions – they can cover vast distances in terms of their annual mobility patterns. This is neatly summarised by Lewis Binford’s statement that ‘archaeologists need to recalibrate their perspective of hunters and gatherers from the 5 foot square excavation unit at a single site to an area of more than 300,000 square kilometers’ (Binford 1983, 110). This was especially pertinent to Mesolithic Scotland where there had once been a focus on individual sites, for example the middens of Oronsay, as if these represented the entirety of the Mesolithic subsistence base. More recently, archaeologists studying the Mesolithic have attempted to undertake a regional approach, as in the Southern Hebrides Mesolithic Project, looking at the region of Islay, Jura, Oronsay, and Colonsay (Mithen 2000), and the

Scotland's First Settlers Project looking at the Inner Sound of Skye (Hardy & Wickham-Jones 2009). While it may be that the spatial areas of even these projects only encompass a fraction of that covered by a single Mesolithic community — Binford's suggested figure above would have covered the entire west coast of Scotland, from Arran in the south to the tip of Lewis in the north — there are some caveats. It is necessary to remember that many of these studies encompass very different environments to those of post-glacial Scotland, and that other studies illustrate considerable variety and complexity in hunter-gather mobility. Perhaps the most important lesson is that mobility may just be a convenient modern catch-all for a complex pattern of movement in which different components varied in geographical scale, as they did in purpose, participants, and speed (see below).

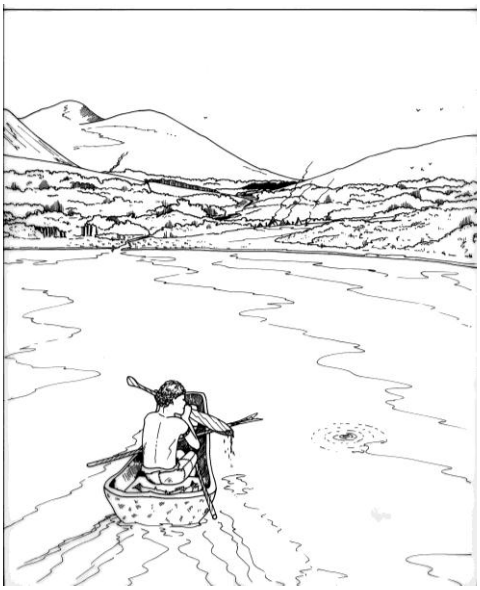

Figure 36: Mobility is a key element of our interpretation of the Mesolithic but it is hard to quantify archaeologically as this reconstruction set around the site at Kinloch on the island of Rum shows, © Alan Braby

Another invaluable insight from ethnographic studies concerns the patterns of mobility – or what is often termed a 'settlement-subsistence' system. In a seminal 1980 article, Binford differentiated between 'logistically' organised hunter-gatherers and what he termed 'foragers'. The former organise themselves around residential base camps, normally occupied for a whole winter or summer season. From these, small groups travel considerable distances to 'task-specific' sites, locations which because of their situation were devoted to particular activities, such as watching for game, fishing, and collecting raw materials. Any resources acquired from these locations, sometime visited over a period of a few days, are returned to the residential base camp. Typically, different groups will be visiting different task-specific sites at the same time so that a range of resources are returned to the resident base for sharing. Binford contrasted this type of mobility pattern with what he termed foraging. This is where the whole group frequently moves their residential base and engages in searching the immediately surrounding landscape for resources without visiting any specific locations. This type of mobility pattern is suitable for relatively homogenous environments, whereas logistical mobility is appropriate for those which are more heterogeneous, in which different resources are found in quite different but predictable locations. These two types of hunter-gatherer mobility are the polar ends of a continuum. Any one community is likely to include aspects of both types of mobility pattern, perhaps switching between them in different seasons. As Binford explained, the nature of a hunter-gatherer archaeological record is strongly influenced by what type of mobility pattern is adopted.

An extreme form of logistical mobility is one in which the residential base becomes sufficiently permanent for the hunter-gatherers to be classified as sedentary. This has been used as a defining feature of so-called 'complex hunter-gatherer' groups (Price & Brown 1985). Without having to continually move their residential camp, hunter-gatherers are able to accumulate material items, maintain social hierarchies, build monumental structures and, perhaps, claim rights over land by acts such as the establishment of cemeteries. Whether any such complex hunter-gatherers existed in European prehistory is a moot point, but this notion has been used as an interpretation of the later Mesolithic archaeology — the Ertebølle/ Ellerbek culture (Price 1985) — from southern Scandinavia and Northern Germany. A prerequisite for hunter-gatherer sedentism is that there is a sufficient naturally replenishing source of wild animals and/or plants in the vicinity of the residential site. The most likely circumstance where this will occur is in coastal locations, which are supplied by a succession of migratory fish species, shellfish and crustaceans, birds, and maybe mammals, throughout large parts of the year, with the possibility of using stored food resources for the leaner seasons.

It is within this conceptual framework of potentially extensive mobility at varied scales, with the possibility of either logistical or foraging modes of organisation, or more likely combinations of both, and the possibility of 'complex' hunter-gatherer groups, that the Mesolithic archaeology of Scotland needs to be examined. This involves dealing, of course, with over 5000 years of human activity during which the climate and environment of Scotland went through significant change. Rather than imagining a single type of Mesolithic settlement-subsistence pattern, verying through the seasons, for this entire period, it should be seen as a continually changing evolution, as hunter-gatherers adapted to changing resource distributions and went through their own process of cultural evolution partly in response to independently conceived social pressures and partly due to environmental drivers. At present not enough is known about how people organised their time and how extensive their cyclic movements were. There are too many unknowns about the scales of mobility operating in Mesolithic Scotland to directly equate the evidence with ethnographic understandings of patterns of annual or even lifetime movements, let alone how these map on to theoretical models of subsistence-settlement patterns.

Estimating overall population size is based entirely on informed speculation based, again, on ethnographical input as well as statistical evaluation of the recovered evidence for Mesolithic activity in Scotland as a whole. From the figure of 62 people for the whole of Scotland in the Mesolithic envisaged fifty years ago (Atkinson 1962), perceptions of the period have moved to recent computer modelling of environmental productivity producing considerably larger numbers in the thousands (Tolan-Smith 2008). Determining the number, size, and composition of groups is, however, extremely difficult given the likely volatility of numbers over this very long period. Consequently it is to a different suite of issues around these topics that researchers begin to address with the archaeological evidence.

Understanding the human scale of life and how individuals articulated within wider social networks is also difficult to understand, especially given the paucity of actual human remains and the nature of the evidence. Consideration of the important issues of gender and childhood are equally difficult. At times, ethnographic evidence for gendered activity has been compared with Scottish archaeological material, for example the association of 'Obanian' middens with putatively female activities (Bonsall 1996). There are, however, alternatives to task differentiation models and traditional approaches to the sexual division of labour in relation to Mesolithic hunter-gatherers which acknowledge personhood and the fluidity of gendered identities across the life course (Finlay 2006b). Consideration of age, individual personalities (e.g. Spikins 2008), and social skills helps to inform likely lifestyle narratives. Technological artefact analysis has also revealed different routines of production and subtle choices and distinctions in techniques which can be used to explore the social contexts of artefact creation and use (e.g. Finlay 2003; 2006; Warren 2006). These can be used to explore how the identities of both individuals and groups are experienced and expressed at different scales. The identification in some assemblages of novice stone workers, probably children, learning to knap (e.g. Coulerach, Islay; see Mithen & Finlay 2000a; Finlay 2008) helps to restore humanity to lithic scatters and offers tangible pathways to addressing prehistoric knowledge acquisition and social values.

The types of landscapes and resources that Mesolithic hunter-gatherers in Scotland were able to exploit were very diverse, including heavily indented coastlines with island archipelagos, coastal lowlands, rolling interior hills, large river valleys, and mountainous uplands. Aurochs, red deer, roe deer, wild boar, and otter were exploited, but less is known about the distribution of these animals in the landscape, especially regarding their presence on the smaller offshore islands. The Holocene woodlands are likely to have provided a diverse array of plant foods, while the coastal zone would have been especially productive with regard to sea mammals, fish, molluscs, crustaceans, seaweed, and birds.

It is indeed from coastal sites that the majority of direct information about Mesolithic subsistence derives, notably the ‘midden’ sites on Oronsay, especially Cnoc Coig (Mellars 1978; 1987) and Sand, Applecross (Hardy & Wickham-Jones 2009) on the west coast and Morton (Coles 1971) on the east coast. Whether this is a true reflection of the significance of coastal resources within Mesolithic diet or simply a consequence of biased preservation and discovery remains unclear; evidence from elsewhere in NW Europe suggests that communities with predominantly inland or coastal territories may have co-existed (e.g. Schulting & Richards 2001). The middens of Mesolithic Scotland have often dominated archaeological approaches to this period, especially as a basis for the reconstruction of subsistence practice, and it is important to stress that there is still little understanding of the reasons for the construction of middens through repeated acts of deposition, nor of the cultural logics that made it appropriate for individuals to deposit certain kinds of materials in certain places (Warren 2007b). Archaeological orthodoxy often suggests that middens are a direct reflection of diet, whereas their relationship with subsistence strategy may be much more complex.

The Oronsay middens, dating to the early 4th millennium cal BC are regarded as later Mesolithic although they could possibly be early Neolithic, as farming economies are established elsewhere in Scotland at this time. Investigation of these sites has shown that limpets, periwinkles, and numerous other types of molluscs and crustaceans were exploited, while large quantities of saithe had been caught (see below for discussion of fishing technology). The mammal bones indicate the presence of otters, possibly hunted for their pelts as completely articulated skeletons were found, as well as grey seal, wild boar, and red deer. The grey seal bones were dominated by those of very young animals suggesting that hunting had occurred during, or shortly after the breeding season, which today is during September and October. The limited range of bone type of red deer and wild boar were primarily those used for making tools, rather than meat bones. It is highly unlikely that either wild boar or deer would have been present on the tiny island of Oronsay, or indeed, or its rather larger neighbour Colonsay, so either joints of meat were brought to Oronsay from further afield or maybe simply the bones themselves for tool-making. There were a large number of bird bones in the middens; although these have not been published, no less than 50 species were represented including shearwaters, lapwings, woodcocks, eider ducks, puffins, kittwakes, corncrakes, and swans – birds from a wide variety of habitats (Grigson, pers. comm.). Although no evidence has been reported, the eggs of these birds are also likely to have been an important food source.

Some of the most intriguing evidence from Oronsay comes from the otolith bones – the 'ear bones' of fish. The size of an otolith is a direct reflection of the size of the fish from which it derived. Because fish grow at a regular rate they can be used to determine the season at which the fish had been caught – assuming one knows the date of spawning. When Mellars & Wilkinson (1980) measured the otoliths from four different middens on Oronsay they found contrasting size distributions, which they interpreted as reflecting different seasons of fishing activity at each of the middens: Cnoc Sligeach in the mid-summer, Cnoc Coig in the autumn, Caistael nan Gillean II in early summer, and Priory midden in the winter.

This evidence could be interpreted as Mesolithic hunter-gatherers inhabiting Oronsay all year round, moving from site to site with the seasons, presumably to avoid the worst of the prevailing winds and be close to the most productive resources (Mellars 1987). The isotopic analysis of human bone from the Oronsay middens (Richards & Mellars 1998) has also been used to infer settlement pattern. Samples from Cnoc Coig have indicated a diet with a very heavy reliance on protein from marine sources – which could be used to argue for a permanent presence on the island. But a sample from another midden, Caisteal nan Gillean II, has indicated a mixed diet of terrestrial and marine protein – which could be used to argue for seasonal movement between the coast and inland regions. Ultimately, the number of samples is too small to draw any firm conclusions. More likely is the alternative that the Mesolithic hunter-gatherers could have been intermittent visitors to the island. Oronsay being part of an extensive subsistence settlement system, this appears more likely in light of the tiny area and highly exposed nature of Oronsay. But until recently there was an absence of contemporary sites on the larger adjacent islands (Mithen 2000). Excavation of one contemporaneous shell midden site at Port Lobh on the west coast of Colonsay confirms that similar sites do exist and highlights that there is a need to be mindful of the biases created by the academic focus given to Oronsay (Finlay 2007a).

Combining the strands of seasonality and chronology, the sites in Oronsay have recently been interpreted as a response to economic stress in the later Mesolithic (Mellars 2004). This explanation is both plausible and convenient, while at the same time mirroring local historical information relating to the use of shellfish as a resource in times of famine (Wickham-Jones 2003). It is backed up by evidence that some earlier middens occur around what has come to be known as the 8.2k event (occurring c. 6200 cal BC), a brief but significant climatic downturn across NW Europe (Alley *et al.* 1997). However, while it is certainly possible that some middens do reflect the use of marine resources in times of hardship, this is unlikely to explain them all. And, if middens are a response to economic hardship, how prolonged were these episodes and how representative of Mesolithic Scotland as a whole?

What is unquestionable about the Oronsay evidence is the diverse range of coastal resources being exploited, or at least consumed. It was once thought that this type of coastal exploitation leading to the creation of middens was a feature of the final stages of the Mesolithic in Scotland, it being a key feature of the so-called 'Obanian' within which the midden from Risga was included. But the discovery of the midden at Sand (Hardy & Wickham-Jones 2009), which dates to a relatively early stage of the Mesolithic, along with that of Ulva Cave (Russell *et al*. 1995) and An Corran on Skye (Saville *et al*. in press), suggests that coastal exploitation had been an aspect of Mesolithic subsistence throughout the period.

The coastal site of Fiskary Bay, Coll, stands in contrast with these midden sites, appearing to be focused on fishing alone (Mithen *et al*. 2007). Although a relatively small area has so far been excavated at this site, only fish bones have been recovered, along with wood charcoal, charred hazelnut shells, and chipped stone. The fish bones were only recovered by sieving excavated sediments through a fine mesh – they were otherwise not visible on the site – which is a, perhaps uncomfortable, reminder of the potential value of standardised recovery strategies as utilised elsewhere in Europe (e.g. Rensink 2006). Although a similar range of coastal resources as represented in the Oronsay middens would have been available at Fiskary Bay, there was no trace of bones from sea mammals, land mammals birds, or molluscs. This may merely reflect the small area excavated as a diverse midden deposit might await discovery. Alternatively, Fiskary might be a specialised fishing camp in contrast to the generalised coastal foraging campsites represented by Cnoc Coig, Morton, and other midden sites. The bones come from a wide range of fish including wrasse, whiting, pollock, sea bass, and flat fish. Most of them appear to have been quite small, less than 30 cm, indicating a preference for inland waters where it seems most likely that they would have been caught by the use of fish traps. The location itself is ideally suited for this with a narrow inlet into the bay across which a wall can be easily built – a wall flooded at high tide but which would then trap the fish in the bay at low tide making them easy to collect in nets. The majority of fishing evidence from the Mesolithic of Scotland seems to indicate in-shore fishing, rather than deep sea fishing (Pickard & Bonsall 2004; but see Parks 2009). The value of the coastal zone in the Mesolihtic is also indicated by the recent excavation of fish weirs and fishing baskets in eastern Ireland (McQuade & O Donnell 2007; 2009; Mossop 2009), although none are known as yet from Scotland.

The Isle of Coll is unlikely to have had a population of red deer or wild boar during the Mesolithic and its woodlands are likely to have been relatively sparse (Wicks, forthcoming). Consequently, it seems likely that the island might have been visited only intermittently and for short periods, perhaps specifically for fishing at Fiskary Bay. The only plant foods evident from the excavation are hazelnuts, suggesting that at least some of the visits occurred during the autumn months.

While the quantity of charred hazelnut shell fragments at Fiskary Bay is limited, these have been found in vast numbers at the Mesolithic site of Staosnaig on the Isle of Colonsay (Mithen *et al*. 2001). This is also a coastal site, located in a sheltered bay on the east side of the island, but lacks any evidence for fishing, shellfish gathering, or exploitation of sea mammals. This may simply reflect the acidic nature of the soils at the site – the same type of sieving as used at Fiskary Bay had been employed but only tiny fragments survived within a unique micro-environment. A series of pits were found at Staosnaig surrounding a larger, shallow depression that contained a substantial quantity of charred hazelnut shell fragments – the remains of at least 40,000 nuts. This feature may have been the base of a hut which was subsequently re-used as a rubbish- or a cooking-pit.

Experimental roasting of nuts in pits similar to those found at Staosnaig has shown that if the shell becomes charred the kernel is inedible. However, it proved difficult to avoid about a fifth of nuts being charred during a roasting event (Score & Mithen 2000). So if those within the large depression were simply those discarded from the ovens represented by the surrounding pits, it implies that up to 200,000 nuts may have been roasted at Staosnaig. Quite why the remnants would be thrown into this depression – rather than just discarded on the ground or into the sea – is unclear; one possibility is that the nuts were being deliberately retained as fuel and burned to provide aromatic fumes for smoking fish or vegetables.

Figure 37: Resource gathering in Mesolithic Orkney, Crown Copyright Historic Scotland

Whatever the precise number of nuts and the process by which they were placed into this depression, the evidence from Staosnaig suggests an intensive exploitation of the woodland on the island, especially because micromorphological analysis of the sediments indicates that the hazelnut shell rich deposit has accumulated very rapidly. Consequently, just as Mesolithic hunter-gatherers may have visited Coll specifically for fishing at Fiskary Bay, so they may also have gone to Colonsay specifically to harvest hazelnuts and, if so, that was not the only plant food being exploited on the island. Meticulous recovery and analysis has also identified the charred seeds and flesh from apples, the charred seeds of cleavers, charred seaweed, and charred tubers and 'bulbils' (small swellings at the intersection of the stem and leaves) of lesser celandine, a member of the buttercup family (*Rannunculus ficaria*). The frequency of the lesser celandine suggests that this plant had been deliberately gathered rather than entering the deposit accidentally. Ethnographic reports describe how it has been used as both a herbal flavouring for food and for medicinal purpose. The range of plant foods available wild in Britain, and the complexity of processing requirements for some of them, has been highlighted in the recent television series *Wild Food* (Mears & Hillman 2007). The development of methodologies for the identification of these resources, including, for example, starch and phytoliths, is a key priority for Mesolithic research and has profound implications for excavation and recovery strategies. Staosnaig and Fiskary Bay appear to be sites where subsistence activity is dominated by one particular activity — harvesting hazelnuts and inshore fishing respectively — in contrast to the much wider range of activities at the shell midden sites on Oronsay, and at Sand, Risga, and An Corran. More problematic to interpret with regard to subsistence are those Mesolithic sites which lack any faunal and floral material, although charcoal fragments and pieces of charred hazelnut shell are frequently present. Classic examples of these are those sites on Jura excavated by John Mercer which have high frequencies of microliths, such as Glenbatrick and Glengarrisdale (Mercer 1974; Mercer & Searight 1986), Starr and Smittons in the south west (Edwards 1996) and those on Islay such as Gleann Mor (Mithen & Finlayson 2000) and Bolsay located on the Rinns peninsula (Mithen *et al*. 2000b).

For sites with limited direct evidence for subsistence, indirect evidence such as their location in the landscape, and the structure of their tool assemblages is used to construct hypotheses about their place in wider systems. Sites do vary in the size and character of the assemblage from small apparently discrete, sites like Fife Ness, near Crail (Wickham-Jones and Dalland 1998), which may represent a short temporal event, to larger palimpsests which probably highlight the use of recurrently favoured locations in the landscape, e.g. at Kinloch, Rum (Wickham-Jones 1986). In this respect some of the Islay sites are of particular interest because they are inland – although only a few kilometres from the coast. The excavation at Bolsay produced more than 5000 microliths from an area estimated to be less than a fifth of the spatial extent of the artefact distribution. The traditional view is that such artefacts were being manufactured as the points and barbs for arrows with which game, notably deer, were hunted. Although microwear analysis has shown that some microliths were used as drills and knife blades, others have impact fractures suggesting that there were indeed used as hunting weapons (Finlayson & Mithen 2000). As well as being present in particularly large numbers, the microliths at Bolsay show far less diversity in form than at many others sites, suggesting specialised activities. Moreover, the rarity of features and lack of spatial patterning in the artefact distributions suggest that the large numbers of artefacts had accumulated through many short-term visits to the site. Taking all of this into account, along with the fact that the Rinns of Islay remains today as a favoured location for hunting deer, it seems likely that Bolsay may have been another task-specific site – one for hunting red deer. Similar interpretations are likely to apply to the microlith-rich sites on Jura and elsewhere in Scotland, although some of these, such as Kinloch on Rùm, have more diverse artefact assemblages suggesting a wider range of activities (Wickham-Jones 1990). At the Sands of Forvie, Aberdeenshire, large lithic assemblages suggest an emphasis on the manufacture of microlithic components and, possibly, the extensive exploitation of starchy plants; one interpretation is that this site was utilised for preparing tools and cord/string, for use elsewhere.

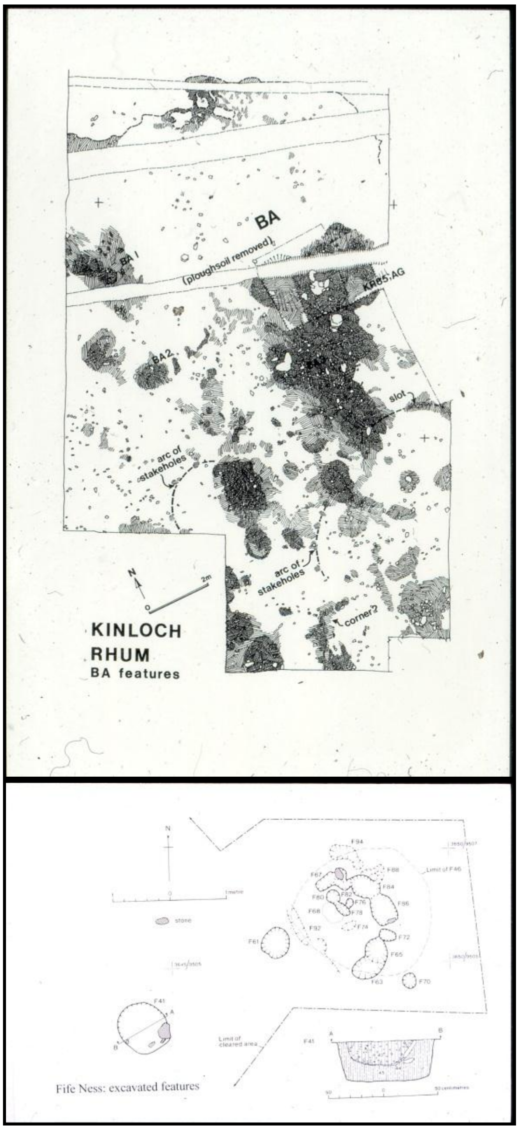

Figure 38: Different types of site provide information on the diverse nature of Mesolithic activity in the landscape. Larger sites with a variety of remains such as that at Kinloch, Rum, may indicate longer or more complex activity sites, whereas small sites such as Fife Ness (Wickham Jones and Dalland 1998) are thought to be the result of briefer activity, possibly even a single, short, specialized period of use, © Caroline Wickham Jones

Some of these microlith-rich sites are located adjacent to inland rivers, suggesting that fishing for salmon may have been the primary subsistence activity. Most notable are sites such as Rink Farm located at the juncture of the Rivers Tweed and Ettrick Water. Sites like Dryburgh Mains and Kalemouth (Callander 1927a; Mason 1931; see also Mulholland 1970; Warren 2005), are all located at key locations today for salmon fishing, and Nether Mills is adjacent to the River Dee (Kenworthy 1981). Problems exist in such interpretations; little is known about salmon behaviour in the early Holocene, especially the predictability of runs in the medium term, and uniformitarian analogies with modern salmon-run timing and abundance are not appropriate (Warren 2005, 57–58). This highlights the over-arching problem of reconstructing past environments for which modern analogies do not exist (Spikins 1999).

Many Mesolithic sites in Scotland lie on or near the coast but it is pertinent to ask whether this is evidence of a true preference for coastal living, or simply an archaeological bias. The latter is most likely, for while Mesolithic sites in the interior are few there has not been the same tradition of research activity (Finlay *et al*. 2002; Finlay in press). Sites such as Chest of Dee, Aberdeenshire (Murray *et al*. 2009) and Ben Lawers, Perthshire (Lelong 2003) indicate that Mesolithic activity penetrated the Highland Zone, and Daer Reservoir, South Lanarkshire (Ward 1995; 1997; 2000a; 2010) and Starr on Loch Doon, Dumfries and Galloway (Affleck 1986) provide evidence in other eco-zones away from the sea. A number of factors that do not operate in the interior have facilitated the discovery of sites in the coastal zone (Wickham-Jones 2004b): active and large scale erosion has worked to reveal sites; the working of agricultural land has resulted in the recognition of lithic scatter sites (especially in the decades preceding the mechanisation of farm machinery); developments such as road workings and building projects have uncovered material; and the emphasis of population today on these areas as opposed to the higher interior land has provided both a community with some interest in archaeology and a focus for development such as that mentioned above. In addition, groundcover in the interior has often militated against the recovery of sites, especially blanket forestry or peat; while the sheer inaccessibility of much of the zone for the population of today has reduced present activity and thus recognition of archaeological remains; this latter point has been reinforced by the systems of land holdings and use over much of the interior. Mesolithic sites in the Highland zone are more or less confined to land belonging to a single landowner with an archaeological interest. Finally, it should be noted that archaeology, as a profession, has contributed to the coastal bias in that the siting of a few large-scale research projects especially on the west coast has both raised awareness among local people to the extent that new sites are recognised, and stimulated further research questions among archaeologists who have then moved into the area with a virtuous circle of yet more projects.

The lack of detailed work in the interior makes it hard to quantify the relative importance of the coast to the inhabitants of Mesolithic Scotland but this is a pattern that has begun to change especially within the last decade or so. The concentration of sites does suggest that the coastal zone may well have formed a preferred location for many activities, at least for many groups. Nevertheless, it is also relevant to query whether it was the coast that was of value or the wider lowlands, many of which lie within easy reach of the coast. The concentration of sites along rivers such as the Dee or the Tweed should be examined in more detail and put into a wider perspective. While the coast offered many advantages: a wide, year round, resource base for foodstuffs; abundant fresh water, easier mobility; lithic materials; shelter; and a lack of insects – many of these features were also to be found along the river valleys.

The relationship between Mesolithic communities and the resources they exploited has long been debated. The deliberate introduction of ungulates to islands such as Shetland is claimed and may indicate a more complex relationship between humans and large mammals than is implied by the idea of 'wild' game and a long interpretative tradition suggests that Mesolithic communities managed their landscapes by deliberate firing (Mellars 1976; Simmons 1996), in order to promote browse. This is not as well demonstrated in Scotland, and the best evidence here comes from the south. It may be that the very different environments of northern Scotland required different strategies. Although no actual remains have been found, it can be assumed that the Mesolithic hunter-gatherers in Scotland had domesticated, or semi-domesticated, camp dogs which provided assistance in hunting, protection, and companionship (Munt & Meiklejohn 2007).

Mesolithic hunter-gatherers needed to acquire more than just food from their landscapes. Firewood and material for making stone artefacts would have also been essential and their collection is likely to have been embedded into other routines of hunting and plant gathering, or vice versa. The site of Coulererach, also in the Rinns of Islay, is adjacent to what is today one of the most flint-rich beaches in the whole of western Scotland being closest to the Ulster source of this material in the glens of Antrim (Mithen & Finlay 2000a). Not surprisingly, therefore, chipped stone assemblages are dominated by the very initial stages of pebble reduction: many tested and then discarded pebbles, large numbers of primary flakes, and numerous unworked pebbles. Whether Coulererach was another task-specific site – raw material acquisition and preparation of cores for transport – or had also been used for generalised coastal foraging activities remains unclear because the peaty acidic soil has destroyed any bone or shell material that may have been present.

Despite the long period covered by the Mesolithic in Scotland, and the fragmentary nature of the evidence, and hence, interpretation, the picture that emerges is generally one of a settlement system that tends towards the logistical mode of organisation in Binford's terms. This is not surprising in light of the environmental diversity of Holocene Scotland and hence the considerable seasonal and spatial variation in the distribution of resources, even before consideration of the extensive change over time that must have characterised these distributions given the dynamic nature of climate change throughout the period. But this does not imply any fixed, rigidly cyclic nature for Mesolithic mobility. All hunter-gatherers have to be flexible to respond to unexpected events such as the beaching of whales, providing a sudden glut of food and raw materials, poor summers for ripening fruit, a failure of the seabirds, and, of course, environmental disasters like the Storegga Slide tsunami, would all have had an impact on the annual routine. Several sites in the Firth of Forth include the bones of whales associated with Mesolithic artefacts – at Meiklewood an antler mattock was possibly left propped against a rorqual whale skull (Warren 2005, 120). Other sites, representing hardship, may be more difficult to identify, but, as indicated above, some studies have examined the possibility that some midden sites may indicate a response to famine conditions (Woodman 2001).

Indeed, one of the most important preoccupations for any hunter-gatherer is simply to observe and know the landscape: the sky, sea, flight of birds, and so forth, from which information can be extracted about where resources might be located. One further site on Islay, Aoradh, has been interpreted as used for precisely this reason – an observation camp – it being located adjacent to the location of a RSPB hide used by modern-day ornithologists (Mithen *et al*. 2000a), while GIS analysis has shown that Mesolithic sites on Islay are located with more extensive viewsheds than one would expect by chance alone (Lake *et al*. 1998).

While it is tempting to infer a logistical pattern of mobility for Mesolithic hunter-gatherers, actually documenting the scale of their mobility is extremely difficult. It is also important to remember that mobility does not necessarily mean that the whole community is mobile, or that mobility takes place year round. Even if there were sites with identical radiocarbon dates from, say, Skye and Arran, it could not necessarily be concluded that these were created by the same community of highly mobile hunter-gatherers, rather than two distinct communities. One possible means of directly tracing mobility is by considering the distribution of raw materials from known sources (see section 5.5). Pitchstone from Arran, for instance, is found at Bolsay on Islay and at Staosnaig on Colonsay, most likely having been directly carried there rather than as a product of down-the-line' exchange (Mithen 2000). Similarly, bloodstone from

Rùm has been found at Mesolithic sites on Ardnumurchan and Morven at distances of *c*. 50Km from source (Clarke & Griffiths 1990). But other sites at an equivalent, or indeed shorter, distance, such as Fiskary Bay on Coll have no traces of bloodstone within its raw materials, which in this case are entirely of flint. In general, it appears that Mesolithic hunter-gatherers probably made use of whatever raw materials were locally available and consequently, using the distribution of any particular raw material type to document patterns of movement or to support the interpretation of extensive exchange networks is open to alternative explanation. Work elsewhere in Europe suggests that geographical distributions of particular materials and particular object-types exist, but that the extent of these overlapping distributions does not always match, implying that caution is required in using any single type of evidence to discuss the scale or extent of any proposed movement (see Bergsvik 2003).

Whatever the extent of Mesolithic mobility, it is unquestionable that activity occurred on islands that required the crossing of at least 20 Km of open and often turbulent water. Unfortunately there is currently no trace of the boats used. Those from Mesolithic Denmark tend to be made from hollowed-out large tree trunks, especially of lime, such as from Tybrind Vig (Andersen 1985) and similar vessels may have been used in some parts of Scotland. Whether trees of equivalent size and quality were available is a moot point and, given the availability of experimental evidence for open sea crossings in hide - covered wooden framed boats (Severin 1978) the use of coracles and larger, easily beached and manoeuvred hide-covered boats is likely. Many of the skills and techniques used to construct these craft would also likely have been used to construct shelters and other structures. The evidence for ground-fast structures (Wickham-Jones 2004a; and section 4.1.2 above) reveals a diverse array of pits, small , putatively roofed enclosures, and stake and post-hole alignments suggestive of structures and other installations (like drying racks). Understanding how these features were built, what they actually looked like, and even what materials were used for their construction, is, however, more problematic. It is here that more experimental work based on archaeological results would help to give substance to the appearance of sites and would allow reconsideration of the longevity and resilience of these seemingly ephemeral structures.

Questions can also be asked about the costume and personal equipment and adornment of these Mesolithic people. Direct evidence for clothing is lacking, and although this is often inferred from the presence of scrapers and microscopic traces thereon of hide-working it cannot be assumed to have been present. Some evidence demonstrates the use of pigments; ochre 'pencils', for example, were present at Morton (Coles 1971). Traces of distinctive minerals in pit fills at Warren Field, Crathes, imply the exploitation of spectacularly coloured purple and green rock outcrops at the Pass of Ballater some 40km from the site (Murray *et al*. 2009) and lumps of similar colourful minerals have been found at other sites (e.g. Mithen & Finlay 2000). Perforated cowrie shells have been recovered from Carding Mill Bay, Sand, Ulva, and several of the Oronsay sites (see Saville 2004c, 200–202). These finds hint at personal decoration and adornment such as the use of bead decoration (Simpson 1996), but the finds are too fragmentary to allow for any meaningful interpretation. There is an absence of the shale and stone beads and tooth and amber pendants found in Mesolithic contexts elsewhere in NW Europe.

Figure 39: Used lump of ochre from the excavations at Sand © Scotland's First Settlers

Evidence to inform any understanding of the ritual practices and religion of Mesolithic communities in Scotland is extremely limited. Elsewhere in northern Europe, naturalistic and shamanic beliefs are seen as dominant motifs of Mesolithic lifeways (e.g. Schmidt 2000; Zvelebil 2003a). Among modern groups these beliefs result in particular practices and are expressed in material culture (Jordan 2001). Global perspectives on recent hunter-gatherer ritual and religion reveal considerable diversity and complexity in ritual practices (see papers in Lee & Daly 2000). These highlight the importance of distinctive landscape features, seasonal events, attitudes towards discard and depositional practices, and the treatment of the dead. With these themes, the meanings of particular places, cultural attitudes towards particular resources, discard, and the dead in these communities in Scotland can be tentatively explored. Regional distinctions and the long duration of the period need to be acknowledged, however, and how understandings of land and seascapes as well as beliefs and practices would change.

No burials are known from this period in Scotland, although this may be a reflection of excavation bias such as the paucity of cave excavations under modern conditions. To date discussion of burial is restricted to the bones found within the Oronsay middens, mainly Cnoc Coig. These are predominately hand and foot bones. One suggestion has been that these are the remnants of bodies that had been laid across the midden to decay as part of a funerary process and once de-fleshed taken elsewhere for burial, leaving some of the smaller bones behind (Pollard 1996). Some of the bones, however, appear to form distinct clusters and because these are composed by those from more than one individual, seem to have been deliberately positioned in that manner (Meiklejohn *et al*. 2005). Moreover, one of these clusters contained the flipper bones from a seal. It is, of course, tempting to read significance into that in light of the frequent role that seals play in Scottish oral traditions in which they are often thought to represent either the souls of the damned, the bewitched, or the reincarnation of those lost at sea. Alternatively, one might suppose that this deposit indicates some kind of link being made between the human and the animal, and this reflects a widespread characteristic of hunter-gatherer cosmology – that animal and human are not seen as sharply differentiated (Conneller 2009).

It would be unsurprising if the Mesolithic hunter-gatherers had not imbued the striking topographic features and dynamic geomorphology of the Scottish landscapes with mythological significance, perhaps creation myths as argued for elsewhere (e.g. Zvelebil 2003b). With regard to the west of Scotland one need only think of the impact that, say, Fingal's Cave of Staffa, the Paps of Jura, or the Sgurr of Eigg makes on people today, and the wealth of stories associated with these landmarks, to easily imagine that they would have played a role in the Mesolithic cultural interpretation of their landscapes. Evidence from Warren Field, Crathes, Aberdeenshire, implies the exploitation of a strikingly coloured rock outcrop (Murray *et al*. 2009). Manor Bridge and the Dookits, both on the Upper Tweed Valley, are located near rocky outcrops immediately adjacent to the River Tweed (Warren 2005). These are far from dominant features, but are locally important and likely indicators of the possible integration of routines of movement and natural features of the landscape.

Art appears to be absent; no figurative art is present on the Scottish bone and antler implements in contrast with other areas of Europe and no incised or decorated pebbles such as those recovered at Rhuddlan, Wales (David & Walker 2004), are yet known from Scotland. During this period symbolic expression may have taken different material forms. A Mesolithic pit alignment at Warren Field, Crathes, is argued to have had a symbolic role, with the deliberate deposition of materials, including food stuffs (Murray *et al*. 2009). The potential role of middens as Mesolithic monuments has seen a great deal of recent attention and has been strongly critiqued (Warren 2007a). Rather than assuming that they are a 'monument' (especially as most middens are not upstanding) a more detailed consideration of the architecture of middens, including the other structures they include, would be a very important contribution to this debate. The movement and redeposition of midden material, and possible associations with burning does appear to be significant more generally in the Mesolithic (e.g. Newton, Islay; McCullagh 1989). Therefore more attention needs to be given to the nature of discard practices and other strategies and exploring how cosmologies and beliefs may be expressed in daily routines.

Of course many significant events in modern hunter-gatherer life such as those marking rites of passage, acts of initiation and healing trances will leave few archaeological signatures but this should not mean that they can be ignored and there are some ways of indirectly approaching these subjects such as looking for periods of ritual exclusion expressed as differential growth markers in teeth. Equally, a more creative and imaginative approach, exemplified recently in *The Gathering Night*, a fictional work by Margaret Elphinstone (2009), presents arhaeologists with the challenge to seek answers to other, often difficult, questions about belief and ritual practice. Fundamentally, however, knowledge about the lifestyles of Mesolithic peoples (and more so for earlier Palaeolithic groups) is highly constrained by the evidence. It is therefore the smallest of traces and such momentary encounters that must be employed to enrich the narratives of their lives in the land and islands now known as Scotland.

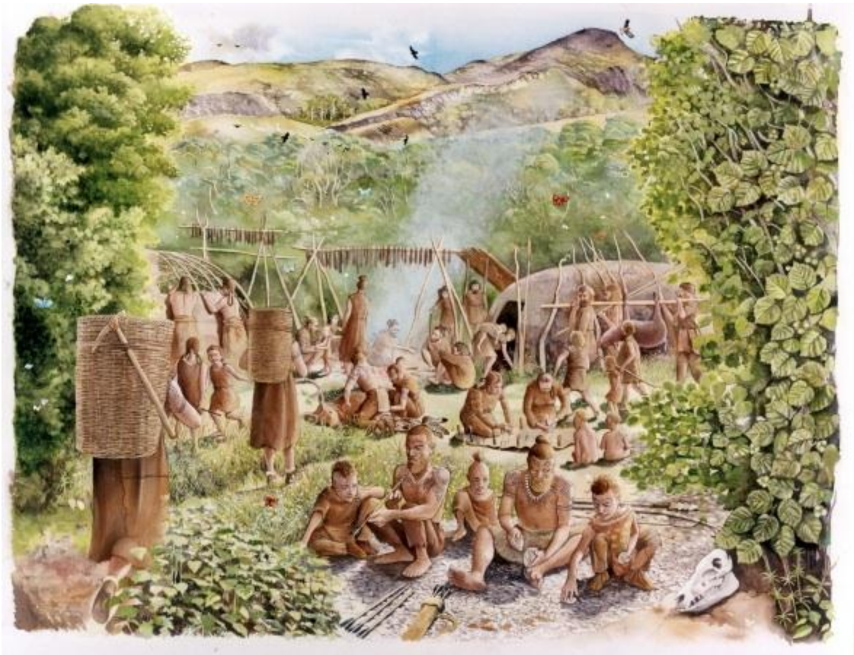

Figure 40: Reconstruction of Mesolithic life at Holyrood Park, Edinburgh, Crown Copyright Historic Scotland

6.2 The Mesolithic–Neolithic transition in Scotland: ways forward

The Mesolithic–Neolithic transition remains one of the most controversial issues in British prehistory and Scottish material is central to the debate. The precise timing of, and the processes involved in, the first appearance of agriculture in Scotland have been the subject of extensive research and a wide range of models has been proposed incorporating data from a very substantial array of disciplines. Some of the most recent of these models are presented here, but the focus is on identifying areas with potential to help move debate forward. This is not to suggest that there is a magic bullet – a single piece of evidence that will resolve all problems – but is to argue that formulating clear models and searching for evidence that might confirm or refute them would be an effective way forward.

A recent review asked researchers to characterise key developments in understanding of the Mesolithic–Neolithic transition over the last *c*. 20 years. Rather surprisingly, 33 per cent of respondents from the UK argued that one of the key changes had been the development of dichotomies in interpretation (Warren 2009). This included dichotomies that opposed hunter-gatherer and farmer, immigrant and native, Mesolithic and Neolithic, interpretative archaeology and archaeological science, but also the existence of very divergent models. This, perhaps, rather dispiriting response may seem surprising, given that a wide range of work on the transition has been carried out, often focusing on timing, subsistence base, ideology, etc., but reflects the quite polarising ways in which debate has sometimes been carried out, especially in terms of the overarching interpretations placed upon the data. Ultimately questions about the kinds of social processes involved in the transition often seem to devolve down to a deceptively simple question: did agriculture arrive in Britain through the movement of people, bringing new ideas and technologies with them, or through the transformation of indigenous hunter-gatherers who gained access to new materials and elected to change their way of life. (Behind both possibilities, and asked rather less frequently, are a further series of questions about why this should have taken place). Across Europe the transition appears to have involved both, and a mosaic of different interactions is recognised (see contributions to Whittle & Cummings 2007). Such mosaics have sometimes been claimed to include Scotland (Milner 2010).

The two dominant models by which the transition in Britain is understood have been developed by Julian Thomas and Alison Sheridan, and are often encountered as part of a long running and sometimes fierce debate in the archaeological literature. These models are explicitly about who was responsible for the transition and reviewing them provides a useful context for considering the nature of current debate.

Thomas (e.g. 2004; 2007; 2008) argues that the transition results from indigenous adoption of novel technologies and material forms obtained through networks of trade and exchange that linked the British Isles and Europe in the Late Mesolithic. He is sceptical that direct continental parallels can be found for all aspects of the new material forms characteristic of the early Neolithic and suggests that indigenous processes lie behind the decision to adopt new forms – transforming these forms and the indigenous hunting and gathering societies in the process. Unfortunately the definition of the nature of these indigenous processes is vague. Thomas notes the absence of non-lithic data for the British Later Mesolithic, and identifies several themes – 'forces that were at work' – in Mesolithic societies: diversification, the importance of persistently significant places, the possibility of funerary practices that were 'precursors for certain aspects of Neolithic mortuary activity', and the possibility of monumentality (Thomas 2008: 65–67). Notwithstanding the problems of the data sets, there is some danger of teleology in Thomas's identification of traits in the later Mesolithic that are argued to be continued in the Neolithic.

In contrast Alison Sheridan (e.g. 2003; 2007; 2010) argues that the transition results from direct colonisation from the continent. Sheridan finds specific origin points on the continent for aspects of Neolithic material culture and tomb architecture, and finds no pre-Neolithic evidence for contact between the Late Mesolithic cultures of Britain and Ireland and the continent. She therefore explains the appearance of the new material forms from specific locations as a sequence of 'waves' of colonisers, sometimes tying these episodes to particular social processes in their continental places of origin. Sheridan also finds little evidence for the role of the Mesolithic in this transition. Indigenous hunter-gatherers are accorded no causational role and they effectively disappear from the archaeological record; not even forming part of the development of any new forms of archaeological culture. Sheridan notes that this results from the rapid integration of the Mesolithic into the Neolithic and the resolution of distinctions within the archaeological data.

These models illustrate the extremes of interpretation – from wholly indigenous in origin to wholly foreign. Without trying to judge particular aspects of the detailed models at the moment, two points have broader relevance. The first is that the different theoretical frameworks lying behind these models mean that the same evidence is being used to argue for wholly different processes. Thus Sheridan argues that the absence of strong evidence for shared material forms in Britain, Ireland, and the Continent during the Late Mesolithic means that Mesolithic cultures in these areas were not in regular and routine contact and thus do not provide a precedent for the continental links provided by earliest Neolithic material culture. Thomas, in contrast, on the basis of ethnographic analogy, argues that differences in material culture cannot be interpreted as evidence for isolation and, on the basis of broader evidence for networks elsewhere in Late Mesolithic Europe, that these networks linked Britain, Ireland, and the Continent. This example clearly demonstrates that in understanding the transition, evidence and theory are inseparable and that the resolution of current impasses will only arise through developments in both fields. More problematically, however, such debates arguably contribute to some scepticism in other disciplines about the ability of archaeology to identify the movement of people through material culture. The claims of genetic reconstructions both of past human populations and of animal populations such as woles, and, thereby, their movements, are often argued to plug this gap – speaking directly of the levels of migration at particular times in history, whereas archaeology has difficulty in so doing (see Oppenhemier 2006 for one statement amongst many).

Secondly, it is notable that in both examples the contribution of the archaeology of the Mesolithic to the transition is somewhat limited. As noted above, although Thomas places particular interpretative emphasis on 'processes' within the Mesolithic these are poorly developed archaeologically. For Sheridan, the nature of the Mesolithic is similarly limited as the initiatives are all continental. For both, the issue of Late Mesolithic isolation or otherwise is important, but the nature of Late Mesolithic society remains rather lost. From the perspective of the Palaeolithic and Mesolithic Panel it is important to note that in Britain most of the discussion of the Mesolithic–Neolithic transition appears to be dominated by Neolithic scholars (Warren 2007). In a European context this is somewhat unusual. Alternative models exist, stressing 'small scale' colonisation, or the interaction of different processes and time scales, but from the perspective of understandings of the Mesolithic, many suffer from similar structural problems and the nature of interactions and social processes is vague.

It is important to stress that Scottish material remains central to debates on the nature of the Mesolithic–Neolithic transition in Britain. The Oronsay middens are frequently cited as evidence for Late Mesolithic settlement systems in Britain; the precise calibration of the human bones from this island, and the significance of the marine influence of diet remain key questions (Milner & Craig 2009; Milner 2010). Similarly, the middens themselves are often cited as evidence for funerary and monumental practice in the Late Mesolithic of Scotland, and by extension, Britain (as in Thomas 2008; see also discussion in Warren 2007). The parallels in ceramic forms and tomb morphology between Achnacreebeag and Brittany have been central to Sheridan's discussions of points of contact for the British and Irish Neolithic (Sheridan 2003). The sudden appearance of timber halls in eastern Scotland stands in some contrast to the often stated absence of such evidence elsewhere (e.g. Murray *et al*. 2009). Finally, the model of climatic change facilitating the adoption of cereal cultivation draws heavily on Scottish data (Bonsall *et al*. 2002). Questions of regional variation within the British Isles have often been somewhat downplayed, but it is clear that Scotland has a significant contribution to the understanding of the Mesolithic–Neolithic transition from a variety of theoretical perspectives.

A way forward?

Moving debate on the Mesolithic–Neolithic transition forward from a Mesolithic perspective requires progress in a number of different fields. The data set for the latest Mesolithic remains sparse: further fieldwork and the generation of new data are necessary; and wetland environments may be especially important given their enhanced potential level of archaeological preservation. However, as noted above, new data alone will not resolve the questions about population movement. Wider theoretical frameworks are required against which the data can be set. The same is true regarding the urgent need for the development and utilisation of the latest analytical methodologies – including residue analysis and use wear – which have important roles in increasing the range of available data.

The following themes are suggested as key fields where further work would help to resolve dichotomous models and begin to make progress on the nature of the transition and the role of different population groups within it. In all of them the use of data from across disciplines is assumed, and in particular the active discussion of genetic research. A European context is vital for such research, and discussion of the Scottish data must be comparative whilst at the same time recognising that Scotland offered its own context within which these transitions took place.

Chronology

If the transformations that indigenous hunter-gatherers faced in the late fifth and/or early fourth millennia BC are to be discussed, then chronology is vital. Advances in dating techniques, including the routine use of AMS dating, have made, and will continue to make, a significant contribution to understanding the temporal framework within which new materials arrived. Bayesian analyses offer significant potential for substantially increasing the resolution of chronologies and are claimed to enable new kinds of histories to be written of the transition (Bayliss *et al*. 2007; 2008; Whittle & Bayliss 2007; Whittle 2007). Issues surrounding the both the marine and freshwater reservoir effects, and the difficulty of modelling combined diets raise significant questions about the reliability of dates obtained on bone (see eg. Brinch Petersen & Meiklejohn 2009, 167–169). Progress in these fields is required. Precise dating may break down the Neolithic package, and allow an understanding of what arrives where and when. Our use of chronologies, of course, is not solely limited to radiocarbon dating and the use of typologies to make broader chronological statements will continue. The dating of palaeoenvironmental sequences carries its own challenges, and the levels of resolution obtained, and the errors associated, are sometimes forgotten in trying to march disparate data sets (Robinson *et al*. 2010, 62).

Discussions of chronologies tend to be crude in comparison with temporal resolution of the processes that are being described and explained. This is exacerbated by imprecision in the use of chronological labels. Researchers move between different ways of labelling: an artefact may be 'Neolithic' in type, but does its appearance on a site meant that the site is culturally, economically, or chronologically Neolithic? Boundaries between periods have a problematic tendency to become hard and fast time lines – whether it be at 4000 BC or 3800 BC, one side is Mesolithic and the other side is Neolithic. Archaeologists have an 'either – or' model, where change may be much more complicated than this. Models are discussed in more detail below, but it is impossible to imagine a transition that did not involve some kind of co-existence of Mesolithic and Neolithic – either two different groups of people interacting or the process by which Mesolithic cultures became those that are recognised archaeologically as Neolithic. This may have been very short, and effectively invisible at the kinds of resolution archaeology often works, but it may have had a duration that is analytically accessible. At present, this is not known, and it would be very helpful if discussion was clear on precisely what interaction was implied and what archaeological visibility this might have.

The use of absolute dates, not labels, would be preferable though archaeologists will never fully escape the use of periodisations. One possibility would be to attempt to formally identify a time frame that is called 'Mesolithic-Neolithic', the period of time in which Scotland moved from the archaeologically defined Late Mesolithic to Early Neolithic, during which different things in different places would be expected to be seen. The final definition of this period would vary according to the models proposed, but forcing a definition would help focus analytical attention on the role of Mesolithic societies and downplay the significance of either/or models. Definitions of such a period would most likely fall between *c*. 4300–3700 cal BC.

The development of models

Although the language of models may seem anachronistic, and not suitably interpretative, the study of the Mesolithic–Neolithic transition would be facilitated by the clear development of models of expected processes that can be compared to the archaeological data. Such models might focus on specific aspects of the transition, or provide overview, but should in all cases attempt to integrate a very wide range of possible data: archaeological, genetic, linguistic, and palaeonvironmental/ palaeoclimatic. This would help avoid the development of a situation comparable to that in Ireland where the contributions from different disciplines tend to work in parallel rather than truly integrating (Cooney 2007). Some contributors have offered relatively explicit models, but gaps are present in almost all examples. Some key areas where models are needed include:

- The nature of population movement/networks of exchange in the Late Mesolithic and Early Neolithic of Britain.

- As noted above, the degree to which Britain was/was not isolated from continental Europe in the Late Mesolithic is of considerable importance to the mechanisms by which the Neolithic arrived in Scotland. It is likely that genetic and isotopic data will be very significant in the development of these models. Comparison with Europe will be very significant. Most models of contact between hunter-gatherers and farmers have assumed a terrestrial boundary between the two groups (e.g. Zvelebil 1998). The impact of a significant water barrier on the nature of interaction requires theorisation (see below).

The nature of seafaring technology and the possibility/constraints this provides for the transition.

Recent contributions have begun to model the timings of putative prehistoric boat journeys (Callaghan & Scarre 2009; Robinson *et al*. 1999) but the understanding of sea faring technology is very poor on the whole. Logboats are well known from contemporary contexts on the continent, but not in Scotland. Bark- or hide-covered vessels are often discussed, and are sometimes assumed to be more seaworthy than dugouts, but they are also archaeologically invisible. The potentials of sea crossings need to be explored, even if discussions remain abstract. Questions need to be asked of the data, including: what role do changing sea-levels and conditions have to play? What vessels are expected? What are the likely carrying capacities of such boats? How long could animals have been kept in boats without landfall? How many animals are required to establish a viable farming community? If the transition is a large scale movement of people that effectively swallows up Mesolithic cultures in Britain and Ireland, how many people does this imply? How many boats, or how many journeys does this necessitate?

Social processes in the Late Mesolithic

As noted above, the nature of social change in the Mesolithic of Britain is poorly understood and appears to play little substantive role in most models. General European models tend to presuppose trends to 'complexity' in Mesolithic societies, often with associated intensification. However these changes are not universal, and may not form such a strong trend over time as is often assumed (Warren forthcoming). Certainly their applicability to Britain is not clear. The data for Late Mesolithic society in Scotland is scant, but the development of models of the nature of Late Mesolithic society and the processes of change that these communities were undergoing is critical.

Interaction with colonisers (either small or large scale)

Many commentators now discuss 'small scale' colonisation, sometimes making reference to the detailed typologies of population movement offered by Zvelebil (1998). The nature of interactions between indigenous hunter-gatherers and colonisers is often unclear. If the process rapidly leads to the disappearance of Mesolithic communities then what caused this? Did they die out (disease? violence? marginalisation?) or were they assimilated (willingly?) and over what time scales? Anthropological analyses suggest all kinds of possible interrelationships between different groups and these need to be fully integrated into archaeological analysis.

Climate Change

Regardless whether one believes that the overall subsistence basis for societies was transformed to a major reliance on domesticates, it is undeniable that the Mesolithic–Neolithic transition in Scotland involved the appearance of new plants and animals. It is also undeniable that, in broad chronological terms, this happened at a time of very significant climate and environmental change, with related impacts on the behaviour of plants and animals. Bonsall *et al*. (2001) argue that a shift to a dry climate facilitated the growth of cereals and thus made the adoption of farming by indigenous hunter-gatherers a more attractive proposition, but why they should make the change at all remains unclear. Suggesting that climate may have played a causational role can lead to accusations of determinism (Thomas 2008, 67). But this dismissal appears misguided. Subsistence must have been related to the productivity of the natural world, which in turn was influenced by changes in climate. There are therefore strong reasons for suspecting that significant climate change may have played a role in the decisions people made about whether to farm, to migrate, to persevere with an older way of life. Tipping (2010), for example, has suggested that climate change at this time destabilised the main subsistence basis for Late Mesolithic communities in Scotland and forced them to consider changing their subsistence strategies. This model provides a context for Late Mesolithic societies actively making decisions.

Setting aside the specifics of Tipping's model, the point here is not that climate change necessarily caused social change, but that climate change may have been important and must be included in models; it influenced the world in which people lived. Discussions of climate change, however, need to ask how change was recognised by communities in the past and why particular decisions were made. It also needs to be embedded in broader discussions of social processes.

Subsistence Change

One of the key areas of debate in regard to the Mesolithic–Neolithic transition has been subsistence change. Scottish data play a key role here, with the isotope based dietary reconstructions from the Oronsay middens providing a powerful complement to the faunal assemblages from Mesolithic middens elsewhere in Scotland and suggesting, to many, a profound reliance on marine resources that sees sudden and dramatic transformation in the early Neolithic (e.g. Schulting & Richards 2002). The extent to which the Oronsay middens are representative of the Mesolithic, the Mesolithic in Scotland, or the Mesolithic in Britain, is open to debate, and more variation is claimed by some (Milner 2006). Likewise, the overall use of isotopes to model such a dramatic dietary change in NW Europe has been sharply debated in the literature (Milner *et al*. 2004; 2006; Hedges 2004; Lidén *et al.* 2004; Barbarena & Borrero 2005; Richards & Schulting 2006). Development in these areas is important. Again a simple tendency to identify a 'hunter-gatherer' diet and a 'farming' diet must be avoided in favour of looking for variation (Milner 2010).

Discussion

The transition from the Mesolithic to the Neolithic in Scotland has attracted, and will continue to attract, significant archaeological debate. The Scottish data are important in a national and European context, and are often cited in these contexts. However, understanding of the processes involved in the transition remains weak. The solution does not necessarily lie in more data – although the potential contribution of new sites and new analytical techniques should not be underestimated. Current models of the transition approach identical data with diametrically opposed interpretations – the data alone cannot resolve these problems. From a Mesolithic perspective, most of the dominant discussions are summary in their treatment of the historical processes of change within indigenous hunter-gatherer groups; even when these are supposed to have been the key drivers of change. There is a tendency for a fragmentation of analysis rather than the full integration of all available data. The suggestion here is that the development of increasingly explicit models of the processes involved will help identify key areas for research and enable the assessment of data against clearly defined parameters. This is not to suggest that archaeologies of this period should be strait-jacketed by models, or that archaeologists need not be interpretative and creative in reconstructions of the processes of the transition. It is, however, to suggest that clarity in discussions, and in the scales and mechanics of the processes being discussed, would a useful way of ensuring that future debate about the Mesolithic-Neolithic transition in Scotland avoids some of the pitfalls of the old.

6.3 Future research recommendations

- Analysis of the relationship between inland and coastal communities
- Further consideration of the issue of burial traditions
- A focus on the possibility of waterlogged or submerged sites with enhanced preservation of material and artefacts rarely found elsewhere
- Further work on art and decoration
- Continued analysis of the transition to farming
- Further work on structural remains and community size

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