Seals, seabirds and saithe: assessing intensification of marine resource exploitation through the Mesolithic of Scotland

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Abstract

This thesis examines the hypothesis for an intensification of marine resource exploitation in the Mesolithic of Scotland. Three key themes are visited; zooarchaeological variability, seasonal resource scheduling and marine intensification. These are explored through existing available sites and primary data collection. Mesolithic faunal assemblages in Scotland are scarce, therefore, the analysis of the site of Sand for this thesis makes an important contribution.

In addition to variation of the zooarchaeological record, even within the small corpus of sites that are available, there is evidence for the highly targeted, seasonal exploitation of marine taxa both at the beginning of the Late Mesolithic and at the end of the period. However, this thesis has found little support for marine resource intensification based on the current zooarchaeological record.

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Author's declaration

The results from Sand were published with James Barrett as co-author in the Sand site volume:

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A paper which drew on the Sand results was presented at the Meso 2005 conference in Belfast and consequently published in the conference volume:

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Chapter 1 Introduction

1.1 *The thesis in context*

This thesis is concerned with the relationship between people and marine resources in Mesolithic Scotland, and with the possibility that the nature of that relationship changed over the course of the period. In particular, it aims to assess the proposition that the Later Mesolithic in this region witnessed an *intensification* of marine exploitation.

The starting point for this study can be found in the work of Paul Mellars, in particular, his research on the small island of Oronsay, western Scotland., which was focused on a series of Mesolithic shell middens. Mellars has suggested that there was a concentration of shell middens during the later Mesolithic and that the cluster of sites on Oronsay may indicate increasing economic stress either from increasing human population density or the over-use of resources (Mellars 2004). He speculates that if this is a real pattern then it could have significant implications for the Mesolithic to Neolithic transition (2004, 175), indeed, that it may be a major factor in explaining socio-economic change:

'The large-scale use of labour-intensive shellfish collection strategies could, in other words, be seen as part of a general pattern of economic 'intensification' during the final Mesolithic stages, which could have provided a major stimulus for the adoption of the new Neolithic regime' (Mellars 2004, 175)

This is a provocative hypothesis. Human isotope work (for example Schulting and Richards, 2002) has confirmed that the human remains from the Oronsay sites had a primarily marine diet, and the fish evidence (discussed in Chapter 5) seemingly points to a highly seasonal, highly targeted fishery. For Mellars the marine diet couple with the fish evidence is indicative of semi-permanent occupation of the island. These arguments raise important questions about the specific historical and ecological conditions in which people lived during the fifth millennium BC, and how those conditions shaped what we now call the Mesolithic to Neolithic transition. That said, they are not without their problems.

The issue of Mesolithic marine resource exploitation in Scotland has not been properly assessed within a wider zooarchaeological context. While the Oronsay middens certainly make an important contribution to our understanding of Mesolithic subsistence practices, the degree to which they are representative of the period as a whole is questionable. This is all the more crucial when we acknowledge a rather more basic problem; that the faunal remains from the Oronsay sites are not fully published and are from very end of the period. This thesis aims to redress this imbalance seen in the zooarchaeological record thus far and establish a stronger foundation upon which to build arguments about the exploitation of marine resources during the Mesolithic. If exploitation *did* intensify during the Scottish Mesolithic we might expect an increase in sites exploiting marine resources, an increase in the amount of marine species to non-marine and either an increase in marine species or increased use of specific taxa.

Until recently there have been few detailed analyses of other Mesolithic faunal assemblages; analysis of the faunal assemblage from the 7th millennium site of Sand by the author in this thesis, therefore, makes an important contribution. The zooarchaeological remains from Sand are substantial with fish especially well represented. Marine taxa dominate the bird and fish assemblages but are largely absent from the mammal assemblage, therefore, the site is well placed to assess intensive use of marine resources. The fish remains in particular offer the chance to assess if subsistence practices thus far only identified at Oronsay, are present.

1.2 *Aims and objectives*

Three key themes need to be addressed which form the objectives of the thesis:

1. To explore variation within the zooarchaeological record
2. To assess the use of marine resources and seasonal resource scheduling
3. To examine the implications of the above in relation to the intensification or not or marine resources in the Mesolithic

In order to address these objectives a number of coastal Mesolithic sites will be compared. The extant zooarchaeological data from An Corran, Cnoc Coig, Cnoc Sligeach, Caisteal nan Gillean I, Caisteal nan Gillean II, Priory Midden and Morton are assessed and the ways in which this data has been previously examined considered

(Chapter 2). The choice of sites for comparison (namely a lack of other suitable zooarchaeological assemblages) is discussed. Chapter 2 also critically reviews past approaches to marine resource exploitation in Mesolithic Scotland. A broader discussion of marine resource exploitation in the Mesolithic, such as evidence for intensification in other areas, notably Scandinavia, places the thesis in a wider context. Past syntheses of the zooarchaeological record and radiocarbon dates are discussed before the excavation history of the comparative sites are considered in turn. These excavations are placed in the context of changing trends and approaches to archaeological investigation of the Mesolithic in Scotland. Finally, the last section of Chapter 2 begins to assess variability within the zoorchaeological record of Mesolithic Scotland by bringing together data from the comparative sites.

The methodology chapter (Chapter 3) focuses primarily on recovery and recording protocols for the two main comparative assemblages; Sand and the Oronsay sites. This includes the York system, used to record the primary data from Sand, Outram's Freshness Fracture Index, quantification methodologies and the calculation of fish size.

Primary data recording and analysis of the Sand assemblage adds to the corpus of sites reviewed in Chapter 2, and Chapter 4 provides the results of my analysis of the mammal, bird and fish remains from Sand. Along with taxonomic abundance and skeletal element patterning (including marrow and fat extraction from mammal bones), season of capture information is discussed for each class of material. How diverse a resource base was exploited and seasonal resource scheduling at the site is assessed.

In Chapter 5 the available published and unpublished mammal, bird and fish bone data for the Oronsay sites is, for the first time, presented together (Grigson and Mellars 1987; Nolan 1986; Wilkinson 1981). In order to provide quantifable data and establish if re-analysis of all the Oronsay fish bone would further interpretation one site, Cnoc Sligeach, was reanalysed, the results are provided in this chapter. At the end of this chapter the fish bone season of capture data from the Oronsay sites is critically revisited.

Chapter 6 draws on the data from Chapters 2, 4 and 5 in order to discuss the three key themes of the thesis; variation in the zooarchaeological record, seasonal resource scheduling and marine resource intensification. Together, this body of data provides the means to begin to discuss variation in subsistence practices in coastal Mesolithic Scotland and further our understanding marine resource use in Mesolithic Scotland.

Finally, Chapter 7 highlights the key conclusions of the thesis. The aims of the thesis are revisited and the contribution of the thesis to our understanding of marine resource intensification in Mesolithic Scotland is considered. Areas for further work, in particular the potential and value of reanalysis of the Cnoic Coig fish material suggested.

Chapter 2 The zooarchaeological record of Mesolithic Scotland in context

2.1 *Introduction*

This chapter highlights the main problems with the existing zooarchaeological dataset for Mesolithic Scotland. Past syntheses of the faunal record of Mesolithic Scotland, trends in subsistence studies and approaches to marine resource exploitation in Scotland and Europe are reviewed. The dating evidence and excavation history of the sites are presented and the suitability of their zooarchaeological remains assessed. A summary of the picture thus far begins to examine variation within the zooarchaeological record of coastal Mesolithic Scotland. Detailed zooarchaeological data for the case study sites of Sand and Oronsay is presented in chapters 4 and 5.

2.2 *Zooarchaeological record of Mesolithic Scotland; available sites*

There are three main problems with the faunal record of Mesolithic Scotland. First is a lack of sites; there are only 14 Mesolithic sites in the whole of Scotland currently available with known faunal remains; An Corran, Risga, Ulva Cave, MacArthur's Cave, Druimvargie, Raschoille Cave, Cnoc Sligeach, Caisteal nan Gillean I, Caisteal nan Gillean II, Cnoc Coig, Priory Midden and Morton. Work undertaken by the author adds Loch a Sguirr and Sand (both part of the Scotland's First Settlers project) to this list. In addition two sites with fish bone in the Western Isles are known but not published (Mithen *pers comms.*, Church and Rowley-Conwy *pers comms.*)

The second problem is recovery and publication. The sites range from Antiquarian-excavated sites to sites excavated to modern standards but still with a range of recovery methods. As discussed further in Chapter 3 the method of excavation and recovery can affect the amount, species and type of bones recovered. In addition to the problems of varying excavation and recovery quality few of these sites have fully published assemblages; this further reduces the already small corpus of sites.

The third problem is the coastal location of sites with faunal remains. There are no inland assemblages and all the available sites apart from Morton are on the west coast. An overview of geographical location of sites is shown in Figure 2.1; MacArthur's

Cave, Druimvargie and Raschoille are all in Oban, Cnoc Sligeach, Caisteal nan Gillean I and II, Cnoc Coig and Priory Midden in Oronsay, the location of Oban and Oronsay is marked on Figure 2.1 rather than individual sites. Whilst this geographical bias may to a certain extent reflect research interest Scotland's Mesolithic archaeology is, of course, not restricted to the coast. Preservation is a major contribution to the bias, bone does not survive well in acidic conditions and it is the very nature of the shell midden, a calcareous environment, which allows bone to survive.

Sea level change is also a major factor in site distribution. Relative sea level change in relation to deglaciation and the consequential glacio-isostatic rebound (where land that had been depressed by the weight of ice, gradually rose back up) is complex (Ballantyne 2004, 36). In essence, after c.8500BP (c.7500BC) during the Main Postglacial Transgression there was a locally rapid rise in sea level on the west coast of Scotland when sea level rise (due to melting ice sheets) was greater than isostatic uplift. Any sites earlier than this would have been located on land that was subsequently submerged by this sea level rise. On exposed coasts sites would likely have been destroyed, whilst where the coastline was more sheltered they would have been buried under sediments (Ballantyne, 2004, 37). The height of the Main Postglacial Shoreline is today visible as a raised beach along the west coast as subsequent isostatic uplift has resulted in a relative drop in sea level. As Ballantyne notes Late Mesolithic sites are often located near to the Main Postglacial Shoreline (at Sand, however, this is not the case, the shell midden is located several metres above the Main Postglacial raised beach in a former sea cave on the Late Glacial shoreline (Dawson 2009)).

Figure 2.1 Map showing location of sites. (Base map by NordNordWest)

In Scotland, zooarchaeological assemblages are restricted to shell middens, found in both rock shelters and caves (the Oban sites, Ulva, Sand, Loch a Sguirr and An Corran) and in open air sites (Oronsay, Risga and Morton). Shell middens, are not a solely Mesolithic phenomenon; in Scotland they are a component of many later prehistoric sites (Wickham-Jones, 2007). Nor are coastal Mesolithic sites restricted to shell middens (for example, Mithen, 2001), but, the bones are. It seems that it is the preservation conditions of the shell middens, which are favourable to bone, that have led to the zooarchaeological bias. Rather than shell middens fitting into a wider picture of animal exploitation in the period, in terms of zooarchaeology they are all we have.

2.3 *Marine resource exploitation in Scotland; approaches and trends*

Until the turn of the 21st century a growing trend in Mesolithic archaeology in Scotland had been to stress the continuity of the subsistence economy between the Scottish (and in a wider context the British) Mesolithic and Neolithic (Schulting and Richards 2003:147, Armit and Finlayson 1996, Mithen 2000). This argument had seemed particularly pertinent to the west coast, where the coastal littoral location of sites and finds of shellfish in chambered tombs could suggest a continuing marine element to the subsistence economy (Schulting and Richards 2003:148, Armit 1996). Important as this approach had been in redressing the image of the hunter-gatherer as a mere bystander who was willingly replaced by a homogeneous 'Neolithic package' the isotopic evidence from human remains challenged this.

Isotopic analysis of human remains allowed for the first time a resource other than inference from the zooarchaeological record (along with plant and shell evidence) to assess what people had been eating. For its main proponents in Scotland, Schulting and Richards, '*Stable isotope analysis bypasses many of the difficulties associated with traditional archaeological approaches to subsistence by directly addressing the long-term diet of the individual.*' (Schulting and Richards, 2002,149).

Schulting and Richard's work applied stable isotope analysis to archaeological human bone collagen in order to provide a direct assessment of the origin of (principally) the long-term protein component of an individual's diet. Palaeodietary reconstruction in Scotland thus far has primarily focused on the stable isotopes of two elements, carbon and nitrogen. From samples of human bone collagen the ratio of ^{13}C to ^{12}C (giving the $\delta^{13}C$ value) and ratio of ^{15}N to ^{14}N (to give the $\delta^{15}N$ value) is measured. The $\delta^{13}C$ value provides an indicator of a marine or terrestrial diet, whilst the trophic level (for example, herbivore versus carnivore) can be inferred from the $\delta^{15}N$ value. Each move up the trophic level in a food chain will result in a higher $\delta^{15}N$ value. Because longer food chains are common in marine environments a very high $\delta^{15}N$ value, therefore, may also indicate a diet composed primarily of marine protein (Schulting, 1999, 204-207; Schulting and Richards, 2002, 153-155; Schulting and Richards, 2000, 55-56; Richards, 2003, 86).

Instead of continuity between the periods, stressed during the 1990s, a rapid change, based on stable isotope dietary evidence was proposed (Richards *et al.*, 2003). Not only did Schulting and Richards' work appear to refute, *contra* (Armit and Finlayson, 1992), the idea of a slow gradual move from the Mesolithic to Neolithic, but also urged caution against linking coastal site location with a marine diet (Schulting and Richards, 2002). However, human remains from Mesolithic Scotland are scarce and the rapidity of change has been challenged (Milner et al., 2004). Whilst confirming the zooarchaeological evidence from the Oronsay mammal assemblage of a primarily marine Mesolithic diet, the work of Schulting and Richards has contributed most significantly to our understanding of general human diet in the Neolithic period rather than Mesolithic. This has led to a rather homogenous view of diet in the Mesolithic as marine versus the Neolithic diet as terrestrial.

At Oronsay the human isotope work appears to confirm evidence for the hypothesis of Mellars and Wilkinson (1980) that fishing on the island was year-round or mostly year-round (discussed in detail in Chapter 5) with a distinct period of fishing at each site. The seasons of fishing suggested are extremely tight: June/July at Caisteal nan Gillean, July/August at Cnoc Sligeach, September/November at Cnoc Coig and at Priory a more ambiguous time period perhaps between December and March. This means that fishing is proposed to have occurred during early summer, mid-summer, autumn and winter with spring the only season not represented.

The human isotopic evidence for a strong marine diet for the human remains found at Cnoc Coig has subsequently led Mellars to suggest that semi-permanent occupation of the island would have been possible and that this may represent economic intensification (Mellars, 2004, Richards and Mellars, 1998). Mellars was writing prior to the publication of Sand and An Corran (Bartosiewicz forthcoming), as discussed in this chapter shell middens with evidence for targeted marine resource exploitation are not just a phenomenon of the very late Late Mesolithic. But, could the concentration of so many middens on Oronsay really be an indicator of marine resource intensification? The small size of the island, believed to have been around 4km in the Mesolithic, means the sites are in close proximity, if there is distinct seasonal use at each site this is truly remarkable, and, a little suspicious. The fish bone season of capture data from Oronsay is reassessed in Chapter 5.

If we accept, as Mellars (2004) favours, that this represents one group living on and moving seasonally around the island (as opposed to visits by groups living elsewhere), several questions must be raised. Why is there such a strict seasonal movement? Why not fish at one site all year around? Could the location of fish around a small island really vary so much according to the time of year? It is also difficult to reconcile Mellars' concession that occupation (given the potential time span of the sites of 700-

800 years) may not have been continuous at the sites with his argument for semi-permanence. Conversely, punctuated activity would seem to be a good case against permanent occupation.

Also based on human isotopic results (Richards et al., 2005) add an even longer time depth to the trajectory of an intensification of marine resources by advocating it is a trend identifiable from the Palaeolithic. Based on the results of a Palaeolithic human with a 30% marine diet from England, they draw on the Oronsay sites as an end-point and propose:

"Our results foreshadow the increasing reliance on marine foods found at later Mesolithic sites in coastal Europe. This, then, is a clear detection of one dietary trajectory that led to increasing reliance on narrow resource bases such as marine foods, and which in some regions eventually led to a reliance on the single resource base of domesticated plants and animals at the onset of the Neolithic (Richards et al 2003, 393)"

This is a powerful statement, it implies that there is increase in marine resource exploitation through time and further than this is a progressive move towards the Neolithic. It assumes that a marine subsistence base is by default narrow; the potential diversity of marine taxa is underestimated. This again highlights the crucial role of zooarchaeology to provide the detail (where available) to complement a broad dietary picture given by human isotope data. Human stable isotopes may provide a valuable picture of long term diet but can mask variation within the zooarchaeological record (discussed in Chapter 6). Zooarchaeological assemblages remain most suited to offering a detailed site-specific picture of the types of mammals, birds and fish caught and consequently inform *how* Mesolithic people may have caught them.

2.4 ***Marine resource exploitation; the wider context***

The idea of coastal semi-permanence, an increase in shell middens and an intensification of marine resources in Late Mesolithic Scotland as a precursor to agriculture owes much, as Mellars acknowledges (2004, 181), to hypotheses in Scandinavia and Europe. But, increasingly interpretation here has moved away from a directional intensification through the Mesolithic with the Neolithic and agriculture as the goal. Rowley-Conwy has strongly argued, with specific reference to complexity, that trends within hunter-gatherer societies (be they archaeological or ethnographic groups) are not directional (2001, 64). Further, for Britain, Ireland and Scandinavia he argues that there was no progressive move towards agriculture in the Late Mesolithic and no archaeological evidence of intensification (Rowley-Conwy 2004).

Taking Scandinavia and Norway as an example, underpinned by a highly marine resource base there is, however, a general trend of semi-permanent, marine-oriented and sometimes complex groups in the Late Mesolithic, for example along the Norwegian coast, Denmark and southern Sweden. Rather than a necessary precursor a strong marine component to the diet has been proposed as a reason for a *delay* in the adoption of domesticates (Bjerck, 2007).

The scale of marine resource exploitation does seem to differ regionally. In Norway, for example, there are not the huge shell middens found along the Scandinavian coast. In Denmark, Mesolithic shell middens are recorded from the 6th millennium BC but the majority are from the very late Mesolithic Ertebølle (Andersen, 2007). Ertebølle shell middens in high densities are known; and large shell middens with deep stratified sequences are often associated with smaller season-specific sites (Andersen, 1995). These large Danish sites are believed to represent permanent or semi-permanent occupations, enabled in part by reliable marine resources, and to indicate a sedentary way of life with a degree of social complexity. Within the Ertebølle, however, as one might expect there is regional variation. In Sweden at the site of Skateholm there is evidence of territoriality but not sedentism (Rowley-Conwy 1998).

As for Scotland sea level change is an issue for visibility of sites along the Scandinavian coast. And Blankholm (2008) has argued that the degree of social complexity in the Ertebolle may have been over-emphasised because early Mesolithic inland sites have in the past been compared with late Mesolithic coastal sites

In Norway, there was rapid coastal colonisation in the early Mesolithic; a marine-based subsistence is not a uniquely Late Mesolithic phenomenon, but in Norway, unlike elsewhere the early coastline survives (Bjerck, 2008, 103). However, in the Late

Mesolithic at coastal sites there is evidence of long-lasting, semi-permanent occupation. Rather than an accompanying narrowing of the resource base (as the Richards *et al* paper would seem to imply) a wider range of resources are exploited but with a greater emphasis on fish, sea birds and sea mammals (Bjerck, 2008).

2.4.1 Past syntheses of the zooarchaeology of Mesolithic Scotland

In terms of previous syntheses of faunal material from Mesolithic sites Lacaille, in his Stone Age of Scotland summarised the fauna from the 'Obanian culture' sites from Oronsay, Oban and Risga (Lacaille, 1954, table V). Over forty years later, in McCormick and Buckland's discussion of faunal change in Scotland the only Mesolithic assemblages to be added were Morton and the mammal from Mellars' work at the Oronsay midden sites (McCormick and Buckland, 1997). Carding Mill Bay was also included in their table of Mesolithic fauna but the dates for this site are Neolithic rather than Mesolithic (Milner and Craig, 2009). Both Lacaille and McCormick and Buckland do not expand on how the animals present might have been caught they are primarily concerned with recording which species were present. The dating programme by Andrew Kitchener and Clive Bonsall of now extinct mammal species in Scotland has added to the picture of what species were present during the Holocene (Kitchener and Bonsall, 1997, Bartosiewicz *et al.*, 1999, Kitchener and Bonsall, 1999). However, this programme is based on geographically spread specimens from throughout the country and is not restricted to archaeological contexts. Pickard's doctoral thesis and subsequent publications (Pickard, 2002, Pickard and Bonsall, 2004) have provided a European wide perspective on fishing in the Mesolithic but only include Morton and the limited published Oronsay data.

2.4.2 Dating

A summary of dates by millennia for the sites listed in section 2.2 is provided here (Table 2.1), a detailed list of radiocarbon dates for the sites in this chapter, with error ranges and laboratory numbers is provided in Table 2.2. Dates come from individual site excavations and also from dating programs that revisit existing sites and target specific artefacts such as those by Bonsall and colleagues (Bonsall and Smith, 1992, Bonsall *et al.*, 1999) and work addressing specific research questions such as Milner and Craig (2009). An important body of work is Ashmore's (2004) large corpus of dates (current up to 2002 when the paper was submitted) for 'early foragers in Scotland'.

Site name/ millennium Cal BC	8th	7th	6th	5th	4th	later
An Corran		X	X	x	x	x
Sand	X	X	x			x
Loch a Sguirr		x				x
Risga			x	x		
Ulva Cave	X	x	x	x		
MacArthur's Cave			x			x
Druimvargie	X	x				
Raschoille Cave		x	x	x	x	
Cnoc Sligeach				x	x	
Caisteal nan Gillean I			x	x		
Caisteal nan Gillean II				x	x	
Cnoc Coig				x	x	
Priory				x		
Morton			x	x		

Table 2.1 Summary table of dates for Mesolithic sites with faunal remains in Scotland, dates and references are provided in Table 2.2

There are problems with these dates. As can be seen from Table 2.1 dates range from the 8th to 4th millennium cal BC and beyond, however, this does not necessarily mean continuous activity at a given site. Human bone that is dated tends not to be Mesolithic but Neolithic or later. MacArthur Cave, for example, has Iron Age human remains (Saville and Hallen, 1994, Milner and Craig, 2009).

In addition to later use of sites, late dates can also reflect large error ranges. As Ashmore discusses, dates taken before the mid-1980s often have large error ranges, sometimes of several hundred years (2004) and errors tended to be underestimated. Some dates used, for example combined charcoal samples, may contain material of different ages and not be representative of a certain context or feature. This is especially an issue for Oronsay and Morton. At Cnoc Sligeach, Oronsay, the oldest date is from the 8th to 7th millennium cal BC but this is from a combined sample of sea shells of various species (Table 2.2). The same sample also provides a date from the 6th millennium cal BC. Of the 10 radiocarbon dates 7 are from mixed samples. This leaves two dates from shell and one date from charcoal, all three of which give dates from the

5th to early 4th millennium but that have at least a 150 year error range. In the summary table (Table 2.1) dates from combined samples are excluded.

Three sites have 8th millennium dates, Sand, Ulva and Druimvargie. At Sand the earliest range of two of the dates only just places the site into the 8th millennium, the majority of dates from the site lie in the7th millennium. Similarly, the 8th millennium date from Ulva is from a soil sample with a 160 year error range. The three dates from Druimvargie do all fall at the beginning of the 8th millennium and later part of the 7th millennium (Table 2.2).

In Table 2.2 the uncalibrated radiocarbon age is the date given by the laboratory and expressed at 1 sigma error. Calibrated dates are expressed as 2 sigma ranges, this means there is 95% chance that the true date lies between the range given. When dating human remains (and mammals) the δ^{13} C figure of the specimen must be taken into consideration and a marine signal accounted for by calibration. This takes into account the marine reservoir effect a phenomenon whereby marine organisms can appear older than their terrestrial counterparts. In some cases recalibration of existing dates is necessary. Milner and Craig report recalibrated dates for 4 dates from Cnoc Coig, Oronsay, due to new research on the marine reservoir correction (Cook 2008 in Milner and Craig, 2009, 176-177, Table 15.6).

Site name	Material	Lab code	Delta 13	Uncal BP	Cal BC	Reference
An Corran	Bevel-ended bone	AA-29316	-29.6	6215±60	5310-4990	(Saville, 1998 in Milner and Craig 2009)
An Corran	Bevel-ended red deer	AA-29315	-21.3	5190±55	4220-3800	(Saville, 1998 in Milner and Craig 2009)
An Corran	Bevel-ended red deer bone	OxA-4994	-21.6	7590±90	6660-6260	(Saville and Miket, 1994 in Milner and Craig 2009)
An Corran	Aurochs	OxA-14752	-22.1	7595±50	6570-6370	(Milner and Craig, 2009)
An Corran	Aurochs	OxA-14751	-22.3	7555±45	6480-6350	(Milner and Craig, 2009)
An Corran	Aurochs	OxA-14753	-21.6	7525±45	6470-6330	(Milner and Craig, 2009)
An Corran	Pig	OxA-13551	-21.5	7485±55	6433-6232	(Milner and Craig, 2009)
An Corran	Human	OxA-13549	-19.4	4650±55	3632-3138	(Milner and Craig, 2009)
An Corran	Human	OxA-13552	-19.9	4535±50	3486-3039	(Milner and Craig, 2009)
An Corran	Human bone	AA-27744	-20.2	4405±65	3340-2890	(Saville, 1998 in Milner and Craig 2009)
An Corran	Human	OxA-13550	-20.5	4360±55	3307-2880	(Milner and Craig, 2009)
An Corran	Tool ruminant bone	AA-29314	-20.6	3975±50	2620-2300	(Saville, 1998 in Milner and Craig 2009)
An Corran	Human	AA-27743	-24	3885±65	2560-2140	(Saville, 1998 in Milner and Craig 2009)
An Corran	Red deer tool	AA-29313	-23.9	3660±65	2230-1870	(Saville, 1998 in Milner and Craig 2009)
An Corran	Pig	AA-27745	-26	3120±60	1520-1210	(Saville, 1998 in Milner and Craig 2009)
An Corran	Bone point (roe deer)	AA-29312	-22	2045±60	210-80	(Saville, 1998 in Milner and Craig 2009)
Sand	Bevel-ended mammal bone artefact B25A NE spit 4 (013)	OxA-10384	-21.07	7855±60	7050-6500	(Ashmore and Wickham-Jones, 2009)
Sand	Bevel-ended mammal bone	OxA-10175	-21.06	7825±55	7050-6450	(Ashmore and Wickham-Jones, 2009)

Site name	Material	Lab code	Delta 13	Uncal BP	Cal BC	Reference
	B25B NE spit 7 (013)					
Sand	Birch charcoal (TP 9)	OxA-9343	-24.608	7765±50	6680-6460	(Ashmore and Wickham-Jones, 2009)
Sand	Bevel-ended mammal bone (TP 9)	OxA-9281	-21.31	7715±55	6650-6440	(Ashmore and Wickham-Jones, 2009)
Sand	Bevel-ended mammal bone B25A NE spit 8 (13)	OxA-12096		7744±37	6650-6470	(Ashmore and Wickham-Jones, 2009)
Sand	Bevel-ended mammal bone (TP 9)	OxA-9282	-20.834	7545±50	6470-6240	(Ashmore and Wickham-Jones, 2009)
Sand	Antler (TP 9)	OxA-9280	-21.756	7520±50	6460-6240	(Ashmore and Wickham-Jones, 2009)
Sand	Bevel-ended mammal bone A1B SW spit 10 (022)	OxA-10176	-20.96	6605±50	5630-5470	(Ashmore and Wickham-Jones, 2009)
Sand	Bevel-ended mammal bone A2B SW spit 10 (22)	OxA-10177	-21.76	6485±55	5540-5320	(Ashmore and Wickham-Jones, 2009)
Sand	Human tooth B25A NE spit 4 (13)	AA-50698	-18.5	3615±65	2150-1770	(Ashmore and Wickham-Jones, 2009)
Loch a Sguirr	Birch charcoal (spit 3)	OxA-9305	-26.587	7620±75	6640-6250	(Ashmore and Wickham-Jones, 2009)
Loch a Sguirr	Bevel-ended	OxA-9255	-21.632	7245±55	6220-6000	(Ashmore and Wickham-Jones,

Site name	Material	Lab code	Delta 13	Uncal BP	Cal BC	Reference
	deer bone (spit 2)					2009)
Loch a Sguirr	Charcoal (spit 6)	OxA-9254	-26.459	2055±39	170BC- AD50	(Ashmore and Wickham-Jones, 2009)
Risga	Antler	OxA-3737		5875±65	4910-4550	(Bonsall and Smith, 1992)
Risga	Red deer	OxA-2023		6000±90	5250-4600	(Bonsall and Smith, 1990 cited in Ashmore 2004)
Ulva Cave	Red deer antler	OxA-3738	-23.6	4780±4450	5750+70	(Bonsall et al., 1994 in Ashmore 2004)
Ulva cave	Patella shell	GU-2602	0.6	6090±70	4710-4350	(Bonsall et al., 1994 in Ashmore 2004)
Ulva Cave	Patella shell	GU-2603	0.4	5930±70	4550-4160	(Bonsall et al., 1994 in Ashmore 2004)
Ulva Cave	Charcoal	GU-2707	-25.4	4990±60	3950-3650	(Bonsall et al., 1994 in Ashmore 2004)
Ulva Cave	Soil	GU-2704	-26.4	7800±160	7150-6250	(Bonsall et al., 1994 in Ashmore 2004)
Ulva Cave	Sea shell (*Patella*)	GU-2600	0.5	8060±70	6660-6260	(Bonsall et al., 1994 in Ashmore 2004)
Ulva Cave	Sea shell (*Patella*)	GU-2601	0.5	8020±70	6640-6250	(Bonsall et al., 1994 in Ashmore 2004)
Ulva Cave	Soil	GU-2705	-23.6	7100±130	6220-5720	(Bonsall et al., 1994 in Ashmore 2004)
MacArthur Cave	Antler	OxA-1949		6700±80	5730-5480	(Bonsall and Smith, 1989 in Ashmore 2004)
MacArthur Cave	Human bone (humerus)	OxA-4485	-21.4	2170±55	368-60	(Saville and Hallen, 1994)
MacArthur Cave	Human bone (femur)	OxA-4486	-21.3	2365±55	755-629, 594-577, 564-356, 290-240	(Saville and Hallen, 1994)
MacArthur Cave	Human bone	OxA-4487	-21.9	2460±55	765-612, 609-	(Saville and Hallen, 1994)

Site name	Material	Lab code	Delta 13	Uncal BP	Cal BC	Reference
	(talus)				407	
MacArthur Cave	Human bone (patella)	OxA-4488	-22.3	2295±60	499-438, 426-183	(Saville and Hallen, 1994)
Druimvargie rockshelter	Bevelled bone from midden	OxA-4608		8340±80	7580-7180	(Bonsall et al., 1995 in Ashmore 2004)
Druimvargie rockshelter	Bevelled bone from midden	OxA-4609		7890±80	7100-6500	(Bonsall et al., 1995 in Ashmore 2004)
Druimvargie rockshelter	Bone barbed point (harpoon)	OxA-1948		7805±90	7050-6450	(Bonsall et al., 1995 in Ashmore 2004)
Raschoille Cave	Red deer	OxA-8396	-21.8	7640±80	6650-6260	(Bonsall et al., 1999 in Milner and Craig 2009)
Raschoille Cave	Red deer	OxA-8397	-21.5	7575±75	6590-6230	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Lynx	OxA-8395	-19.9	7496±50	6440-6230	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Red deer	OxA-8398	-21.6	7480±75	6460-6110	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Red deer	OxA-8535	-21.4	7265±80	6340-5920	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Hazelnut	OxA-8439	-25.1	7250±55	6220-6010	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Sea shell (cockle)	OxA-8539	3.0	7580±45	6170-5920	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Sea shell (cockle)	OxA-8540	2.6	7300±50	5880-5660	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Sea shell (cockle)	OxA-8501	1.4	7390±55	5990-5730	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Red deer	OxA-8538	-22.1	6460±180	5750-4950	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Charred	OxA-8438	-26.3	5115±55	4040-3780	(Bonsall, 1999 in Milner and Craig

Site name	Material	Lab code	Delta 13	Uncal BP	Cal BC	Reference
	hazelnut shell					2009)
Raschoille Cave	Charred hazelnut shell	OxA-8440	-21.8	4995±45	3940-3660	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (child or juvenile)	OxA-8432	-20.4	4980±50	3940-3650	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (femur, child)	OxA-8431	-20.6	4930±50	3910-3630	(Bonsall, 1999 in Milner and Craig 2009)
Rascoille Cave	Human bone (humerus)	OxA-8433	-20.2	4920±50	3800-3630	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (humerus)	OxA-8441	-21.2	4900±45	3780-3630	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (humerus)	OxA-8442	-21.0	4890±45	3780-3540	(Bonsall, 1999 in Milner and Craig 2009)
Raschiolle Cave	Charcoal	OxA-8536	-27.2	4880±60	3800-3520	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (humerus)	OxA-8404	-21.6	4850±70	3790-3380	(Bonsall, 1999 in Milner and Craig 2009)
Raschiolle Cave	Human bone (humerus)	OxA-8443	-20.4	4825±55	3710-3380	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (child femur)	OxA-8434	-21.1	4720±50	3640-3370	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (adult humerus)	OxA-8444	-21.1	4715±45	3640-3370	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (vertebra)	OxA-8399	-21.4	4630±65	3650-3100	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (rib)	OxA-8400	-20.3	4640±65	3650-3100	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone (humeus)	OxA-8435	-22.5	4680±50	3630-3360	(Bonsall, 1999 in Milner and Craig 2009)
Raschoille Cave	Human bone	OxA-8537	-21.8	4535±50	3490-3040	(Bonsall, 1999 in Milner and Craig

Site name	Material	Lab code	Delta 13	Uncal BP	Cal BC	Reference
	(humerus, child)					2009)
Raschoille Cave	Human bone (femur, child)	OxA-8401	-21.1	4565+65	3520-3030	(Bonsall, 1999 in Milner and Craig 2009)
Cnoc Sligeach	Inner part of sea shells (several species)	Birm-4631	-0.1	8220+170	7500-6200	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Cnoc Sligeach	Same sample	Birm-463	-1.2	7210+130	5800-5620	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Cnoc Sligeach	Various shells of Arctica islandica same sample as Birm-464m	Birm-4641	0.2	6910+160	5850-4850	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Cnoc Sligeach	Various shells of Arctica islandica	Birm-464m	0.2	6840+190	5900-4700	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Cnoc Sligeach	Shell (Patella sp. various specimens)	Birm-462m		6390+160	5500-4300	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Cnoc Sligeach	Animal bones probably from several layers	GX-1904		5755+180	5300-4000	(Mackie 1972 cited in Ashmore, 2004)
Cnoc Sligeach	Pectin maximus shell	Brm-4651	-1.3	6010+150	4950-3950	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Cnoc Sligeach	Pectin maximus shell	Birm-465m	-2.2	5900+150	4800-3800	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Cnoc Sligeach	Shells Patella spp also Birm-462	Birm-4621	-1.5	5850+140	4800-3800	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Cnoc Sligeach	Charcoal	BM-670		5426+159	4700-3900	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean I	Charcoal	Q-3008		6190+80	5320-4850	(Switsur and Mellars, 1987 in Ashmore 2004)

Site name	Material	Lab code	Delta 13	Uncal BP	Cal BC	Reference
Caisteal nan Gillean I	Charcoal	Q-3007		6120+80	5290-4800	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean I	Charcoal	Q-3009		6035+70	5210-4720	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean I	Charcoal	Q-3010		5485+50	4540-4040	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean I	Patella shells	SRR-1458b	0.9	5890+70	4500-4050	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Caisteal nan Gillean I	Charcoal	SRR-1458a	-26	4750+180	4300-2800	(Jardine and Jardine, 1983 cited in Ashmore 2004)
Caisteal nan Gillean II	Charcoal	Q-1355		5460+65	4500-4000	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean II	Charcoal	Birm -347		5450+140	4750-3800	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean II	Charcoal	Q-3011		5450+50	4500-3990	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean II	Shells Patella	Birm-348		5850+310	5400-3100	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean II	Shells Patella	Birm-348B		5720+140	4550-3650	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean II	Shells patella	Birm-348C		5570+140	4450-3500	(Switsur and Mellars, 1987 in Ashmore 2004)
Caisteal nan Gillean II	Charcoal	Birm-346		5150+380	5300-2600	(Switsur and Mellars, 1987 in Ashmore 2004)
Cnoc Coig	Charcoal	Q-3006		5675+60	4690-4360	(Switsur and Mellars, 1987 in Ashmore 2004)
Cnoc Coig	Charcoal	Q-3005		5650+60	4670-4350	(Switsur and Mellars, 1987 in Ashmore 2004)
Cnoc Coig	Charcoal	Q-1353		5645+80	4800-4250	(Switsur and Mellars, 1987 in Ashmore 2004)
Cnoc Coig	Charcoal	Q-1354		5535+140	4800-3950	(Switsur and Mellars, 1987 in

Site name	Material	Lab code	Delta 13	Uncal BP	Cal BC	Reference
						Ashmore 2004)
Cnoc Coig	Charcoal	Q-1351		5495+75	4550-4000	(Switsur and Mellars, 1987 in Ashmore 2004)
Cnoc Coig	Charcoal	Q-1352		5430+130	4700-3800	(Switsur and Mellars, 1987 in Ashmore 2004)
Cnoc Coig	Human bone	OxA-8014	-12	5430+55	4000-3800	(Richards and Sheridan, 2000)
* recalibrated		OxA-8014			3930-3650	(Milner and Craig, 2009)
Cnoc Coig	Human bone	OxA-8005	-16	5480+55	4200-4000	(Richards and Sheridan, 2000)
*recalibrated					4230-3910	(Milner and Craig, 2009)
Cnoc Coig	Human bone	OxA-8019	-12.4	5615+45	4200-4000	(Richards and Sheridan, 2000)
*recalibrated					4060-3770	(Milner and Craig, 2009)
Cnoc Coig	Human bone	OxA-8004	-12.4	5740+65	4300-4000	(Richards and Sheridan, 2000)
*recalibrated					4250-3910	(Milner and Craig, 2009)
Priory Midden	Charcoal	Q-3001		5870+50	5000-4450	(Switsur and Mellars, 1987 in Ashmore 2004)
Priory Midden	Charcoal	Q-3000		5825+50	4950-4400	(Switsur and Mellars, 1987 in Ashmore 2004)
Priory Midden	Charcoal	Q-3002		5717+50	4800-4340	(Switsur and Mellars, 1987 in Ashmore 2004)
Priory Midden	Charcoal	Q-3003		5510+50	4600-4000	(Switsur and Mellars, 1987 in Ashmore 2004)
Priory Midden	Charcoal	Q-3004		5470+50	4550-4000	(Switsur and Mellars, 1987 in Ashmore 2004)
Morton site B	Bevel-ended tool animal bone	OxA-4610		5180+70	4230-3790	(Bonsall et al., 1995 in Ashmore 2004)
Morton site B	Bevel-ended tool	OxA-4611		5475+60	4460-4140	(Bonsall et al., 1995 in Ashmore 2004)
Morton site B	Bevel-ended bone tool	OxA-4612		5790+80	4830-4450	(Bonsall et al., 1995 in Ashmore 2004)
Morton site B	Pooled charcoal	Q-928		6115+110	5500-4600	(Coles, 1971 in Ashmore 2004)

Site name	Material	Lab code	Delta 13	Uncal BP	Cal BC	Reference
	(may be mix of older and younger)					
Morton site B	Charcoal	Q-988		6147±90	5400-4700	(Coles, 1971 in Ashmore 2004)
Morton site B	Pooled charcoal sample (may be mix of younger and older charcoal)	Q-981		6382±120	5650-4850	(Coles, 1971 in Ashmore 2004)

Table 2.2 Radiocarbon dates from sites with faunal remains

Note to Table 2.2 : Calibration programs used: Ashmore used INTCAL98 (Stuiver et al., 1998) and OxCal 2.18 or 3.5 (Bronk Ramsey, 1995, Bronk Ramsey, 2000), Saville and Hallen used CALIB 3.0.3 (Stuiver and Reimer, 1993), Ashmore and Wickam-Jones used OxCal 3.9 (Bronk Ramsey, 2003) and INTCAL98 (Stuiver et al., 1998), Richards and Sheridan used INTCAL98 (Stuiver et al., 1998) and OxCal 3.3 (Bronk Ramsey, 1995).

2.5 *An Corran, Loch a Sguirr and Sand*

The most northerly of the sites available for comparison are situated within a relatively small area around the Inner Sound on the east coast of the Isle of Skye, the island of Raasay and the Applecross Peninsula on the mainland (Figure 2.2).

Figure 2.2 Location of An Corran, Loch a Sguirr and Sand around the Inner Sound (Base map by Gaba)

2.5.1 An Corran

Rock blasting for road works led to rescue excavation of the rock shelter at An Corran in late 1993 and into 1994 (Saville and Miket, 1994). The shell midden was beneath disturbed upper levels and Saville and Miket estimate that one fifth of the rockshelter was excavated. The final report is forthcoming and no other excavation details are yet published, the zooarchaeological report by Bartosiewicz, however, has been made available for inclusion in this thesis prior to publication of the site report.

Faunal remains were recovered from seven major contexts from the midden; 31, 34, 36, 37, 38, 40, 41 (Bartosiewicz, forthcoming). Material from the later, disturbed contexts was not included. Recovery was by hand collection and all excavated material was sieved through 1-4mm meshes. Preservation of surface texture was good but the assemblage was highly fragmented. A total of 2603 identified specimens were recovered, 4783 unidentified specimens were also recorded.

The mammalian taxa from An Corran can be divided into two groups. The first group are taxa found in the midden as a direct result of the people using the site; *Bos* sp. (most likely aurochs), red deer, pig (wild boar and indeterminate) roe deer, otter, hare, large canid (either dog or wolf) and brown bear (Table 2.3). Ten of the pig specimens were identified to wild boar based on size, the other specimens could have been either domestic or wild.

Based on size the *Bos* specimens were initially identified as domestic cattle (domestication leads to a reduction in size) however, three of the specimens were dated and produced Mesolithic dates. Domestic cattle are traditionally a Neolithic phenomenon and for this reason, after dating, the *Bos* specimens were thought instead to be small aurochsen (Milner and Craig, 2009). Small aurochsen are known from Europe and due to sexual dimorphism there is an overlap in size between the largest Neolithic domestic cattle and the small wild cattle (Prummel, 2011, Rowley-Conwy, 2003). At present there is no evidence of local cattle domestication in Mesolithic Scotland or indeed across other parts of Europe. Mitchondrial DNA evidence (maternal lineage) has shown that European domestic cattle are descended from domesticated Near Eastern aurochsen rather than European aurochsen; domestic cattle have spread geographically rather than repeated local domestication (Scheu et al., 2008, Tresset et al., 2009). In Ireland domestic cattle have been found in a Late Mesolithic context at the site of Ferriter's Cove (Woodman et al., 1997), a direct date as Mesolithic, does not, therefore, fully rule out a domesticated specimen. The presence of domesticates at Ferriter's Cove before the establishment of agriculture in Ireland is important and, Tresset has argued, may be evidence of open sea sailing trips from the continent by farmers (Tresset, 2003). Analysis of the mtDNA of the An Corran specimens, then, should take place; it would confirm identification, and, *if* any of the specimens were domestic the geographical region of the wild descendent would be able to be identified.

The second group of taxa, comprised mostly of small mammals; pigmy shrew, bank vole and field vole, Bartosiewicz suggests are likely to have been washed into the rockshelter from higher up the cliff by rainwater or may have burrowed into the midden (and are omitted from the summary table). The amphibian remains are also likely to be at the site due to similar processes (and also omitted from the summary table). Wild cat could also be in this second group, the animals could have used the rockshelter prior to the build up of the midden and may have been responsible for some of the small mammal bones (Bartosiewicz, forthcoming).

The birds are mostly sea birds; great auk, puffin, gannet, cormorant, white-tailed eagle, pomarine skua and gull sp.. Willow tit, thrush family and perching birds (Passerine order) Bartosiewicz (forthcoming) suggests are likely to be natural additions to the midden and reflect the woodland setting. Many of the species are represented by only a few specimens, it is unclear how much of the bird remains comes from human procurement versus natural death (Table 2.4).

Fish species present in order of abundance were salmon or trout, eel cod, whiting, saithe, cuckoo wrasse, plaice and dab. The most abundant family was the cod family. In addition to the fish identified to cod, whiting and saithe, 1589 specimens were identified to the cod family but not further identifiable to species. Specimens belonging to the sea scorpion family but not identifiable to species were also recorded (Table 2.5).

	common hare	wild cat	otter	brown bear	Canid	wild pig	pig indet.	roe deer	red deer	bovine	small ruminant	large ruminant	small artiodactyl
Neurocranium fragment							2	2	3			3	
Frontale													
Nasale													
Os incisivum												1	
Zygomaticum							1	1	1				
Maxilla									1	1			
Mandibula						1	2	5	5			5	
Upper tooth						1	1	11	5	3			
Lower tooth						2		13	6				1
Atlas								1	1				
Epistropheus							2	1	2	1			
Cervical vertebra							3	3	3	1	3	4	6
Thoracic vertebra							4	4	6		1	4	5
Lumbal vertebra							2	6	4	1	1	7	1
Sacral vertebra								1					
Rib							5		4	5	7	40	228
Sternum											5		6
Scapula											1	5	
Humerus	1						1	1	1		1	2	1
Radius									3	2	2	6	2
Ulna		1	1				1	2	5		1	2	3
Carpalia							1	6	5	2			
Metacarpus	1					3	7	15	39			4	
Ilium								1	1				
Acetabulum pelvis								1	1				1
Femur	1						1	5	5	1	3	9	6
Patella								1	1				
Tibia	4					1		11	6			8	3
Fibula							1						
Calcaneus							1		1				
Astragalus									4				
Centrotarsale							3	1	1				
Metatarsus						2	4	16	36			4	1
Phalanx proximalis	1	1		1	1		6	3	7				
Phalanx media	1	1					6	2	6		1		1
Phalanx distalis							3	1	4				
Long bone									6		16	124	413
Flat bone												143	608
TOTAL	**9**	**3**	**1**	**1**	**1**	**10**	**57**	**114**	**173**	**17**	**42**	**371**	**1286**
Antler (206.8 g)									41				

Table 2.3 An Corran mammal NISP and element distribution (Bartosiewicz, forthcoming, Table 26)

	great auk	gannet	cormorant	white-tailed eagle	pomarine skua	gull sp.	guillemot	puffin	willow tit	thrush	perching bird	bird indet.
Neurocranium fragment												2
Frontale								1				
Mandibula	3					1		1				1
Atlas												
Epistropheus	1											
Cervical vertebra	1							4				5
Thoracic vertebra	1							2				
Synsacrum			1									3
Rib												21
Sternum						1						3
Clavicula								1				1
Coracoideum	2							9				3
Scapula	1							4				
Humerus	2	1	3					16				7
Radius				1				7				3
Ulna	2		1					14			4	7
Carpometacarpus			2				1	6			1	
Femur	1			1				1	1			2
Patella												
Tibiotarsus	2				1			4		1	2	9
Tarsometatarsus	1							2	2			2
Phalanx proximalis					1			8				4
Phalanx media								1				2
Phalanx distalis												2
Long bone												33
Flat bone												3
TOTAL	17	1	7	2	2	2	1	81	3	1	7	113

Table 2.4 An Corran bird NISP and element distribution (Bartosiewicz, forthcoming, Table 25)

	eel	salmon/trout	Cod	saithe	Whiting	gadid	cuckoo wrasse	cottid	dab	plaice
Vomer			3	4		1				
Parasphenoideum			2	4		3				
Basioccipitale						7				
Prooticum		1								
Exoccipitale						1				
Otolith			1	2		2				
Angulare			4	2		6				2
Dentale	2		4	9	3	5				
Pharingeal tooth							2			
Premaxillare			16	13	2	47	8			
Maxillare		1	7	9		44				
Suboperculare								1		
Branchyostegale						3				
Palatinum		2				4				
Quadratum			2	1		6	1		1	
Hyomandibulare			1			1		1		1
Epihyale						3				
Ceratohyale		3	1							
Hypohyale						1				2
Urohyale		1				1				
Scapula			1							
Coracoideum		1	1							
Posttemporale						6				
Cleithrum			1			5				1
Basipterygium						1				
Atlas			1			7				
Vertebra Praecaudalis	29	74	3			919	15	3		21
Vertebra caudalis	22	53				514	13	15	8	6
Radii		2								4
Pterygiophori						2				3
TOTAL	53	138	48	44	5	1589	39	20	9	40

Table 2.5 An Corran fish NISP and element distribution (Bartosiewicz, forthcoming, Table 24)

2.5.2 Sand

The Mesolithic site at Sand was identified in 1999 by the Scotland's First Settlers project led by Karen Hardy and Caroline Wickham-Jones. This project aimed to explore local mobility and resource exploitation in the seascape of the Inner Sound, from the coast of Skye in the east to the Applecross peninsula of the mainland to the west (Finlayson *et al.*, 1999, Hardy and Wickham-Jones 2000, Hardy and Wickham-Jones, 2009b). This involved extensive field survey and test pitting across the area. Following survey at Sand initial test pits were dug in 1999 and open area excavation conducted in 2000. The site and all excavated material is fully analysed and published together in a comprehensive online site report, including specialist reports as a Scottish Archaeological Internet Report.

Figure 2.3 The rockshelter at sand (photograph by the author)

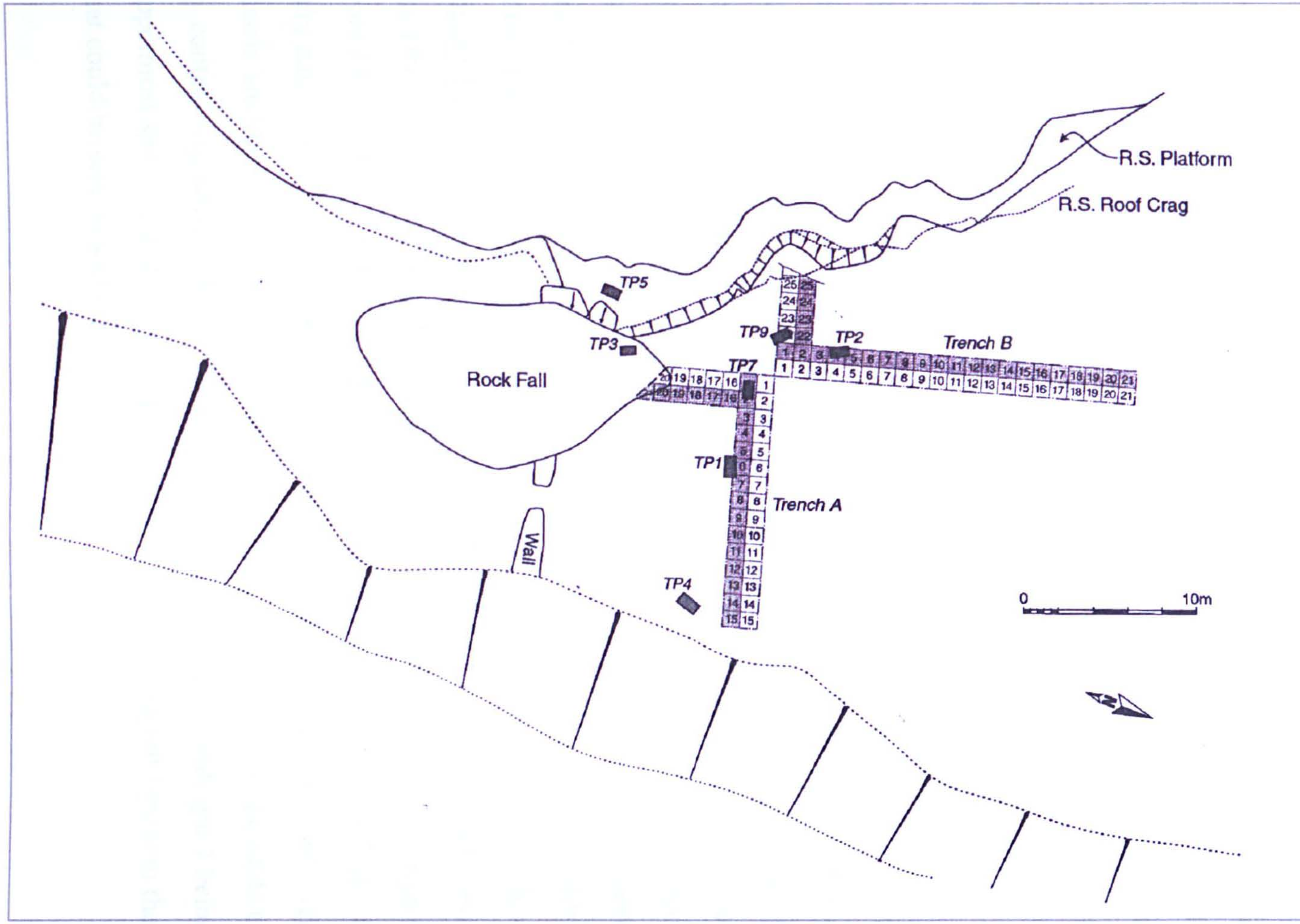


Figure 2.4 Location of 1999 test pits (TP) and 2000 Trench A and B excavations (Hardy and Wickham-Jones 2000, 49, Figure 9

The rockshelter at Sand is a former sea cave, a shallow rock overhang with a large flat, 'terrace' area in front (Figure 2.3). The site is around 27 m above current sea level and 500m from Sand bay, a small bay with active sand dunes (Wickham-Jones 2009b). The shell midden, predominantly comprised of limpet shell, was located in front of the overhang rather than directly underneath it. During survey, shells had been found in the rockshelter and shell and lithics had been found in a mole hill. In 1999 nine test pits each 1m by 0.5m were excavated under the rock overhang, along the terrace and around the rockshelter (Figure 2.4). Of these, test pit 9 revealed a rich midden deposit including lithic, zooarchaeological and shell remains. From this test pit there were 4 radiocarbon dates, all dated to the 7^{th} millennium BC (Table 2.2).

Figure 2.4 shows the location of the 1999 test pits and larger trenches from 2000. Test pits 6 and 8 mentioned in the 1999 Data Structure Report were excavated at a smaller nearby rockshelter (SFS005 Sand 2) and are omitted from Figure 2.4. In 2000 two L shaped trenches were excavated, trench A was 21x2m and trench B 25x2m, each trench was excavated in $1m^2$ grids (Hardy, 2009). The excavations identified 3 edges of the midden, estimated at 8x8m and up to 1m deep. It is estimated $50m^3$ of material was present and that 16% of this was excavated. Turf and topsoil was removed from all parts of both trenches and then four areas focused on, A, B1, B2 and B3 (shown in Figure 2.5). The trenches were positioned to cover the midden deposits revealed by the 1999 test pits and an adjacent area of terrace. Test pit 9, the midden rich test pit from 1999 is shown in Figure 2.4 located within Trench B in square B22B. By their very nature shell middens are difficult to excavate; the Sand midden had a very loose matrix and the excavators faced this by excavating in spits. Where possible excavation by context was attempted, but the majority was by 5cm spits, with spit 1 being the uppermost spit. Contexts were largely assigned after excavation based on the divisions that could be seen in section.

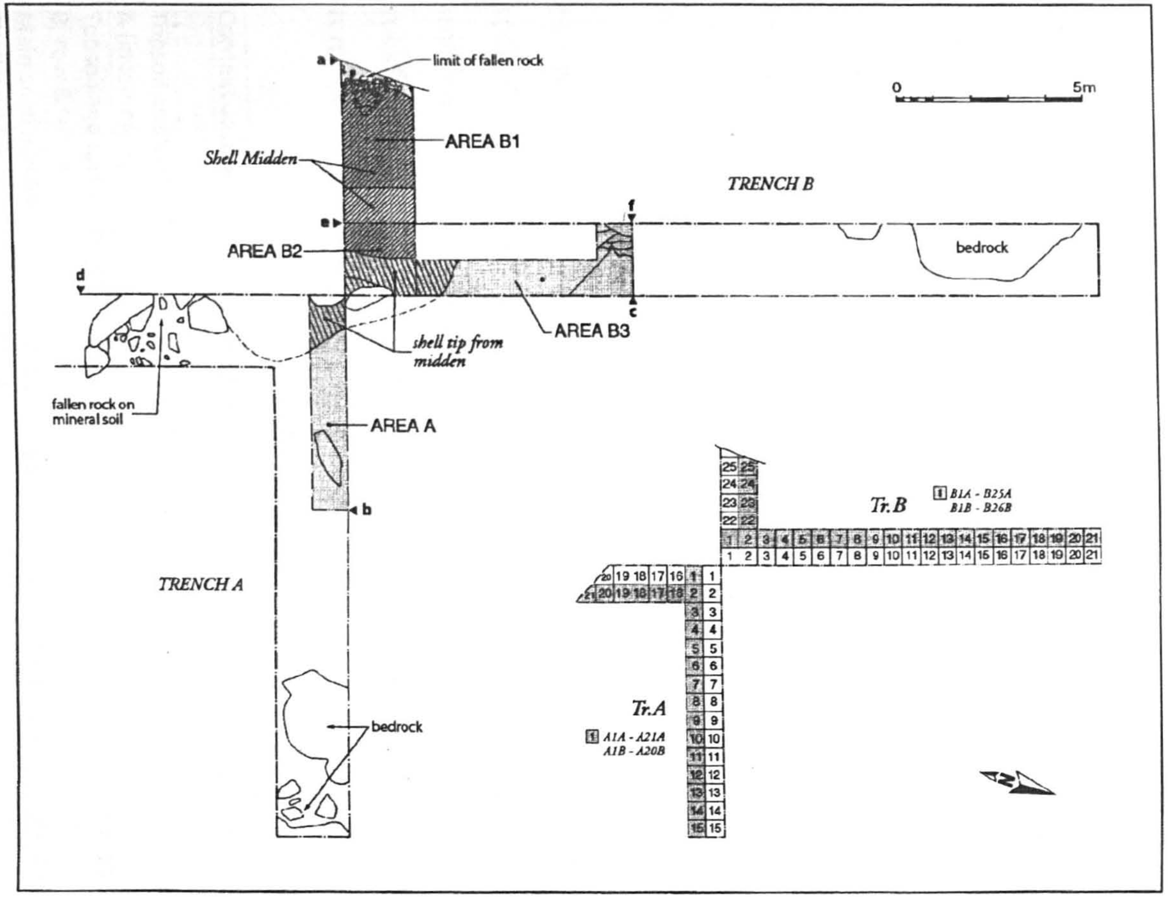


Figure 2.5 **Plan of excavated areas at Sand and trench numbering system (Hardy and Wickham-Jones, 2000, 54, Figure 10)**

2.5.3 *Contexts at Sand*

Twenty-nine contexts were identified in total. Some of these are given as context 'x or y' (for example context '1 or 2') and in some cases up to 3 different contexts are given together, for example '13/23/24' which appears to reflect the ambiguity over context boundaries within the shell midden or uncertainty in assigning contexts (Table 2.6). From the section drawings it seems that the same context number has been used to describe stratigraphically distinct contexts that are very similar. For example, in the south facing section of Area B1 two areas of context 013 are marked, but they are separated by context 009, stratigraphically both cannot be 013 (Figure 2.6). The context resolution table produced after excavation (Table 2.6) groups contexts according to context type. This would appear to confirm that during excavation contexts *were* used descriptively. Three main series of midden contexts were recorded, the main shell midden in areas B1, B2 and B3; shell midden in area A and an organic rich silt, described as rich in mammal bone and antler, in areas A and B3 (Table 2.6).

Hardy and Wickham-Jones believe the midden built up against a rock platform in the rock shelter and then slumped downslope. They state that the stratigraphy of the midden is complex, several episodes of slumping and slopewash are described and rockfall recorded (Figure 2.6). The four main areas of excavation are now considered in turn.

Context description	Context numbers	Area
Topsoil and turf in Trench A (incomplete)	1, 1/2, 1/3	ALL
Topsoil and turf in Trench B, row B	1, 1/2, 1/3	B2, B3 and to N
Main shell midden	13, 11, 12, 13/23, 13/24, 13/23/24, 24	B1, B2, B3
Shell midden	27, 28	A
Sandy soil with heat cracked stone	17, 18, 29, 17/27	A
Palaeo-channel and below	5, 14, 14/21	B3
Slopewash over palaeo-channel	7/8	B3
Lower organic rich silt (below midden)	22	A and B3
Natural	21, 26, 25	ALL

Table 2.6 Sand context resolution (Wickham-Jones pers comm.)

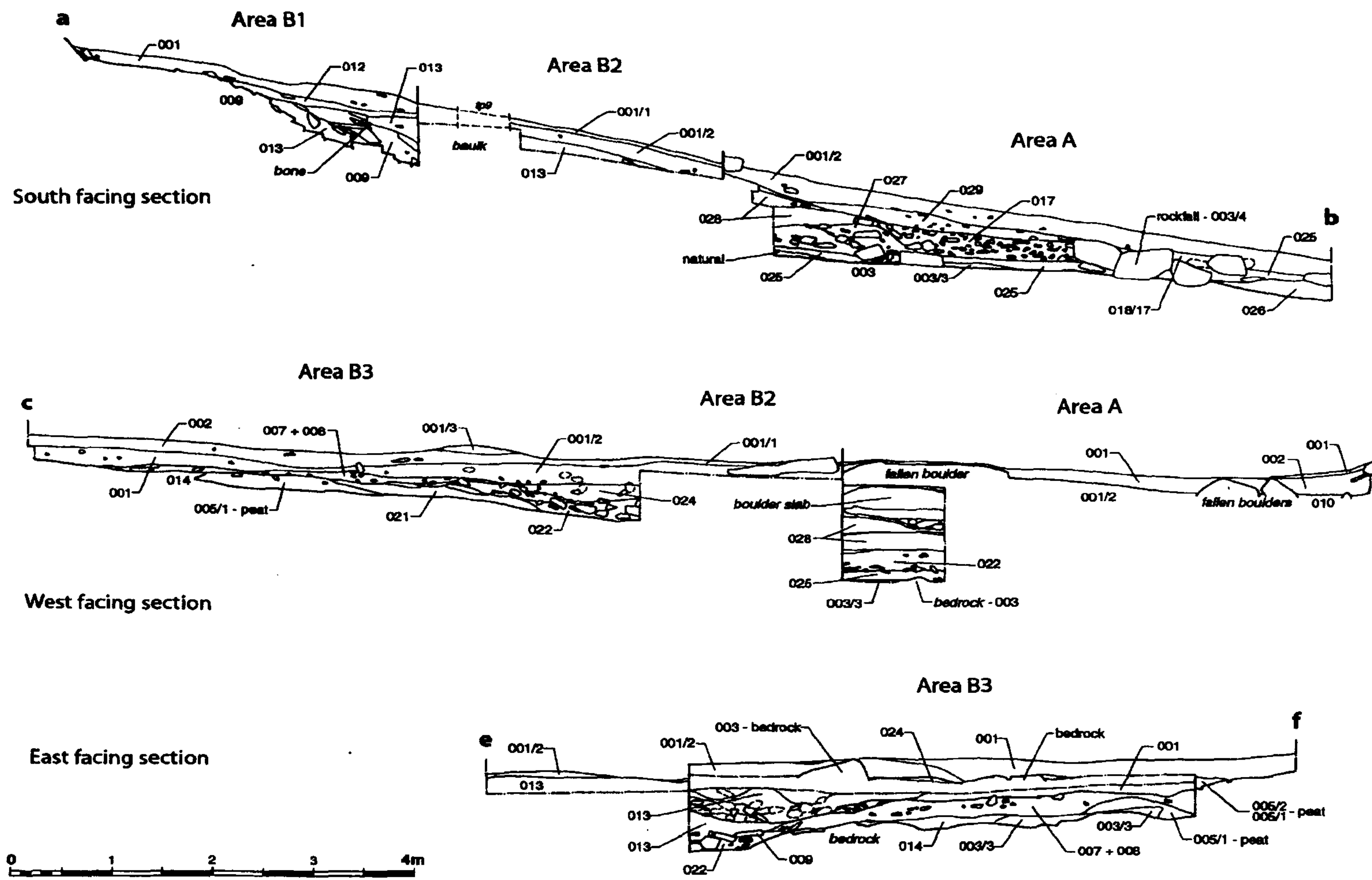


Figure 2.6 Sections from Sand. Sections are marked on Figure 2.5

The majority of deposits in the main shell midden were from area B and composed of context (013) a dense mass of consolidated shell which underlay the topsoil and turf layers (001, 001/002, 001/003). At the base of the main shell midden large fragments of mammal bone and antler were noted. The only visible stratigraphic variation within this was a dark grey and ashy layer of shells (011) in area B1. Unfortunately, it subsequently became apparent that a grid square numbering error made during excavation meant that contexts 011 and 013 could not be distinguished post-excavation and both are described in the context resolution table as main shell midden. Also in area B1 at the top of the midden the shells were more degraded and a clear band of crushed shell was recorded in section (context 012, Figure 2.6). This crushing has been interpreted as evidence of a possible path through the rock shelter at any time since the deposition of the material (Hardy, 2009): this context is also described as main shell midden. In Area B3 a layer of tipped shells (024) was noted but the relationship between 013 and 024 is not clear due to animal disturbance; both contexts are described as main shell midden. In the south west corner of B3 was an organic-rich palaeo-channel (context 5). A slopewash layer of small stones overlain it (context 007/8) and degraded bedrock, some worn to fine sand was found below (context 14, 14/21).

In Area A six grid squares were fully excavated (A1B-A6B); these ran downhill away from the midden and two sections are shown in Figure 2.6. Squares A1B and A2B were close to Test Pit 7 from the 1999 season. In the topsoil of Trench A animal burrows were recorded. The shell midden contexts (027 and 028) are believed to be material from the main shell midden that has slumped downslope and therefore be of a similar date to the main shell midden. This redeposited material is described as as 'shell midden' rather than 'main shell midden'.

Below the midden in Area A were fire-cracked stones (contexts 017, 018, 029 and 017/027) which the excavators believe relates to activity elsewhere at the site. Animal disturbance was found at the edge of the midden and in upper layers but none is noted from the main deposits. The site has produced dates and artefacts later than the Mesolithic, however, Hardy states that the later activity, including some small scale smithing does not seem to have disturbed the earlier deposits. But, even if disturbance has not been great it is clear that there has been movement within the midden and material redeposited. When the site was identified lithics were found in a molehill, this also clearly demonstrates, *contra* Hardy (2009) that earlier deposits **have** been disturbed, even if on a relatively minor scale.

No soil horizons or vegetation regeneration was noted within the main shell midden, this and the large quantity of shell has led to the interpretation that the accumulation was rapid and continuous (Hardy 2009a) and Hardy asserts that the radiocarbon dates support this interpretation. From the main shell midden there are 4 dates, 3 taken from bevel-ended bone tools from the NE corner of square B25. Three spits are dated, all assigned to context 13: spit 4 is dated to 7050-6500 cal BC, spit 7 to 7050-6450 cal BC and spit 8 to 6650-6470 cal BC (Table 2.7). This does seem to indicate that certainly in that part of the site the midden built up in the second half of the 7th millennium. The midden could have accumulated over around 50 years, should the dates be from the youngest ends of these ranges, but, if the widest range of dates is considered accumulation could have occurred over 600 years. Given the lack of soil or vegetation build up, however, a shorter accumulation does seem more likely.

However, also from the same context and same square was a human tooth, dated to 2150-1770 cal BC (Table 2.7). This confirms not only that the site has been used at a much later date but also that material *has* percolated down. It must also be noted that only one small area of one of the main shell midden contexts has been dated, the rest of the material may or may not be contemporary. A sensible interpretation in this situation, however, is to assume that much of the material that has been recognised as archaeologically similar is of a Mesolithic date whilst acknowledging the caveat that some later material may be incorporated and further dating might change this interpretation.

Context	Description	Material	Cal BC	Zooarch material from this context?
13	Main shell midden	Bevel-ended mammal bone artefact B25A NE spit 4	7050-6500	Yes
13	Main shell midden	Bevel-ended mammal bone B25B NE spit 7	7050-6450	Yes
13	Main shell midden	Bevel-ended mammal bone B25A NE spit 8	6650-6470	Yes
22	Organic rich layer	Bevel-ended mammal bone A1B SW spit 10	5630-5470	Yes
22	Organic rich layer	Bevel-ended mammal bone A2B SW spit 10	5540-5320	Yes
13	Main shell midden	Human tooth B25A NE spit 4	2150-1770	yes

Table 2.7 Radiocarbon dates from Trenches A and B (Ashmore and Wickham-Jones 2009)

In addition to the dates from the main shell midden contexts, two dates were obtained on bone from the contexts collectively described as organic rich and shell free, although shells *were* recorded from those contexts (Milner 2009). Both dates are from context 22, from the south west corner of square A1B, spit 10. As the organic rich midden is stratigraphically below the shell midden contexts Hardy and Wickham-Jones initially interpreted this as an earlier phase but dates of 5630-5470 and 5540-5320 cal BC (Table 2.7) instead confirm a later sixth millennium date. The redeposited shell midden (contexts 027 and 028) is believed to have slumped on top of these later deposits. In places rock fall was found in between the organic rich silt and midden deposits. Intriguingly also from this area in square A2B, spit 8 a Neolithic ground stone axe found at the interface between context 22 (organic rich) and 27 (redeposited shell midden) and overlain by more redeposited shell midden.

A Neolithic artefact would suggest a 5th millennium not 6th millennium date. Clearly, it is hard to explain the axe and it calls into question the integrity of this area of the site. It perhaps indicates (as the excavators favour) that the shell midden deposits did not slump onto the later organic rich layer until much later and after early Neolithic use of the site. Dating is a huge issue, the only dates from the organic rich layer are from bevel ended tools, is it possible that given their relatively small size they could have percolated down from the slumped main shell midden deposits into the organic rich layer? More dating of non-artefactual mammal remains are needed to help clarify this.

In terms of analysis of the zooarchaeological remains, bone was recovered from all broad context divisions and within this from all contexts apart from context 018. Although material was recovered from the dated contexts, as for the organic rich layer the only bone directly dated was that which had been used to make bevel ended tools. More dating of non-artefactual zooarchaeological material from throughout the site is needed.

2.5.4 Loch a Sguirr

Loch a Sguirr was identified on the island of Raasay in 1999 by the Scotland's First Settlers Project (Hardy and Wickham-Jones, 2009b). Mesolithic dates were obtained from test pit 1; a 1mx0.5m trench at the back of the shelter. Three radiocarbon (Table 2.2) dates were obtained from trench 1; from spit 2 (6230-6000BC), spit 3 (6640-6250BC) and spit 6 (AD50-170). Despite the Mesolithic dates the small faunal assemblage (domesticated mammal specimens, amphibian and fish) is not suitable for inclusion as a comparative dataset. Many of the spits identified during excavation are comprised of thin lenses, and the later date from spit 6 (below spits 2 and 3) suggests that the deposits have been subject to disturbance. It is unclear which spits the mammal remains, a cattle metacarpal and 2 specimens of neonatal sheep or goat, and the amphibian bones were from (Hardy and Wickham-Jones, 2009a). These remains are unlikely to be Mesolithic as domestication is thus far a Neolithic phenomenon. Most of the diagnostic fish bones from trench 1 were recovered from spits 4 and 5 which are not dated and lie above spit 6 which has produced the youngest date (Parks, 2004).

2.6 *Risga, Ulva and the Oban sites*

Moving south is the Island of Risga on Loch Sunart, Ulva Cave on the Island of Ulva, just off Mull and several sites are located around the town of Oban (Figure 2.7).

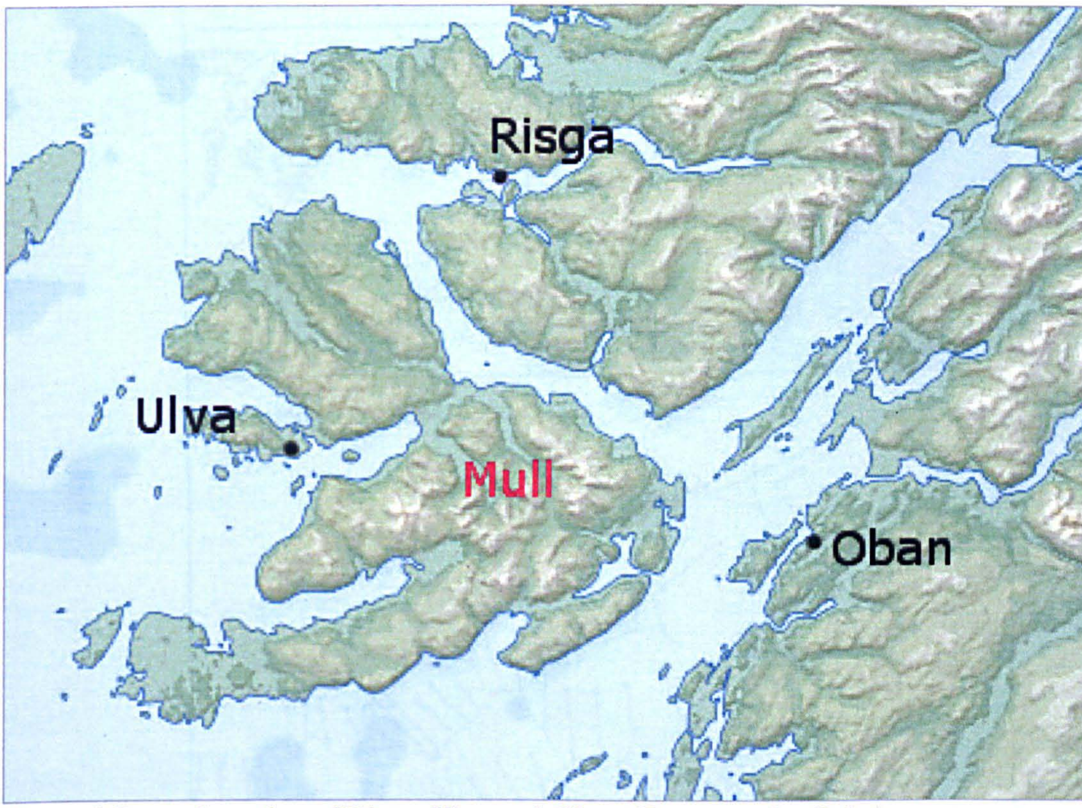


Figure 2.7 Location of Risga, Ulva and Oban (Base map by Gaba)

2.6.1 Risga

Risga was first excavated in 1920 by Ludovic Mann and more extensive work took place in 1921-1922 by Bishop's agent Keith MacKewan. Mann wrote a brief article on his work for the Glasgow Herald. MacKewan did not publish his work but communicated his progress by letter to Bishop, and boxed up and sent material from his excavation. Details from both accounts are reproduced in Pollard *et al.* (1996). Mann's newspaper article appears less concerned with the details of Risga but a more general picture of 'Oransay man'. MacKewan's letters include no plans or sections, Pollard gleans that the site, which originally appeared as a mound had a complex stratigraphic sequence which included a shell midden layer and a 'soot layer' (1996, 170). It is impossible to stratigraphically place the faunal remains and other artefacts.

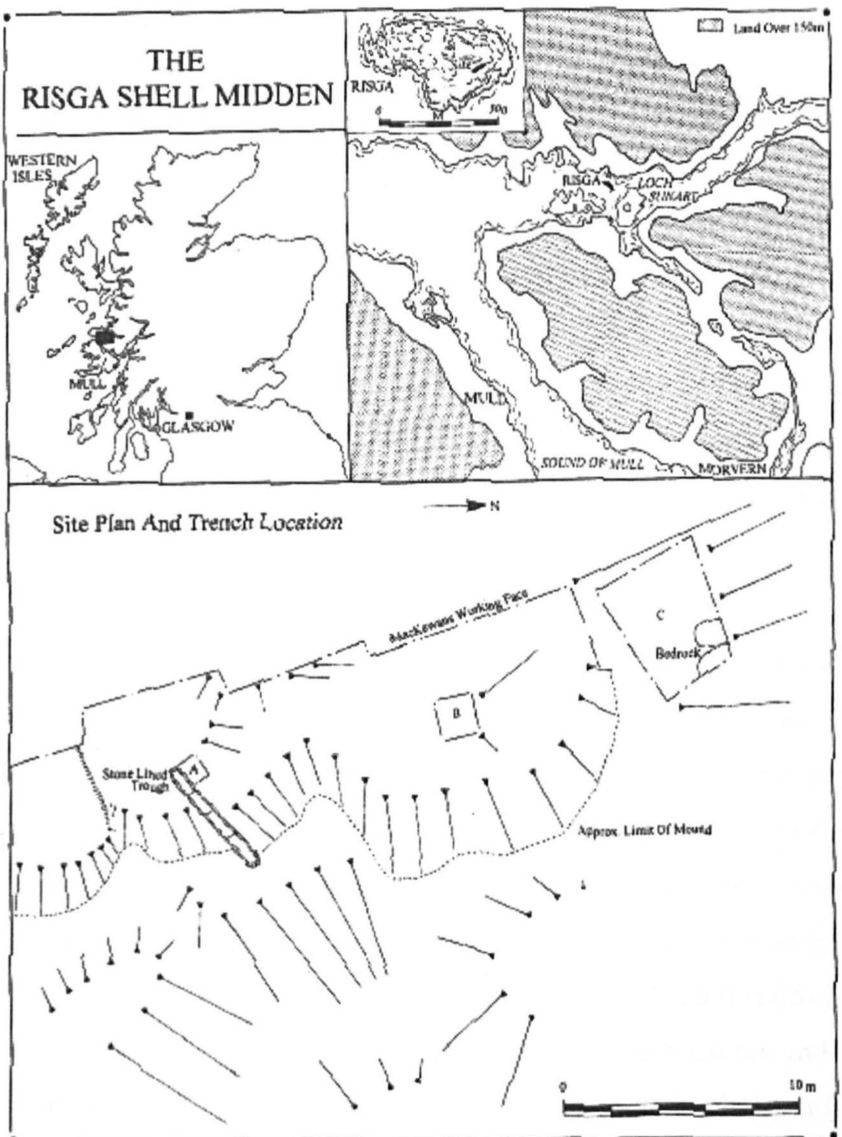


Figure 2.8 Risga location and site plan by Pollard *et al.* (1996, 173, Figure 10.1)

Aside from MacKewan mentioning that red deer was recovered, the species list for Risga comes from Mann's article in the Glasgow Herald. However, it is difficult to tell if his account of the fauna is specifically concerned with Risga or if it is a more general comment on the shell middens that had already been discovered. The latter seems more likely as the species list is suspiciously close to that given by Grieve and Bishop for Cnoc Sligeach and Caisteal nan Gillean I:

'Oronsay man had no knowledge of domestic mammals, agriculture, pottery, textiles, of metals, but he was a skilled fisher, hunter and boatman. In Scotland his dietary consisted chiefly of products of the sea. His kitchen middens contain remains of crabs, including the fiddler crab, haddock, conger eel, skate, grey mullet, bream (both sea and black), wrasse, angel fish [angel shark], *tope, ray and the now despised spiny dogfish* [now known as spurdog]. *'(Pollard et al., 1996,179).*

Mammals listed are pine marten, red deer, boar, otter, rorqual, common seal and grey seal. His description of the birds in particular lends further doubt to whether these species were present at Risga; *'large number of birds which he perhaps snared or trapped, such as the guillemot, gannet, razorbill, gull, tern, water rail, goose, shag, cormorant and red-breasted merganser'* (Pollard *et al.*, 1996, 179), as the one species that Mann describes picking from the midden, great auk, earlier in his article does not feature in that list.

Foxon's 1991 thesis examined the worked material from Risga and similarly concludes that the list that Mann gives is a general impression of what was available to 'Oronsay man' rather than taxa found at the site aside from Mann's specific reference to great auk. From Foxon's work the only other mammal, bird or fish species to positively be identified from the site is red deer in the form of worked bone and antler (Foxon does also identify limpet, winkle, mussel, oyster, whelk, razor and crab). Foxon also references comment from Grigson that *Bos* sp. and pig (not specified if wild or not) are amongst the remains from Risga in the Glasgow Art Gallery and Museum and Hunterian Museum (Foxon, 1991). Risga is one of the sites included in Lacaille's table of fauna at 'Obanian' sites (Lacaille, 1954, 241 Table V). Lacaille describes the bone as fairly fresh-looking and states that this aided identification, but the species list is essentially the same as that given in Mann's account with the omission of sea bream, wrasse and ray and Foxon suggests that rather than having identified the bones himself as he implies (1954, 229) Lacaille has just used Mann's species list.

More recent survey and excavation by Pollard took place at Risga between 1993 and 1997 (Figure 2.8). Test pits revealed that the earlier excavations in the 1920s had removed all *in situ* midden deposits and excavation focused on undisturbed archaeology around the midden (Pollard, 2000). No further zooarchaeological remains were found.

Given the uncertainty of the species from Risga antiquarian excavations the site is omitted from the summary table.

2.6.2 *Ulva*

Fieldwork led by Clive Bonsall of Edinburgh University took place 1987-1991 and then resumed again in 1999. Fieldwork is still ongoing at the time of writing (2012). Despite the longevity of the research project few details are published and no comparative zooarchaeological dataset available. In the 1994 preliminary report no species information is available, mammals (including antler) and fish are listed only as present (Bonsall *et al.*, 1994). Twenty-two shellfish were present with limpet, perwinkle and dogwhelk the predominant species.

2.6.3 *MacArthur Cave, Oban*

In 1895 Anderson published an excavation report of MacArthur Cave in the *Proceedings of the Society of Antiquaries of Scotland.* The Society funded the excavation but Anderson himself did not take part (Pollard, 1994). The cave was excavated by John Munro and it is Munro's working diaries, letters from another local man, Walter Higgin, and two visits to the site by Anderson on which Anderson's account is based. MacArthur's cave was excavated stratigraphically, the approximate depth and a description of each layer recorded (Anderson, 1895, 215), and the size of the cave sketched. The cave was discovered during quarrying, Anderson describes how the roof of the cave lay blasted on the floor.

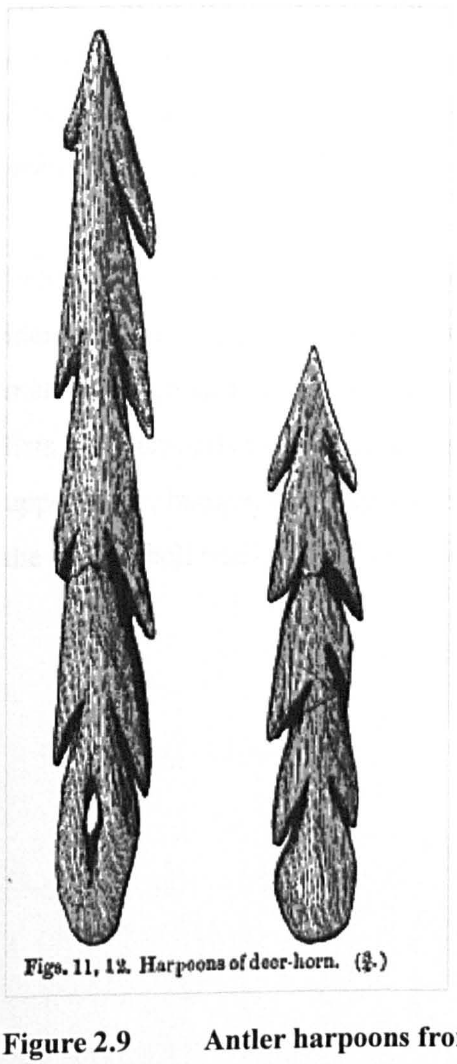


Figure 2.9 Antler harpoons from MacArthur cave (Anderson, 1895, 223)

Underneath the cave floor, a black earth layer, were shell midden deposits the 'upper shell bed', various species of shellfish, land and sea mammal bones and patches of burnt material. The mammal bones were broken and splintered. A layer of gravel separated this layer and another similar shell midden deposit, the 'lower shell bed' which was in part intercalated with the gravel. Amongst the bone artefacts recovered were antler harpoons and bevel ended antler and bone (Figure 2.9).

Shellfish identified were limpet, whelks, periwinkle, mussel, oyster, cockle, razorshell and Tapes. Edible crab was also recorded as present. The human bones recovered were identified by Turner (1895), his assistant, Simpson looked at the animal bones. Prior to Simpson's identifications Anderson notes the following:

'Fishbones are numerous, but usually in bad preservation. They indicate, in many cases, fish of very considerable size, such as might have been captured even by the largest of these harpoons; but the species have not been determined, although I thought I recognised the lower jaws of a wrasse and a saithe among the number of better-preserved ones'(1895, 228).

In Simpson's notes, included in Turner's (1895, 423) paper, however, the fish are not identified to species. As to be expected for the time no quantification of any of the material is given but Simpson does note that some of the bones were burnt. Simpson lists the mammals present as red deer, ox, pig, dog and badger some bird and fish in the upper layer; badger, red deer, ox, roe deer, small birds and fish in the shell bed and in the lower shell bed ox, red deer, roe deer, otter, cat, pig, badger, small birds and fish.

2.6.4 Druimvargie rockshelter, Oban

Quarrying also led to the discovery of the Druimvargie rockshelter. As for MacArthur's cave John Munro led the excavation, helped by his son and another man. Anderson then published the results alongside a description of artefacts from various sites on Oronsay (1898). Underneath talus in the rockshelter a mix of shell and bone midden deposits c.4feet thick was found, the upper layer of which was mixed with burnt material.

In addition to various shellfish; limpets, perwinkels cockles, oysters and large pectens, Anderson lists red deer, wild boar, otter, small wild-fowl and 'but few fishbones were detected' (1898, 299). Anderson notes that fewer bones were recovered from Druimvargie compared to MacArthur's cave. It is impossible to assess if fewer faunal remains really was a feature of the site or if it reflects a difference in standard of excavation.

2.6.5 Raschoille cave, Oban

Rescue excavation was carried out by the Lorn Archaeological and Historical Society (Connock, 1985) but is not suitable for inclusion as a comparative dataset. There is no zooarchaeological report but Connock notes that few bones of larger mammals were recovered but that there were abundant remains of rodents, small mammals, amphibians and birds. A 'myriad' of fish bones from small fish were noted, the only taxa identified was wrasse. Connock suggests that the fish may have been brought into the cave by fish-eating birds and notes that some of the bones looked like they have may have formed part of bird pellets.

2.7 *Oronsay sites*

Five shell midden sites are known on Oronsay (Figure 2.10). Two of these, Cnoc Sligeach and Caisteal nan Gillean I, were first excavated in the late 1800s and early 1900s. Caisteal nan Gillean II, Cnoc Coig and Priory Midden, were identified in the research programme led by Paul Mellars, in the late 1970s and early 1980s. Mellars also conducted further fieldwork at Cnoc Sligeach and Caisteal nan Gillean I. Mellars writes that where possible the middens in his programme of work were excavated stratigraphically. When no stratigraphic layers were visible then the deposits were divided into units of arbitrary depth, though the Mellars states this was normally 10-12cm. This is important to note because the units are not necessarily related to a particular depositional event, however, it is tempting to interpret the evidence by unit whilst the material within the units are not necessarily stratigraphically equal. When a stratigraphic layer was around 10cm thick then the deposit was divided into upper and lower units to allow greater sampling resolution (Mellars, 1987). A preliminary report on the mammal remains was published in the site volume (Grigson and Mellars, 1987). The bird bone from the sites is unpublished but some data from Cnoc Coig is available in an unpublished PhD thesis (Nolan, 1986). The fish bone is largely unpublished (Wilkinson, 1981) apart from a paper concerned with seasonality and saithe otoliths (Mellars and Wilkinson, 1980). The shellfish and crustacea are unpublished, however some species are mentioned in the text or shown in photographs of the site volume (Mellars, 1987) and are included in the summary tables towards the end of this chapter.

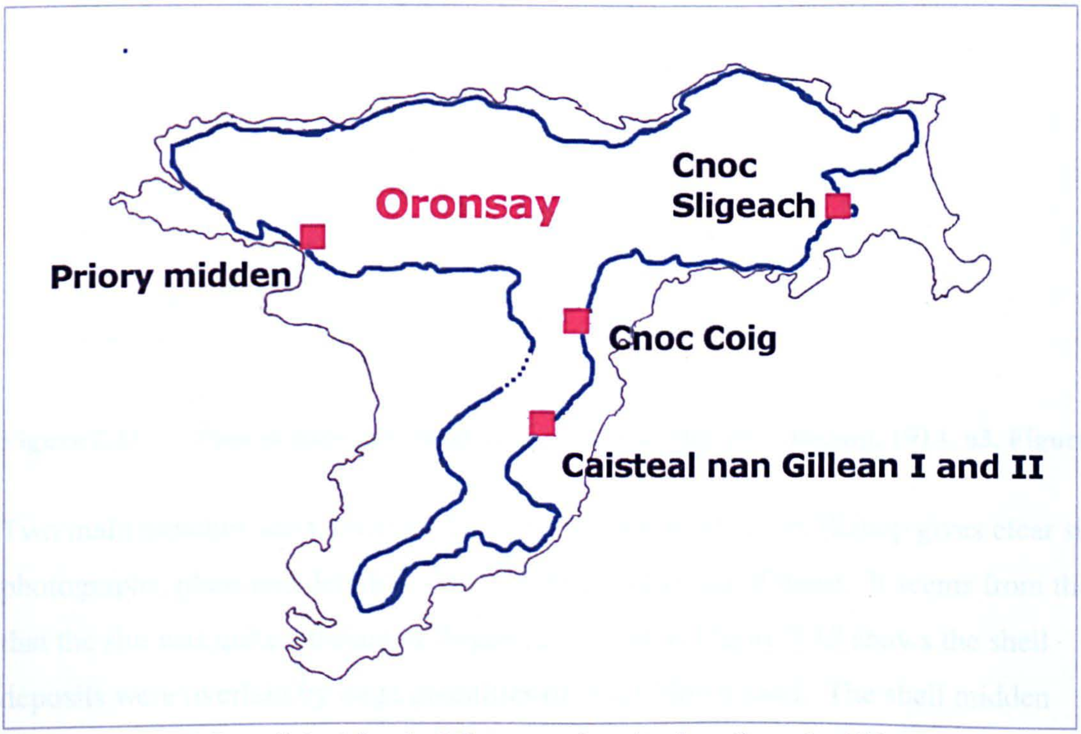


Figure 2.10 Map of the island of Oronsay showing location of midden sites and island shoreline at time of midden accumulation in blue (redrawn after Mellars and Wilkinson, 1980, figure 1.2)

2.7.1 Cnoc Sligeach

The first excavation at Cnoc Sligeach took place in 1884 by William Galloway. No report was published but the work is mentioned in Anderson's 1898 paper. Further, substantial, excavation took place between 1911-1913 by Buchanan and Bishop the results of which were published by Bishop in 1914 (Anderson, 1898, Bishop, 1914, Mellars, 1987, 196).

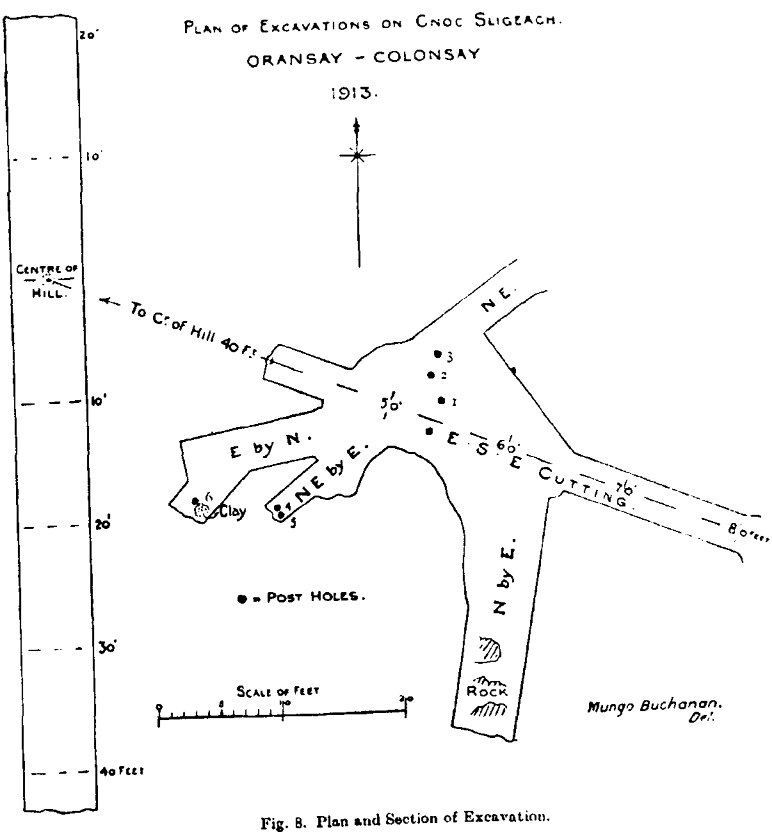


Figure 2.11 Plan of Bishop's excavations at Cnoc Sligeach (Bishop, 1914, 63, Figure 8)

Two main trenches were excavated and in the published report Bishop gives clear site photographs, plans and detailed section drawings for one of these. It seems from these that the site was quite substantial (Figure 2.11) but as Figure 2.12 shows the shell deposits were overlain by large quantities of wind-blown sand. The shell midden deposits were around 60cm at the thickest and as Bishops's generalised section shows evidence of activity was found below the shell layers (Figure 2.13).

Figure 2.12 Photograph showing the amount of wind-blown sand overlying midden deposits at Cnoc Sligeach (Bishop, 1914, 74, Figure 17)

The faunal remains recovered from the shell midden were identified by staff at the British Museum, only a list of species present is given (Bishop, 1914, 105-107). The mammal remains, grey seal, common seal, otter, red deer, wild boar and dolphin (sp.) were identified by Andrews. 'Limpet scoops', harpoons and pins and borers of bone and antler were also found. Cormorant, shag, goose, water-rail, tern, gull (sp.), razorbill, guillemot, great auk, gannet, redbreasted merganser and potentially shelduck and ringed plover were identified by Newton. Fish identified by Regan were conger eel, black sea-bream, ballan wrasse, sea-bream, angel-fish (also known as angel shark), tope, thornback ray, spurdog (given as spiny dog-fish). In addition, Newton also looked at fish bone from a post hole and identified haddock otoliths. The amount of burnt material is not given but when discussing material that had been found in the beach deposits at the base of the midden (thought to have been moved by wave action from deposits higher up the midden) Bishop describes some partially burnt antler, bird and mammal fragments.

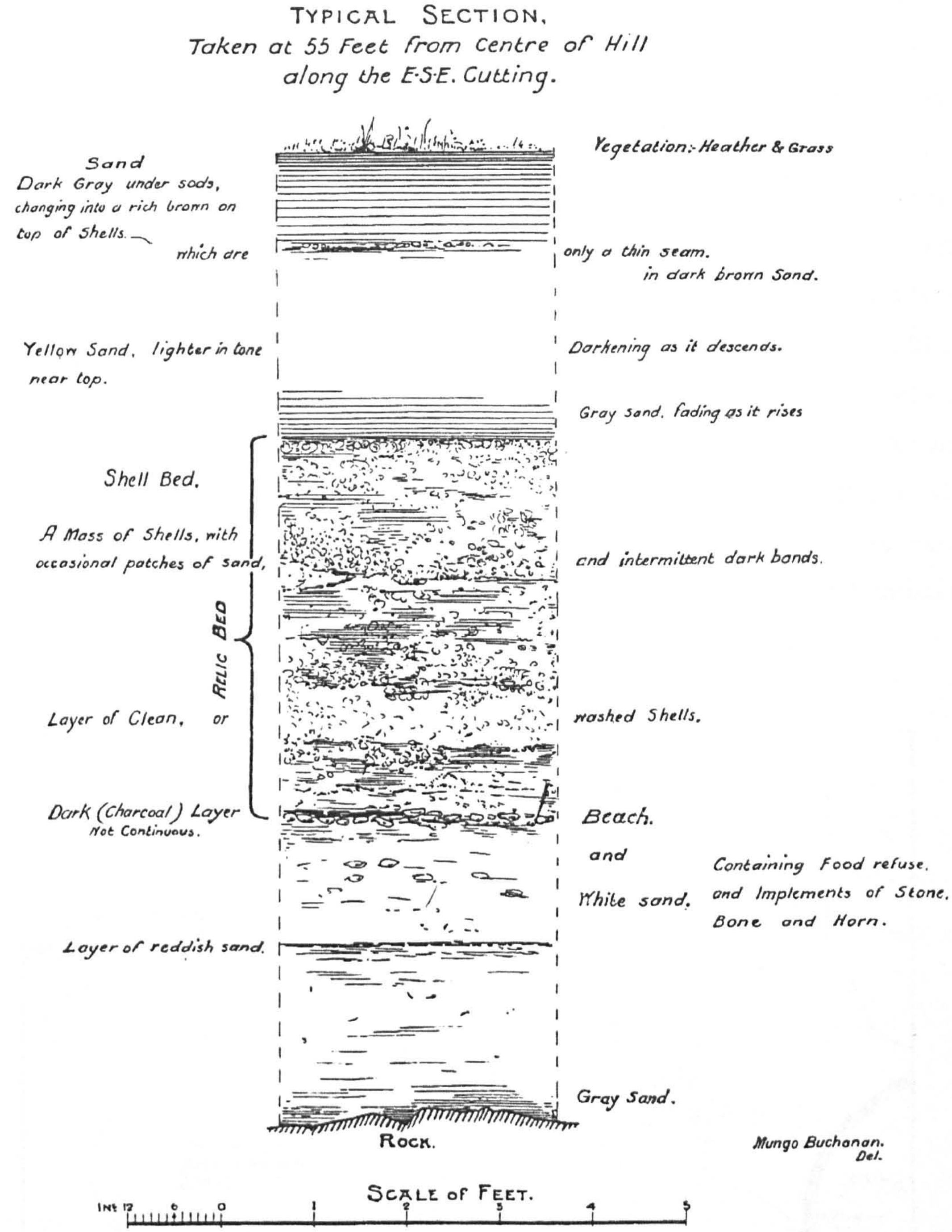


Fig. 18. Typical Section 53 feet from Centre of Hill.

Figure 2.13 'Typical section' from Cnoc Sligeach drawn by Buchanan (Bishop, 1914, Figure 18)

In the late 1970s two small trenches, A and B, were excavated by Mellars (1987), the primary aim was to check stratigraphy as recorded by Bishop and to collect stratified samples of midden for analysis. Trench A was initially excavated 1.5x1.5m, however, due to wall collapse the trench was not fully excavated. Trench B (1.5x1.0m) was located near to the current summit of the site (Figure 2.14). Modern soil and wind-blown sand overlay a layer relict agricultural layer (Mellars suggests around a few centuries old) containing scattered, incorporated midden material. The layers between this and the shell midden were composed of sand with a soil horizon. The midden material was between 45-55cm deep and sloped, Mellars suggests that material from the top of the midden was redeposited on the sides. Two layers were recorded, the upper layer was characterised by a high density of shell and abundant burnt material. Mellars suggests that rather than the deposits being *in situ* they are from elsewhere on the site with the burnt material likely to be from the clearing out of a hearth. Underneath the midden layers dune sand with no archaeological material was recorded.

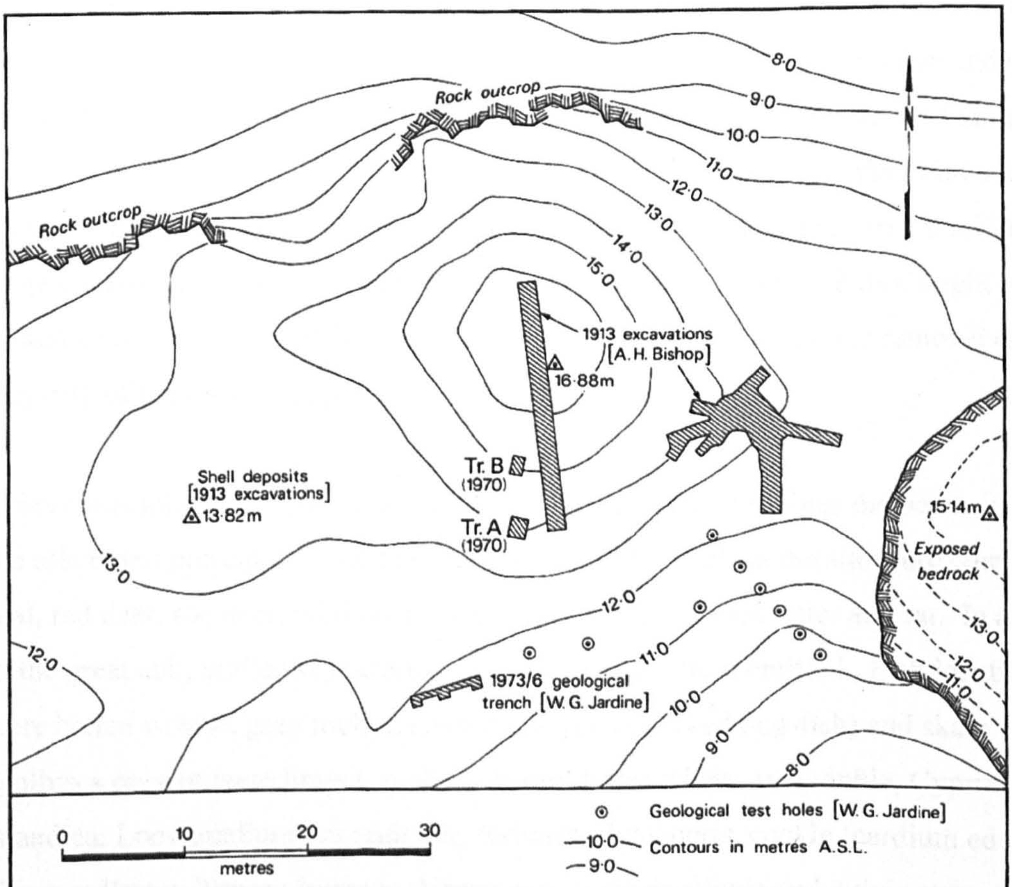


Figure 2.14 **Areas excavated at Cnoc Sligeach (Mellars, 1987, 195, Figure 13.4)**

Grigson's analysis of newly excavated material and reanalysis of the Cnoc Sligeach mammal confirmed all species identified by Andrews apart from common seal and dolphin (Grigson and Mellars, 1987) and these species are omitted in the summary table. It is worth noting that Lacaille includes the identification of weasel from Cnoc Sligeach. Weasel did not appear in Bishop's report and later re-identification of the material by Grigson did not find weasel (Grigson and Mellars, 1987, 278). Additional bird species not recorded in Bishop's excavations but recorded in Nolan's thesis are included in the summary table.

2.7.2 Caisteal nan Gillean I

This site was excavated by Galloway and Grieve in the late 1800s over several visits, with Grieve publishing the results (Grieve, 1882, 1883 cited in Mellars 1987, Grieve, 1885a). Anderson (1898) also commented on the artefacts from the site. Prior to Galloway and Grieve's excavation Caisteal nan Gillean was a tall mound. As for Cnoc Sligeach it seems that much of this height was due to sand dune formation and Grieve writes that excavation was dangerous due to the amount of sand excavated through to get to the shell deposits (1885a, 51). Mellars (1987) estimates that the midden deposits were originally just under 2 and a half metres deep. Galloway and Grieve initially suspected that the site was a Bronze Age burial mound and that a burial might be underneath the mound. What began as a small trench turned into the removal of the majority of the midden deposits.

Grieve was most interested in the greak auk remains and describes the bones in detail, the other taxa present are listed (1885a, 54-55). Mammals at the site were common seal, red deer, roe deer, wild boar, sheep, rabbit, pine marten, otter and rat. In addition to the great auk, guillemot, razorbill and wild swan were identified. Fish identified were ballan wrasse, grey mullet, spurdog (given as picked dog-fish) and skate. Molluscs present were limpet, scallop, oyster, horse whelk, periwinkle, Cyprina islandica, Loevicardium norvegicum, Axinoea glycymeris, cockle (cardium edule), Tapes pullastra, Tapes virgincus, Venus casina, Ensis siliqua and Trivia europea. Edible crab was also recorded. Grieve notes that many of the fragments of red deer and roe deer had been 'rubbed' and were broken. The sheep and rabbit remains he describes as better preserved and most likely recent. In his 1954 synthesis Lacaille appears to have added rorqual and weasel to the species list. As discussed for Risga it is difficult to assess if Lacaille did actually re-examine the faunal assemblage; nothing in his discussion of Caisteal nan Gillean I suggests that he did (1954, 211-218).

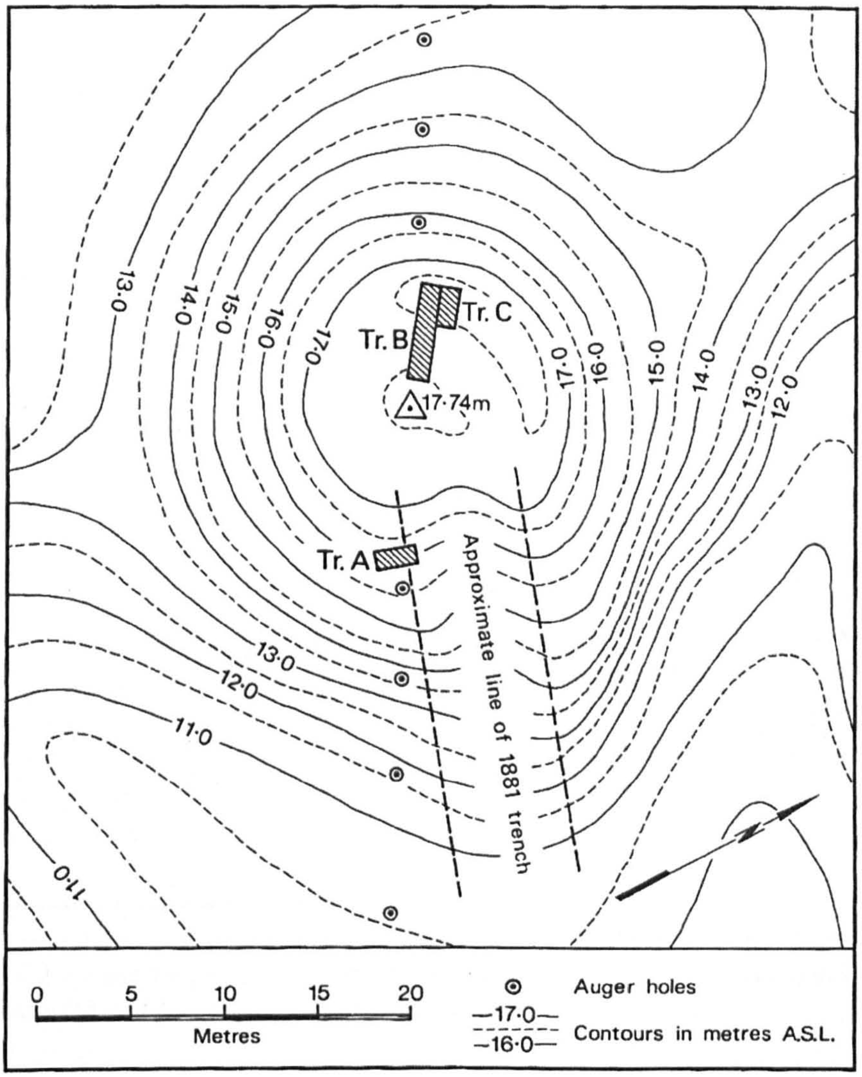


Figure 2.15 Areas excavated at Caisteal nan Gillean I (Mellars, 1987, 172, Figure 11.20)

Mellars excavated three trenches, A (at the edge of the midden where the deposits are steeply sloping), B and C (nearer the centre), located undisturbed deposits (Mellars, 1987, 175-181) and the infill of the earlier excavations (Figure 2.15). The stratigraphy for the trenches was similar, post-midden sand with evidence of various rapid accumulations, erosion and stabilisation of the dune (Figure 2.16). The underlying midden deposits Mellars writes were 40cm at the deepest point and two phases of accumulation was observed. The first phase was dense, loose shell. Above this the shell had more charcoal, burnt shell and a high density of heat-fractured stones. An *in situ* hearth was recorded in trench C. When compared with the depth of midden that Grieve recorded Mellars states that the deposits he excavated represent a small part of what was likely to have been a complex sequence of midden deposits. The sand below the midden did not contain any archaeological material. In trench A the post and pre midden sand was less uniform to that in trenches B and C with more visible palaeosols and a slower rate of accumulation. The majority of the midden deposits in trench A were less shell dense that in trenches B and C. Mellars believes this was due to a slower rate of shell accumulation at the edges of the midden, and the shell may be secondary deposition from midden further up the slope.

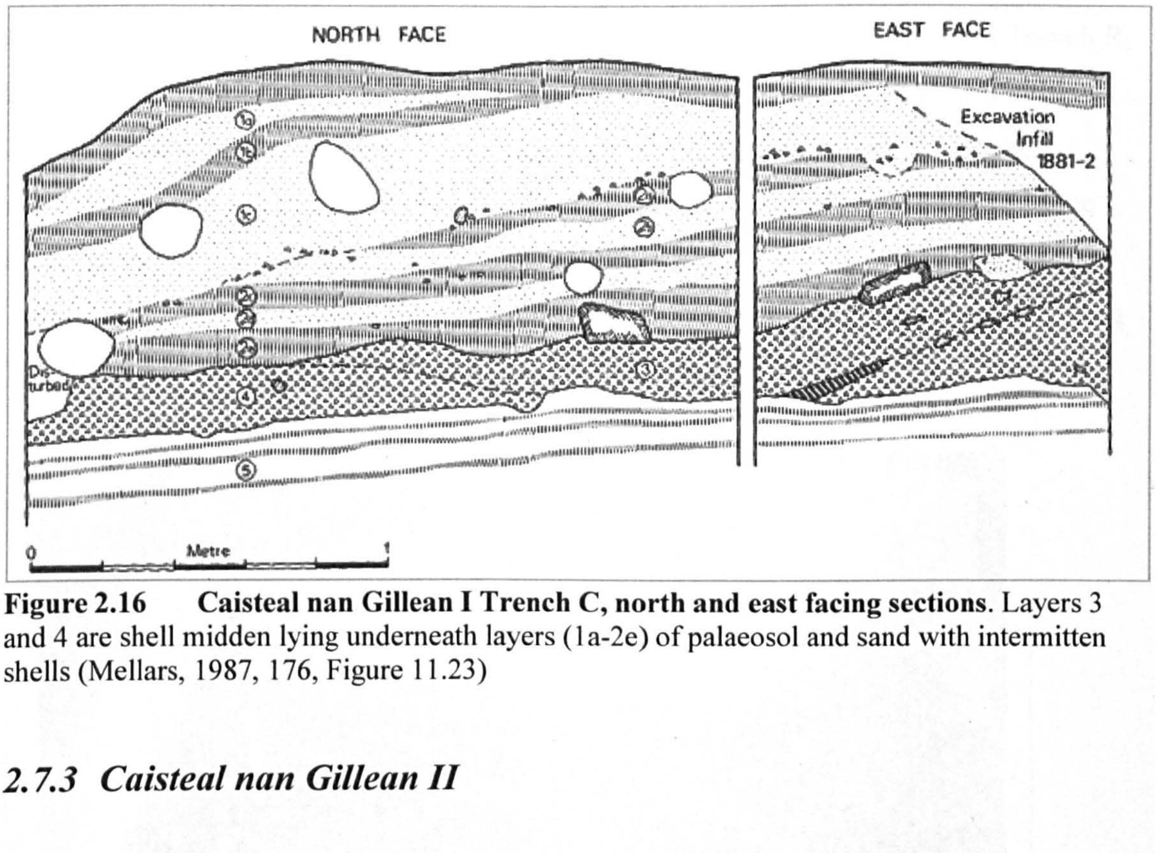


Figure 2.16 Caisteal nan Gillean I Trench C, north and east facing sections. Layers 3 and 4 are shell midden lying underneath layers (1a-2e) of palaeosol and sand with intermitten shells (Mellars, 1987, 176, Figure 11.23)

2.7.3 Caisteal nan Gillean II

Following augering at the site to identify the extent of the midden five small trenches were excavated. From the augering Mellars states that the midden was over an accumulation of sand which had stabilised with vegetation before the site was used. The deepest shell deposits and the centre of the midden coincided with the rise of the pre-midden sand (Mellars, 1987, 156-168). Four trenches were excavated, Trench P close to the centre of the site, and Trenches Q, R and U towards the edges of the midden. Each trench was 1.5x2m, this was reduced to 1.5x1m in the lower levels of trenches Q, R and U due to the risk of collapse from the sand above. In all four trenches the midden deposits were overlain by substantial amounts of wind-blown sand. Mellars suggest that this accumulation began relatively recently, over the last few centuries, potentially initiated by agricultural activity. Underlying the midden deposits in all trenches was pre-midden sand overlying bedrock without any archaeological material.

Trench P contained the deepest shell midden deposits, c.55-60cm maximum. The deposits were uniform, mostly a loose structure with high density of shell (Figure 2.17). Only in certain areas of the trench were distinct contexts visible including what Mellars describes as 2 occupation surfaces where hearths (identified based on areas of very compact, crushed and burnt shell) or fire cracked stones were present. Aside from these two layers the accumulation of the midden is believed to have been rapid. In Trench R, further away from the centre of the site the midden deposits were thinner and as in Trench P loosely consolidated. In the remaining two trenches, Q and U, the shell midden deposits were less dense and contained more sand. Mellars believes in these areas, at the edge of the site, the deposits accumulated over a long period of time. In Trench Q a small pit or posthole was found at the bottom of the midden deposit cutting into the pre-midden sand below.

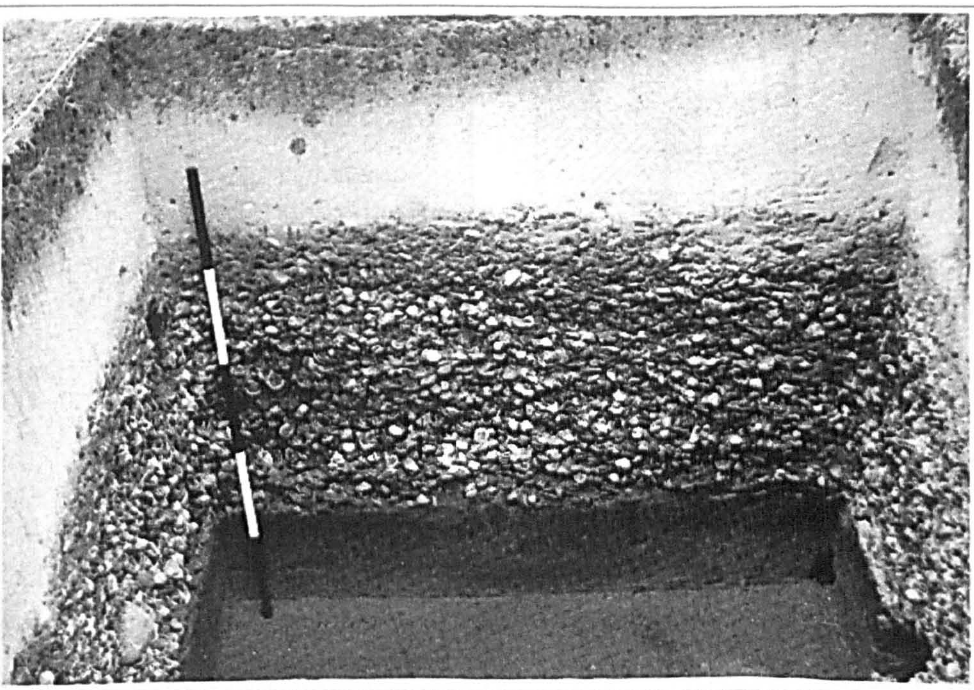


Figure 2.17 Caisteal nan Gillean II south facing section in Trench P, ranging rod is 1m (Mellars, 1987, 161, Figure 11.8)

2.7.4 *Cnoc Coig*

This site was the most extensively targeted by Mellars' research project over 4 seasons. In particular the excavations aimed to; explore in detail the spatial analysis of artefacts, extensively sampling and to look for evidence of structural features. Cnoc Coig was the only site excavated by Mellars to be excavated in part by open area, in addition 23 1mx1m sampling pits and 20 trenches were excavated (Figure 2.18). The site project monograph does not give the sizes of the trenches (other than the sampling pits) excavated but does give an estimation of the total area excavated. It is estimated that combining all excavation methods 196m^2, around 70-75% of the midden, was excavated (Mellars, 1987, 219-240)

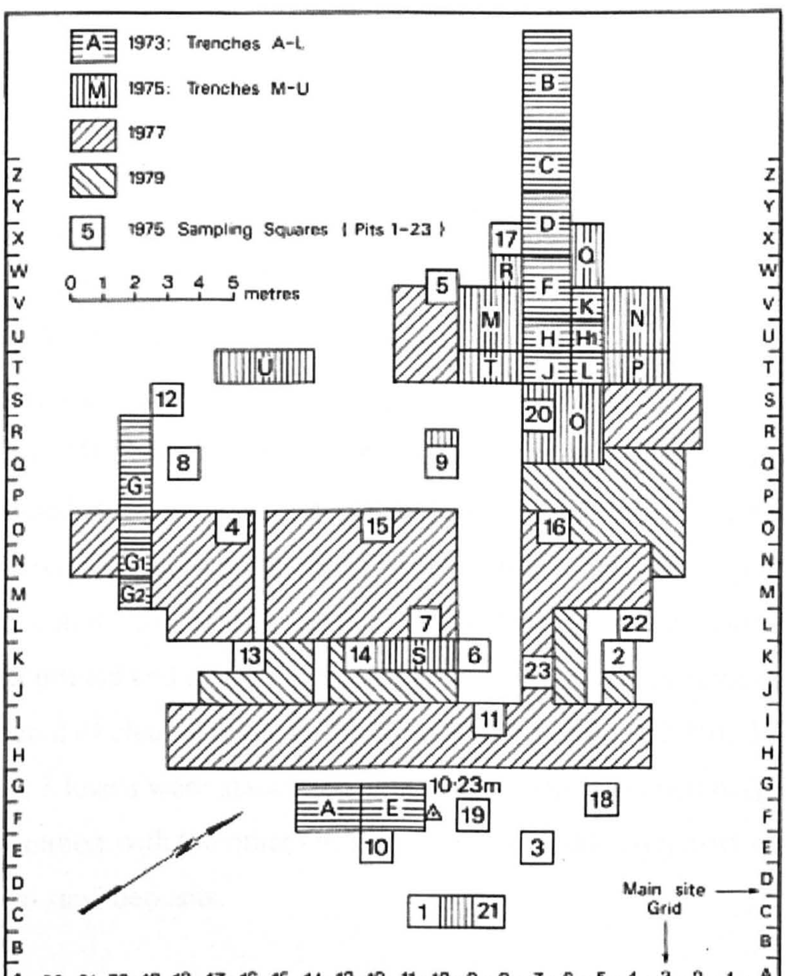


Figure 2.18 Plan of excavated areas 1973-79 (Mellars, 1987, 220, Figure 14.6)

Beginning with the statigraphically lowest levels of the site unlike the other Oronsay sites the pre-midden sand layers at Cnoc Coig contained archaeological material. A thin layer of archaeological material (Mellars describes as 'occupation material') was thought to have been contemporary with the main period of sand dune formation when the surface of the dune had stabilised with vegetation. This layer included hearths, heat cracked stones, shells and patches of fish bones and was excavated in a 25x25cm grid. To Mellars it is clear that '*the whole of this 'pre-midden' occupation horizon represents a very brief period of human activity on the site, most probably resulting from a single episode of occupation.' (Mellars, 1987, 232).*

Between the pre-midden sands and shell midden deposits proper was approximately 20-30cm of sand without archaeological material. Turning to the main midden deposits, Mellars writes that in the central area of the site there were 3 distinct phases of accumulation; each phase had a distinct location at the site. Aside from location the phases do not seem to vary greatly. As the excavation at Cnoc Coig was over a much larger area Mellars' stratigraphic account is generalised, however, it is very difficult to match up the stratigraphy description with section drawings. A brief summary of the stratigraphy of the central part of the site is given here. Phase 1 (grid squares K-N/6-8 and L-M/5-6) included a circular structure, hearth complex and dense loose accumulations of shells deposited in an area c.5-6m wide. The deposits in phase 2 (grid squares H4-H9) were of similar character but the shells were deposited in a more localised area producing a dome shape with total thickness c.65-70cm. Within phase 2 there were blown sand horizons which Mellars interprets as a break of perhaps 2 or 3 consecutive seasons of occupation. The shell midden deposits in phase 3 were again concentrated and dome shaped with 3 clearly defined horizons of burnt shell, fish bones, charcoal of cleared out material from a hearth (Figure 2.19). In addition to hearths the phase 3 levels were associated with a semi-circular structure (grid squares H-J/12-15). In common with the other Oronsay sites the midden deposits were overlain by wind-blown sand deposits.

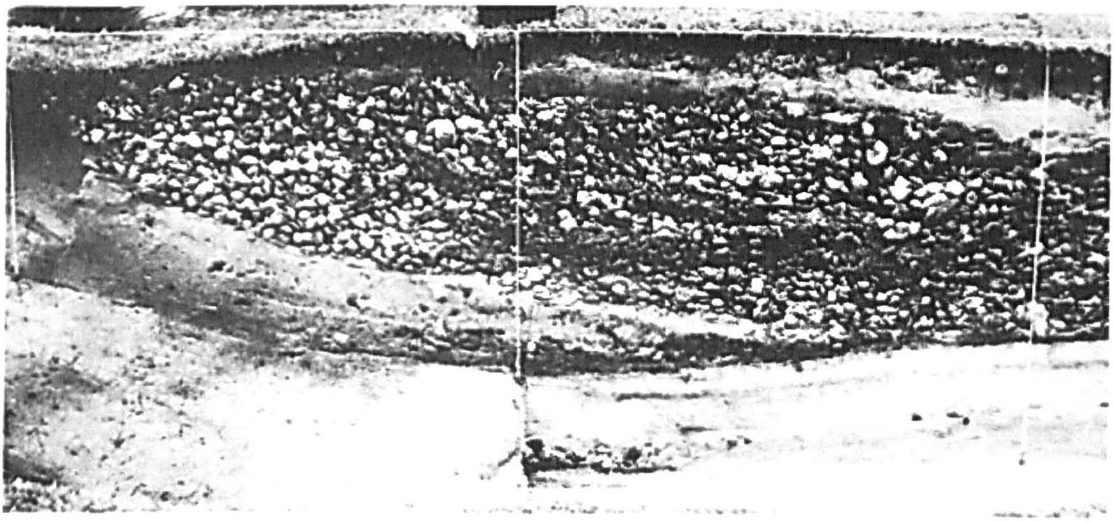


Figure 2.19 Super-imposed hearths at Cnoc Coig in east facing section of grid squares R2-4 (Mellars, 1987, 229, Figure 14.14)

2.7.5 Priory Midden

Mellars estimates that originally this midden may have been around 25-30m in diameter. One trench was excavated at Priory Midden, due to the post-midden sand deposits an initial trench 2.0x1.5m trench became a 1.5x1.5m 'control' which for the deepest deposits was further reduced to a 1.0 x1.0m trench (Mellars, 1987,182-191). The trench was excavated stratigraphically as midden layers were interspersed with deposits of wind-blown sand. As for all the sites the shell midden was overlain by wind-blown sand. Underneath this were layers that could be grouped into 3 phases (Figure 2.20). The lowest phase was wind-blown sand and intercalated narrow bands of shell and other archaeological material. Phase 2 was composed of shell rich midden deposits between 60-80cm deep divided into lower and upper units. Charcoal, burnt shell and heat fractured stones were present in both units. In the lower unit the burnt material is related to two well defined hearths. A pit or similar dug into the midden and believed to be Mesolithic was found in phase 2. In phase 3 the midden deposits were again less substantial and intercalated with wind-blown sand but contained concentrations of shell, burnt stone and fish bones.

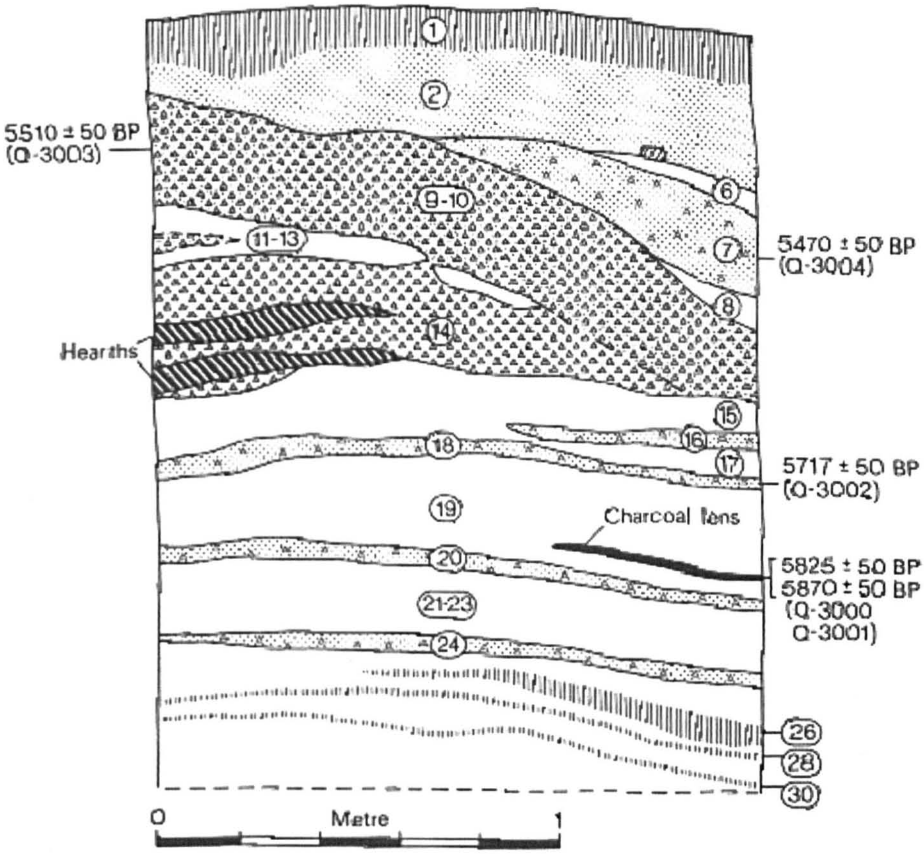


Figure 2.20 Priory Midden north face of section in sondage zone. Phase 1 (layers 15+), Phase 2, (layers 9-14), Phase 3 (layers 3-8), wind-blown sand layers in white (Mellars, 1987, 185, Figure 12.3)

2.8 *Morton*

Field work at Morton, Tentsmuir, Fife was conducted by Candow 1963-1967 following collection of surface finds of lithics (Coles, 1971, 284). Two areas of occupation on a rocky promontory were found, site A and site B, subsequent excavation by Coles took place 1969-1970 (Figure 2.21, Figure 2.22). The sites were situated on a rocky promontory believed to be have been an island during high tide at some stage. At site A hearths, living floors and post holes from shelters and windbreaks were recorded. Site A produced lithics but only fragments of bone were recovered.

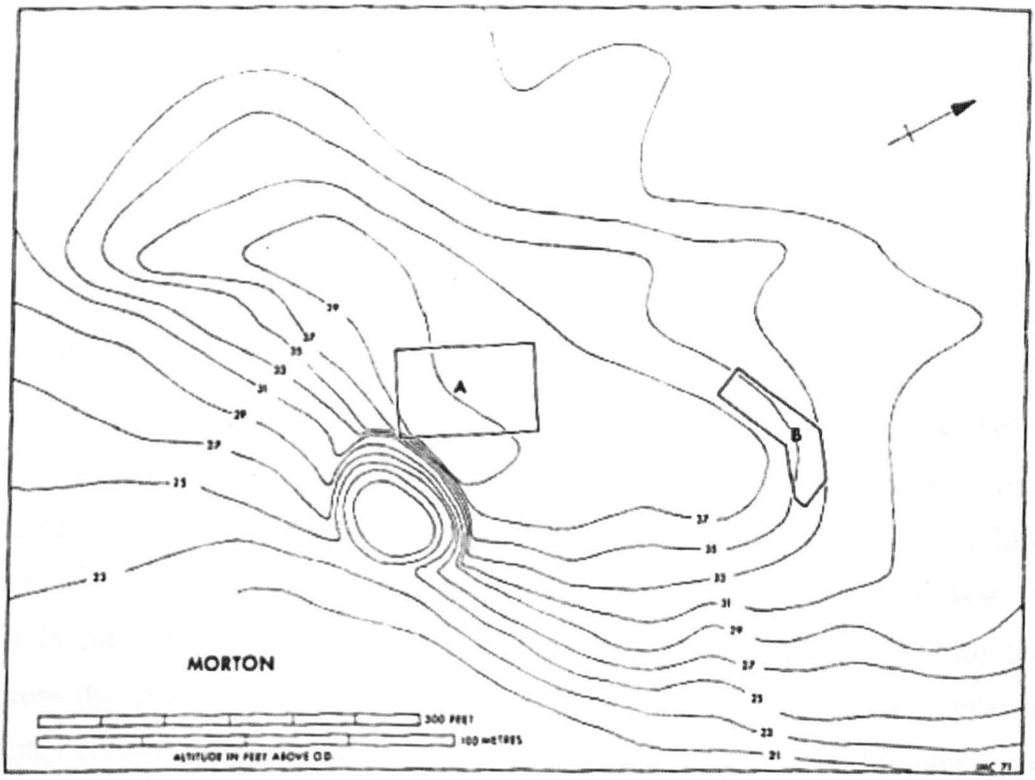


Figure 2.21 Location of Morton site A and B (from Coles, 1971, 288, Figure 3)

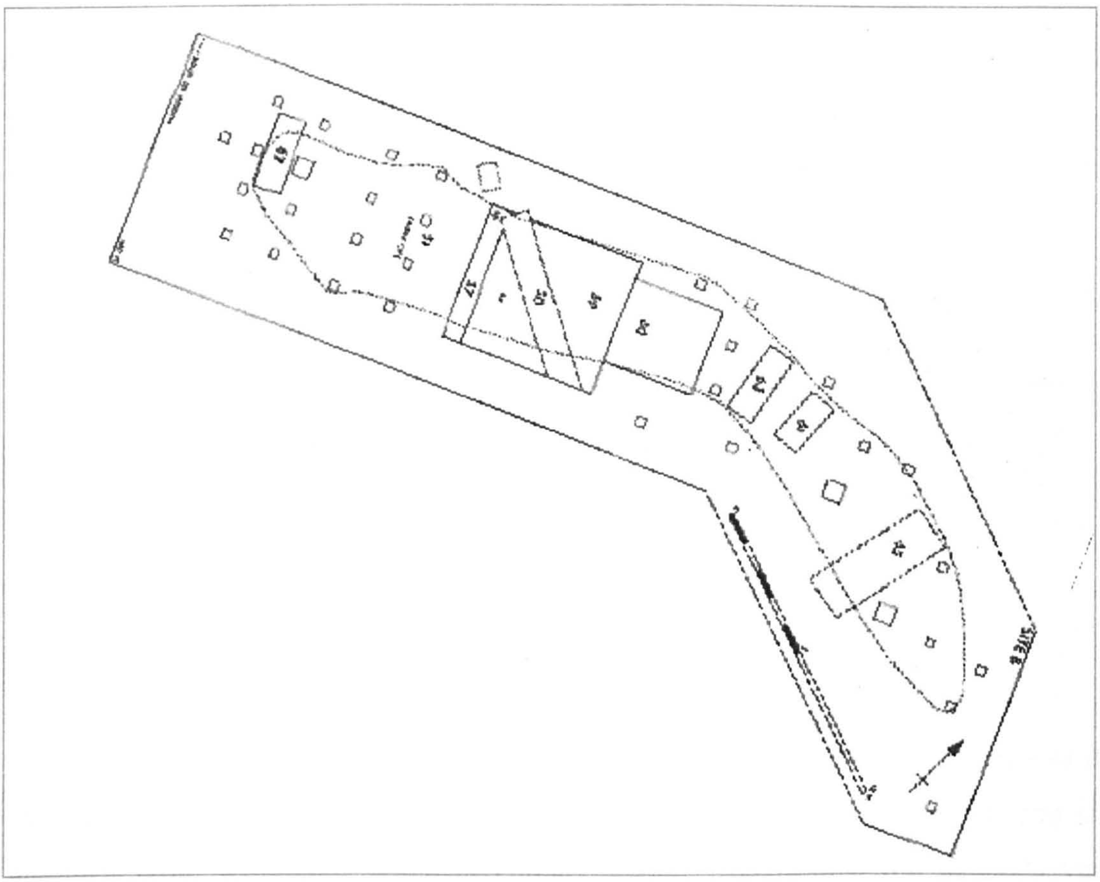


Figure 2.22 Morton site B, areas and test pits excavated, dotted line indicates extent of the midden (from Coles, 1971, 342, Figure 29)

At site B a midden of shell, bone and stone was found. The density of the shells varied and in places Coles states there was evidence of them accumulating quickly. Below the midden were beach deposits from the main post-glacial shoreline and the midden was overlain by deep sand and soil deposits. Initially an arbitrary cutting was made to obtain column samples and dating material. This was extended to provide a section across the midden, larger areas of the midden were then excavated in intervals and further column samples taken. The midden was 30 x3.5m and varied in thickness from around 80cm at its deepest but generally around 10-45cm thick. Coles estimates that around 75% of the midden was excavated (1971, 341-343).

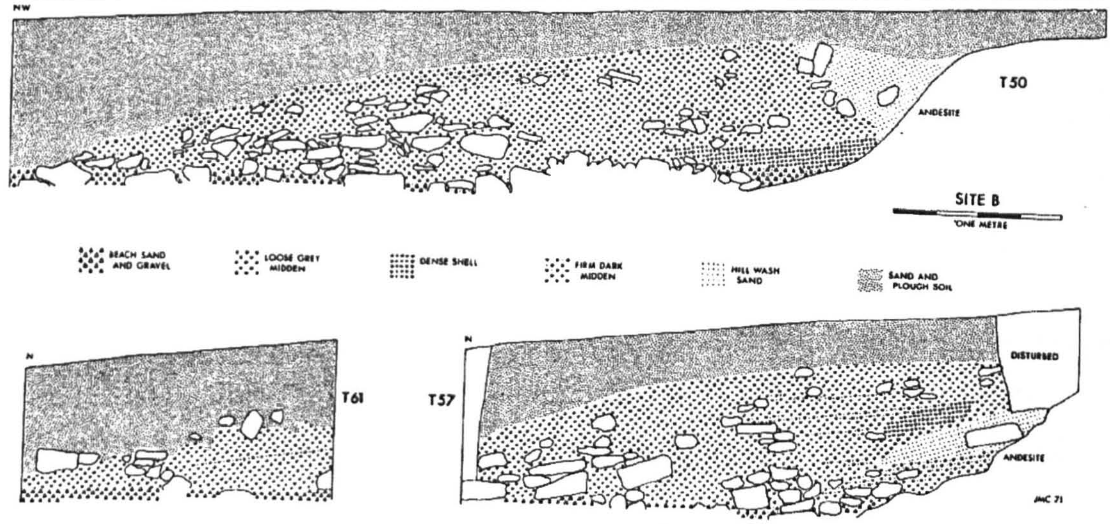


Fig. 30
Sections of the midden at Site B, Morton.

Figure 2.23 Sections from site B, Morton (Coles, 1971, 344, Figure 30)

The density of the shells varied in the midden and there was evidence of heaps of these accumulating rapidly. The lowest levels of the midden were mixed sands and shells amongst large weathered boulders (Figure 2.23). Above this the deposits varied, generally sand, rock weathering, shell and charcoal. Coles notes that in some places the shells were more concentrated, in addition, layers of weathering were noted. The weathering horizons are described as thin, firm, dark deposits of mostly broken shell within a 'black earth' and as evidence of episodes of abandonment of the midden. Settings of stones for hearths or to support windbreaks of posts or stakes were found within the upper midden along with several stone packed post or stake holes (1971, 232). Based on the identification of old midden surfaces several discrete phases of midden use were recorded.

Bone was distributed throughout the midden but was most abundant in the upper midden. 1818 specimens of bone were recovered from the midden, the material was fragmentary, this is reflected in the percentage identifiable to species, 3% of mammal, 9% of birds and 10% of fish. Bone was mostly recovered in the upper part of the midden

Only 23 mammal bone specimens were recovered, identified by Allo (in Coles, 1971, 349) and the minimum number of individuals also calculated, given here in parenthese; red deer (2), roe deer (1), aurochs (6), wild boar (1), hedgehog (1) and specimens thought to be bank vole (1). Coles notes that 38 'spatula like' (presumably bevel-ended) tools were found, all from the shafts of long bones (1971, 314). Four were identified to red deer metapodia, the remainder were thought to be either red deer or aurochs, it appears these specimens were not included in the total number of identified specimens.

Bird bones (217 specimens identified by Cowles) were recovered from 30 distinct areas across the site, species included members of the gull family (Laridae), auk family (Alcidae), fulmar, shag and cormorant (Coles, 1971, 350). Quantification of the bird bones is by number of separate occurrences at the site not by number of identified specimens, nor are the elements present discussed. However, from the number of occurrences it appears that gannet and guillemot occurred most frequently. Coles suggests that the bird bones (along with mammal and fish) are the remains of individual meals (1971, 155).

Fish bone (943 specimens identified by Wheeler) were found in 28 distinct deposits in the midden, the majority of the identified bones were cod, haddock was also present and single specimens of turbot, sturgeon and a calcified specimen of salmon or trout (salmonid) were present (Coles, 1971, 351). The elements present are referred to in the text: 'numerous head bones' and abdominal and caudal cod vertebrae, a turbot dentary, a salmonid vertebral centrum and sturgeon dermal scute. As for the size of the fish present the cod were mostly over 50cm total length with some over 1m, the turbot was over 75cm estimated total length, the salmonid from a fish of estimated 5kg in weight and the sturgeon estimated to be around 3m total length (and approximately 250kg in weight).

Forty gastropod and bivalve taxa were recorded at Morton (Clegg in Coles, 1971, 353-359), many were single specimens or fragments. Clegg also produced a shorter list based on which taxa were most likely to have been collected for food or as a by-product of food-related activities, where 'A' is primary food interest, 'B' assigned for abundance or ease of collection and 'C' casually taken taxa. The shorter list which includes limpet, periwinkle, oyster and mussel is used in the summary towards the end of this chapter.

Unusually, the lithic assemblages from each phase are discussed together with the zooarchaeology. In area T57 one group of lithics described as bashed lumps, a core, several flakes and a microlith were associated with cod, haddock, guillemot, cormorant, thrush, red deer and unidentified mammal in addition to the shellfish making up the bulk of the midden (Coles, 1971, 346). One of the last occupations of the midden red deer, cod, haddock, guillemot, cormorant, thrush, 4 bone tools (1971, Figure 15), and a small lithic assemblage of several bashed lumps and flakes were found together. Coles interprets these as representing transitory stages in the accumulation of the midden. One occupation horizon, in areas T50 and T59 was believed to have been evidence of a longer stay, from this phase 285 bones were recorded including mammals, birds and fish.

2.9 *Excavations in context*

In addition to location, the comparative sites available fall into two distinct groups, those assemblages available as a result of antiquarian excavations and those excavations conducted since 1960. Antiquarian excavations lacked now-standard excavation and fine recovery methods, however, for some of the sites detailed in this section some level of stratigraphic recording was attempted.

The antiquarian excavations took place when the large Danish shell middens or kitchen middens were being excavated in the late 1800s and many of these antiquarian excavators were aware of this work on the continent. More importantly, perhaps, was an awareness of Piette's work in France identifying what was thought to be the Mesolithic (although now it would be described as Epipalaeolithic (Woodman, 1989)).

Present in Anderson's 1895 paper and his later report (1898) on the Druimvargie rockshelter, Oban and three shell mounds from Oronsay, is a clear understanding of the relationship of the Oban cave sites to the raised beach on which they are situated. When discussing the age of the MacArthur Cave, Anderson uses the position of the cave and the type of fauna present to determine that the cave is not Palaeolithic, and instead reasons that it must be Neolithic. Similarly, Turner in his report on the bones from

MacArthur Cave places the age of the caves as Neolithic. By 1898, however, Anderson's interpretation had been modified, and he states:

"It is evident that these three shell-mounds in Oronsay and the MacArthur and Druimvargie Caves at Oban belong to the same archaeological horizon, - a horizon which has not heretofore been observed in Scotland, but closely corresponding with the intermediate layers in the cavern of Mas d'Azil, on the left bank of the Arize in France, explored and described by M. Piette, and which he has seen reason to claim as filling up the hiatus that has been supposed to exist between the palaeolithic and the Neolithic." (Anderson 1898, 313)

That the Oban and Oronsay sites belonged to this 'hiatus' period was based on the similarity of the tool and faunal assemblages of the west coast Scottish site and the French evidence. By 1914 the existence of a period between the Palaeolithic and Neolithic in Scotland was firmly established, as the title of Bishop's report on the Cnoc Sligeach shell midden, Oronsay, demonstrates: "An Oransay shell-mound – A Scottish pre-neolithic site". Bishop clearly recognises Cnoc Sligeach as comparable to Piette's site and states that his aim in excavating the site is to demonstrate this 'Azilian' occupation on Oronsay, to investigate the sea level at the time and to correlate the occupation of Oronsay with the Oban caves.

Anderson raised many of the questions pertinent to the study of shell middens today; the use of shell fish for food or bait, why the mammal bones were so fragmented, and the function of bevel-ended tools. For the former, Anderson makes no clear decision, but on the second point believes that the bones were broken for tool making rather than marrow extraction, due to non-marrow rich bones also being broken and the large number of bone tools present. For the bevel-ended tools Anderson draws on both archaeological and ethnographic comparison to suggest that they were used for hide working, a hypothesis still valid today.

'Similar tools have been found in the Swiss Lake-Dwellings, and are still made and used for dressing skins by the Esquimaux and other skin-clad trihes of the Arctic regions.' (Anderson, 1895, 223)

Also of relevance is Anderson's discussion of the bone and antler harpoons, Anderson calls them fish spears. At the time, the harpoons were unique on mainland Scotland but similar tools had been found on Oronsay at Caisteal nan Gillean (Grieve, 1885a). The conclusion that the harpoons are fish spears was based on comparison with archaeological remains from caves in France and Swiss lake dwellings, and comparison with the Danish kitchen middens. The European examples targeted freshwater species, but Anderson notes that sea fish were taken in Denmark, based on fish spears found in the same context as flat fish and mackerel remains (1895, 226).

Turning to the more recent excavations, by the time Coles's work at Morton, was published in the early 1970s the use of the term Mesolithic in Scotland was well established. The Oronsay project was conducted at a time when ecology and economy were at the forefront of archaeology as Mellars' edited book in 1978 'The Early Postglacial Settlement of Northern Europe: an Ecological Perspective' and the title of the excavation monograph 'Excavations on Oronsay: Prehistoric Human Ecology on a Small Island' attest (Mellars, 1978, Mellars, 1987). In the following years large research projects such as the Southern Hebrides Mesolithic Archaeological Project (SHMAP) focused on a more landscape based approach (Mithen, 2001). The Scotland's First Settlers project (SFS) was firmly rooted in a landscape approach which did, however, still result in the major excavation of only one site at Sand. Although conducted as a separate recue excavation An Corran is within the SFS survey area and thus adds to the regional picture of the Inner Sound.

2.10 ***Summary of zooarchaeological remains***

The summary tables list species recorded in published sources, two unpublished PhD theses and Bartosiewicz's forthcoming work discussed in the previous sections. This may include taxa that are only presented by a few or single specimens. Discussion of the shellfish and crustaeceans are ouside the scope of this thesis but a summary table is included (Table 2.11). The mammals are broadly divided into terrestrial and marine taxa (Table 2.8). It should be noted that the otter, whilst classed as a terrestrial mammal, could have a mainly marine diet and thus a marine isotope signal. Red deer is present at all sites and is the only mammal species to be ubiquitous. From the

Antiquarian excavations it is difficult to ascertain if the absence of other taxa at sites is really a reflection of poor recovery and lack of identification or reflects different resource use. Wild boar or *Sus* sp. is present at all sites except Caisteal nan Gillean II and Priory Midden; roe deer and aurochs (or specimens identified to *Bos* sp.) are less common. The only large carnivore is the brown bear from An Corran. Turning to smaller-sized taxa otter is present at all sites except Morton. Whilst hedgehog, badger, pine marten and wild cat are present at individual sites they are not widespread. Despite the coastal location of the sites, the mammals on the whole are terrestrial; only from the Oronsay sites is seal present (grey or common).

A huge range of bird taxa have been recorded at Mesolithic sites, on presence of taxa alone this suggests a exploitation of a wide resource base, especially from Cnoc Coig (Table 2.9). Many of these birds have very clear habitats, seabirds such as guillemots and razorbills spend much of their life at sea coming to the coast to breed whilst the water-rail is found in freshwater wetlands. Other birds such as the gulls and raven are less restricted: the raven, for example, is found along rocky coasts, mountains and woodland. It must be remembered that the habitat of birds may have varied in the past, they are provided here as a quick guide. In addition, woodland and freshwater areas may not actually be located a huge distance from the coast. Taxa identified only to family level are not assigned a habitat. Despite the large overall number of bird taxa it is the auk family, including the guillemot razorbill, puffin and the great auk, cormorant and shag and members of the gull family that consistently appear to have been targeted across most sites.

A similarly large number of fish taxa are present. Dividing the fish by habitat as for birds and mammals, is more difficult, all of the species listed are marine species. However, all the species are either inshore fish or as young fish can be caught from the shore. The age (and therefore size) of a fish can determine how deep and how close to the shore specimens are found. This is especially the case for species such as saithe and cod, younger specimens are found close to the shore, larger specimens in deeper water (Wheeler, 1969). Only 'fish' were recorded as present at Druimvargie and this along with only 2 species recorded at MacArthur's Cave is probably a reflection of the lack of fine recovery methods and these are excluded from the following discussion. Some interesting patterns do emerge from (Table 2.10). At the Oronsay sites dogfish family fish were only recorded from Cnoc Sligeach and Caisteal nan Gillean I. Ray and shark family fish are present at the Oronsay sites but absent from Morton and An Corran. Ballan wrasse, shanny, eelpout, eel, conger eel, pollack and saithe are present at the majority of the Oronsay sites and many of these species at An Corran. Interestingly, few other cod family fish (Gadidae) aside from saithe and pollack are recorded as present at the Oronsay sites. Sturgeon and turbot are restricted to Morton and this may be related to the location of the site on the east coast or a different fishing strategy.

The general pattern of mammal, bird and fish use in the Mesolithic of Scotland when assessed only on presence or absence of taxa is one of the consistent use of a relatively narrow range of mammals but a much wider range and more inter-site variation of bird and fish taxa. This summary does not take into account the number of identified specimens, relative abundance of species or skeletal element patterning; few sites have such quantifiable data. The sites *with* quantifiable data: Morton, An Corran and the Oronsay sites are compared in more detail along with the Sand data in the discussion chapter.

	Common name	Latin name	Cnoc Coig	CNG II	Priory	Cnoc Sligeach	CNG I	An Corran	Druimvargie	MacArthur's cave	Morton
Terrestrial	Hedgehog	*Erinaceus europaeus*									x
	Common hare	*Lepus europus*						x			
	Bank vole	*Clethrionomys glareolus*									?
	Rat	*Rattus sp.*					x				
	Brown bear	*Ursus arctos*						x			
	Canid							x			
	Pine marten	*Martes martes*					x				
	Badger	*Meles meles*								X	
	Otter	*Lutra lutra*	x	x	X	x	x	x	x	X	
	Wild cat	*Felis silvestris*						x		X	
	Aurochs	*Bos primigenius*						x			x
	Bos sp.									X	
	Red deer	*Cervus elaphus*	x	x	X	x	x	x	x	X	x
	Roe deer	*Capreolus capreolus*					x	x		X	x
	Wild boar	*Sus scrofa*	x			x	x	x	x		x
	Sus sp.							x		X	
Marine	Grey seal	*Halichoerus grypus*	x	x	X	x					
	Common seal	*Phoca vitulina*	x				x				
	Seal sp.										
	Small cetacean		x								
	Large cetacean				X						

Table 2.8 Summary of Mesolithic mammal remains in Scotland (Grieve, 1885b, Anderson, 1895, Anderson, 1898, Bishop, 1914, Coles, 1971, Grigson and Mellars, 1987, Bartosiewicz, forthcoming)

	Common name	Latin name	Cnoc Coig	Cnoc Sligeach	CNG I	Morton	An Corran	Druimvargie	MacArthur's cave
sea and shore birds	Great northern diver	*Gavia immer*	x						
	Fulmar	*Fulmaris glacialis*	x			x			
	Manx shearwater	*Puffinus puffinus*	x						
	Gannet	*Sula bassana*	x	x					
	Cormorant	*Phalacrocorax carbo*	x	x		x	x		
	Shag	*Phalacrocorax aristotelis*	x	x		x			
	Cormorant or Shag								
	Shelduck	*Tadorna tadorna*	x						
	Shelduck?			x					
	Long tailed duck	*Clangula hyemalis*	x						
	Eider duck	*Somateria mollissima*	x						
	Red breasted merganser	*Mergus serrator*		x					
	White-tailed sea eagle	*Haliaeetus albicilla*					x		
	Pomarine skua	*Stercorarius pomarinus*					x		
	Ringed plover?	*Charadrius hiaticula*		x					
	Woodcock	*Scolopax rusticola*	x						
	Common tern	*Sterna hirundo*		x					
	Sandwich tern	*Sterna sandvicensis*	x						
	Knot or sandwich tern?	*Calidris canutus* or *Sterna sandvicensis*	x						
	Razorbill	*Alca torda*	x	x	x	x			
	Guillemot	*Uria aalge*	x	x	x	x	x		
	Black guillemot	*Cepphus grille*	x						
	Puffin	*Fratercula arctica*	x			x	x		
	Great auk	*Alca impennis*	x	x	x		x		
	Little auk	*Alle alle*	x						
	Kittiwake	*Rissa tridactyla*				x			
inland, freshwater or woodland	Whooper swan	*Cygnus Cygnus*	x						
	Bewick's swan	*Cygnus columbianus*	x						
	Mallard	*Anas platyrhynchos*	x						
	Quail	*Coturnix coturnix*	x						
	Water-rail	*Rallus aquaticus*		x					
	Willow tit	*Poecile montanus*					x		

	Common name	Latin name	Cnoc Coig	Cnoc Sligeach	CNG I	Morton	An Corran	Druimvargie	MacArthur's cave
Mixed									
	Greylag goose	*Anser anser*	x						
	Teal	*Anas crecca*	x						
	Velvet scooter	*Melanitta fusca*	x						
	Common scooter	*Melanitta nigra*	x						
	Great black-backed gull	*Larus marinus*				x			
	Gull sp.	Laridae	x	x			x		
	Raven	*Corvus corax*	x						
	Carrion or hooded crow	*Corvus corone* or *Corvus cornix*				x			
	Wild swan sp.	Cygninae			x				
	Goose sp.	Anserinae	x	x					
	Thrush family	Turdidae				x	x		
	Perching bird	Passeriformes					x		
	Small wildfowl							x	
	'Small birds'								x

Table 2.9 Summary of Mesolithic bird remains in Scotland (Grieve, 1885b, Anderson, 1895, Anderson, 1898, Bishop, 1914, Coles, 1971, Nolan, 1986, Bartosiewicz, forthcoming)

Common name	Latin name	Cnoc Coig	CNG II	Priory	Cnoc Sligeach	CNG I	Morton	An Corran	Druimvargie	MacArthur's cave
Dogfish	*Scyliorhinus caniculus*				x					
Tope	*Galeorhinus galeus*				x					
Spurdog	*Squalus acanthias*				x	x				
Monkfish	*Squatina squatina*				x	x				
Skate	*Raja batis*					x				
Thornback ray	*Raja clavata*	x	x		x					
Ray family	Rajidae	x	x	x		x				
Shark or ray			x	x		x				
Sturgeon	*Acipenser sturio*						x			
Salmon or trout	*Salmo salar or Salmo trutta*	x					x	x		
Eel	*Anguilla Anguilla*	x	x	x	x	x		x		
Conger eel	*Conger conger*	x	x		x	x				
Saithe	*Pollachius virens*	x	x	x	x	x		x		x
Pollack	*Pollachius pollachius*	x		x	x					
Cod	*Gadus morhua*						x	x		
Haddock	*Melanogrammus aeglefinus*				x		x			
Whiting	*Merlangius merlangu*							x		
Ling	*Molva molva*	x			?					
Rockling sp.	*Gaidropsarus/Rhinonemus/Ciliata*									
Hake	*Merluccius merluccius*	x								
Red sea bream	*Pagellus bogaraveo*				x	x				
Black sea bream	*Spondyliosoma cantharus*				x					
Sea bream	*Spondyliosoma cantharus or Pagellus bogaraveo*				x					
Ballan wrasse	*Labrus bergylta*	x	x	x	x	x				
Cuckoo wrasse	*Labrus mixtus*					x		x		
Wrasse family	Labridae									x
Shanny	*Blennius (Lipophrys) pholis*	x	x	x	x	x				
Eelpout	*Zoarces viviparus*	x		x	x	x				
Grey mullet	Mugilidae					x				
Sea scorpion	*Taurulus bubalis*	x		x						
Cottid	Cottidae							x		
Turbot	*Scophthalmus maximus*						x			
Flatfish cf Flounder	*Platichthys flesus*				x	x				

Common name	Latin name	Cnoc Coig	CNG II	Priory	Cnoc Sligeach	CNG I	Morton	An Corran	Druimvargie	MacArthur's cave
Plaice family	*Pleuronectidae*							x		
Dab	*Limanda limanda*							x		
'fish'									x	

Table 2.10 Fish remains from shell middens in Mesolithic Scotland (Anderson, 1895, Anderson, 1898, Bishop, 1914, Coles, 1971, Mellars and Wilkinson, 1980)

Habitat	Common name	Latin name	Sand	Cnoc Coig	CNG II	Priory	Cnoc Sligeach	CNG I	Morton	Druimvargie	MacArthur's cave
Gastropods											
intertidal on rocks, sheltered & exposed areas	Common limpet	*Patella vulgata*	x	x		x	x	x	x	x	x
intertidal on rocks	Flat/Purple-tipped top shell	*Trochus umbilicatus*					x				
rocky shores in crevices, amongst stones & under seaweed	Grey top shell	*Trochus cineranius*					x				
offshore, variety substratres including rock and sand	Common whelk/Buckie	*Buccinum undatum*					x		x		
offshore to 1000m, variety substrates including rock and sand	Red whelk	*Neptunea antiqua*							x		
	dogwhelk	*Nucella lapillus*	x				x		x		
	larger whelks										x
	smaller whelks										x
	cowrie	*Trivia arctica*					x				
shallow rock	Common or edible perwinkle	*Littorina littorea*	x				x		x		
shallow rock/shallow vegetation	Flat periwinkle	*Littorina littoralis*	x				x		x		
shallow rock		*Littorina rudis*					x				
	periwinkle									x	x
	topshell	*Gibbula cineraria*	x								
shallow rock	rough periwinkle	*Littorina saxatilis*							x		
shallow rock	small periwinkle	*Littorina neritoides*							x		
		Natica alderi							x		

Bivalves											
shallow rock	Common mussel	*Mytilus edulis*	x				x		x		
	Bearded mussel	*Modiolus barbatus*					x				
	Mussel sp										x
	Common European oyster	*Ostrea edulis*					x	x	x	x	x
	cockle'									x	
offshore muddy sand	cockle sp.	*Cardium echinatum*					x		x		
shallow mud	Common cockle	*Cerastoderma edule*	x								x
	cockle sp.	*Cardium norvegicum*					x				
	cockle sp.	*Cardium tuberculatum*					x				
	Great scallop	*Pecten maximus*	x	x			x				
		Venus casina					x				
	Scallop sp.	*Pecten sp*					x	x			x
	Chequered carpet shell	*Tapes decussatus*					x				
		Tapes sp.									x
offshore muddy sand	Heart cockle	*Arctica islandica*					x		x		
	Razorshell	*Ensis ensis*					x				
		Ensis sp.	x								
		Desinia exoleta							x		
offshore sand		*Venus striatula*							x		
	Pullet carpet shell	*Venerupis pullastra*							x		
	Banded wedge shell	*Donax vittatus*							x		
shallow mud	Baltic tellin	*Macoma balthica*							x		
	Rayed trough shell	*Mactra stultorum*							x		
offshore gravel	Elliptical trough shell	*Spisula elliptica*							x		

	Common otter shell	*Lutraria lutraria*							x		
	Oval Piddock	*Zirfaea crispata*							x		
	White Piddock	*Barnea candida*							x		
	European sting winkle	*Murex erinaceus*					x				
	Razorshell sp	*Solen*					x				
	Razorshell										x
	Tapes										x
Land snails	Land snail sp	*Helicella barbara*					x				
	Land snail sp	*Vitrea sp?*					x				
	Common door snail	*Clausilia bidentata*					x				
	Grove snail	*Cepaea nemoralis*					x				
	Smooth glass snail	*Aegopinella nitidula*					x				
	Land snail sp	*Hyalinia sp*					x				
	Smooth grass snail	*Vallonia pulchella*					x				
	Slippery moss snail	*Cochlicopa lubrica*					x				
	Crystal snail	*Vitroea crystallina*					x				
	Rounded snail	*Pyramidula rotundata*					x				
	Herald snail	*Carychium minimum*					x				
	Land snail sp	*Jaminia muscorum*					x				
Crustaceans											
	Edible crab	*Cancer pagurus*	x				x		x		x
	Fiddler crab	*Portunus puber*					x				

Table 2.11 Gastropods, bivalves and crusteacea from Mesolithic shell middens in Scotland (Anderson, 1895, Anderson, 1898, Bishop, 1914, Coles, 1971, Mellars, 1987, Milner, 2009)

Chapter 3 Methodology

3.1 Introduction

In this chapter a summary of the recovery and sampling strategies from both sites is presented. Sampling at the site level and also at the zooarchaeological analysis level is considered. The methods of quantification used and the calculation of fish total length are discussed.

3.2 Recovery techniques and sampling procedure

The advantages of bone assemblages retrieved by some sort of sieving as opposed to hand collection alone are well documented, for example, (Payne, 1972, Clason and Prummel, 1977, Wheeler and Jones, 1989, Shaffer and Sanchez, 1994). The efficiency of hand recovery is dependent on several factors such as the excavator, conditions of excavation and size of bones present. Hand recovery during excavation has a known bias towards large bones. This not only affects small sized animals like fish where both range of species and element distribution tend to be under represented (Wheeler and Jones, 1989, Nagaoka, 2005). It can also affect the element representation of large mammals (Payne, 1972,59).

It is rarely practical, in terms of time, money and archaeological value for all excavated material to be wet-seived. But a consistent recovery method, both by sieve size and, if sampling, by volume, allows recovery to be standardised across deposits and allow intra- and (hopefully) inter-site specific comparison (O'Connor, 2000). Typically, within Britain it is common practice for wet sieved material to be sieved using a 1mm mesh for the heavy fraction and 500micron for the floating fraction. The amount of material analysed in post-excavation will depend on several factors. Even if 100% wet sieving has taken place this does not necessarily mean that all of the material will be recorded. The same questions of time, money and archaeological significance, pertinent during excavation, may call for judgement sampling of the material. Similarly, the cut off point at which mesh size the bones are recorded to (for example greater than 1mm, greater than 4mm) may vary according to the recording methodology used by the zooarchaeologist. Here the recovery strategies for the two case studies are compared.

3.2.1 Sand on site recovery and sampling

The recovery strategy at Sand is simple; there was no subsampling, all excavated material was wet sieved using a flotation tank. For the floating fraction 1mm and 0.3mm sieves were used and a 1mm mesh for the heavy fraction (Hardy and Wickham-Jones, 2000). Some bone was collected by hand during excavation, but the remaining excavated material was wet-sieved. The bone recovered from the floating fraction and hand collection was minimal and was combined with the rest of the material prior to analysis. Initial post-excavation sorting was carried out by volunteers and students at Applecross during the excavation season the majority, however, was sorted by students at the University of Edinburgh. Bones were sorted into the categories bird, mammal (burnt and un-burnt), teeth, fish and otoliths.

3.2.2 Sand recovery and sampling at the recording stage

For the purposes of recording, the greater than 4mm fraction of the mammal and bird bone was recorded, and for fish the 2-4mm and greater than 4mm fractions recorded. In practice, this meant sieving each bag of material to the required mesh size using an Endecott sieve set prior to recording and then returning to the bag afterwards.

As substantial Scottish Mesolithic faunal assemblages are so rare, material from all contexts was recorded. Based on the final context divisions made by the excavators well after excavation some of the material recorded became unsuitable for site interpretation due to post-depositional movement. However, given how few comparable assemblages are available the decision to err on the side of caution and record all material still seems justified.

3.2.3 Oronsay on site recovery and sampling

As described in chapter 2, Oronsay was first investigated in the 1800s. Later excavation took place from 1970-1979 by (Mellars, 1987). The material from the last phase of excavation forms the second case study and a subset of the fish remains are analysed in this thesis. Therefore, an explanation of the methods used in recovering the material are presented here (Mellars, 1987a, 133-138).

Unlike Sand, the recovery history of these sites is not straightforward. Extensive open excavation took place at Cnoc Coig, with more limited excavation and sampling applied to Cnoc Sligeach, Priory Midden, Caisteal nan Gillean I (CNGI) and Caisteal nan Gillean II (CNGII). Each site is discussed in turn below, but generally, following hand collection, excavated material was wet-sieved on site using a ¼ inch (c.6mm) or 1/8 inch mesh (c.3mm). Column samples were sieved through a 2mm and 1mm mesh. The aim "was to ensure that the samples collected for analysis were as far as possible representative of the *general* composition of the midden deposits within the particular area being sampled, rather than reflecting some highly localized feature, such as a concentration of fish skeletons." (Mellars, 1987a, 138). The column samples were often taken from the face of the trench, so the samples could follow the stratigraphy where observed: "in practice, this usually led to the discarding of a certain amount of material from immediately above and below each stratigraphic interface, to minimize the extent of any contamination or overlapping in the contents of adjacent samples."(Mellars, 1987a, 137). Whilst Mellars states that samples normally weighed between 10-20kg it is unclear if a standard volume of material was taken.

During excavation at Cnoc Coig and Caisteal Nan Gillean II some categories of artefacts were recorded by 3-dimensional co-ordinates. Of the zooarchaeological material this included large specimens of mammal and bird, fish bones judged to be larger than usual or somehow distinctive, and all bone and antler artefacts (Nolan, 1986).

3.2.4 Cnoc Coig

From the 1973 season all excavated material from the main excavation trenches A-GI was wet sieved on-site through a ¼ inch (c.6mm) and 1/8 inch (c.3mm) mesh. The 23 sampling pits excavated in the 1975 season were also sieved to the same mesh sizes. The bagged up sieved fractions were then sorted on Colonsay at the excavation's base. This proved too labour intensive so from 1975 onwards the sieving of material from the trenches was reduced to "a sequence of dry and wet sieving of the excavated material through a ¼ inch mesh" (Mellars, 1987b, 222). Sieved residues were sorted on site alongside excavation. It is unclear which material was dry- and which wet- sieved. Contradictory to this recovery information given by Mellars, Wilkinson states in his thesis that *all* material excavated from the trenches was sieved to 1/8 inch (Wilkinson, 1981, 16). This may mean that any fish remains from the trenches that he looked at were from this recovery level only and no hand collected material was recorded. The column samples from 13 of the test pits were sieved through 1mm and 2mm meshes for fish bone analysis. Thirty-eight small concentrations of fish bone from various points across the site were also sieved to 1mm and 2mm (Wilkinson, 1981). It is unclear if the fish bone concentrations were fully excavated or sampled.

3.2.5 Caisteal nan Gillean I, Caisteal nan Gillean II, Priory Midden and Cnoc Sligeach

Two test pits were excavated at Caisteal Nan Gillean I (in the backfill of 19th century excavation) and small samples taken from both. At Caisteal Nan Gillean II four trenches were excavated and the material was sieved to 1/8" (c.3mm), column samples were also taken. At Priory Midden one trench was excavated and the material sieved to 1/8" (c.3mm), column samples were taken from the trench. Column samples were taken from one trench at Cnoc Sligeach. Column samples from all sites were sieved to 2mm and 1mm.

3.2.6 Oronsay recovery and sampling at the recording stage

For the purpose of the results published in the 1987 volume (Grigson and Mellars, 1987) the mammal remains from the various trenches at Cnoc Coig (using the c.3mm and c.6mm mesh recovery after hand collection) were combined.

The published work on the fish remains (Mellars and Wilkinson, 1980) discussed otoliths from single columns from Cnoc Sligeach, Caisteal nan Gillean II and Priory Midden and from fish bone concentrations from Cnoc Coig; all samples had been sieved to 1mm. However, not all the 1mm fractions from the sites were recorded by Wilkinson, Table 3.1 summarises the samples he recorded and to what mesh size (information taken from his unpublished PhD thesis,Wilkinson, 1981, 150-151, 204). Although fish bone was recovered by all recovery methods Wilkinson primarily focused on the fish remains from the column samples and fish bone concentrations in his thesis.

Site	Sampling	Samples	>2mm recorded?	>1mm recorded?
Cnoc Coig	50 columns from test pits	1a to 14d	yes (only partial for last 9)	no
Cnoc Coig	38 small concs from whole site	1 to 38	yes for 10 samples; only for otoliths in remainder	yes for 10 samples; only for otoliths in remainder
Cnoc Coig	30 units from 2 large concs/layers in SE quadrant			
	lower level, 6 units	L1 to L6	yes for otoliths and for all bones in two samples	otoliths and all bones in two samples
	upper level, 24 units	L7 to L30	only for otoliths	otoliths in one sample
Priory	one column 11 samples	1 to 11	Yes	otoliths in 3 uppermost units
Cnoc Sligeach	one column with 5 samples	28 to 32	Yes	otoliths only
CNGII	four trenches each with column of 2-5 samples	A to R	Yes	otoliths from samples EFGHJ, QR
CNGI	five samples taken from two tests pits	2 to 5	otoliths yes in 4 samples; all bones in samples 4 & 5	otoliths yes in 4 samples; all bones in samples 4 & 5

Table 3.1 Summary of fish remains identified by (Wilkinson, 1981)

3.3 Recording methodology; Sand and Cnoc Sligeach reanalysis

The recording methodologies used follow those in the York system, an interactive recording database (Figure 3.1), developed at the University of York (Harland *et al.*, 2003). The York system was chosen as it was the system in use in the department, but with hindsight, a modification should have been made to allow recording of a wider range of mammal elements. The York recording protocol uses a series of quantification code classifications to determine in how much detail a certain element (or fragment of) should be recorded. In this section the quantification codes are defined and the criteria recorded for each described.

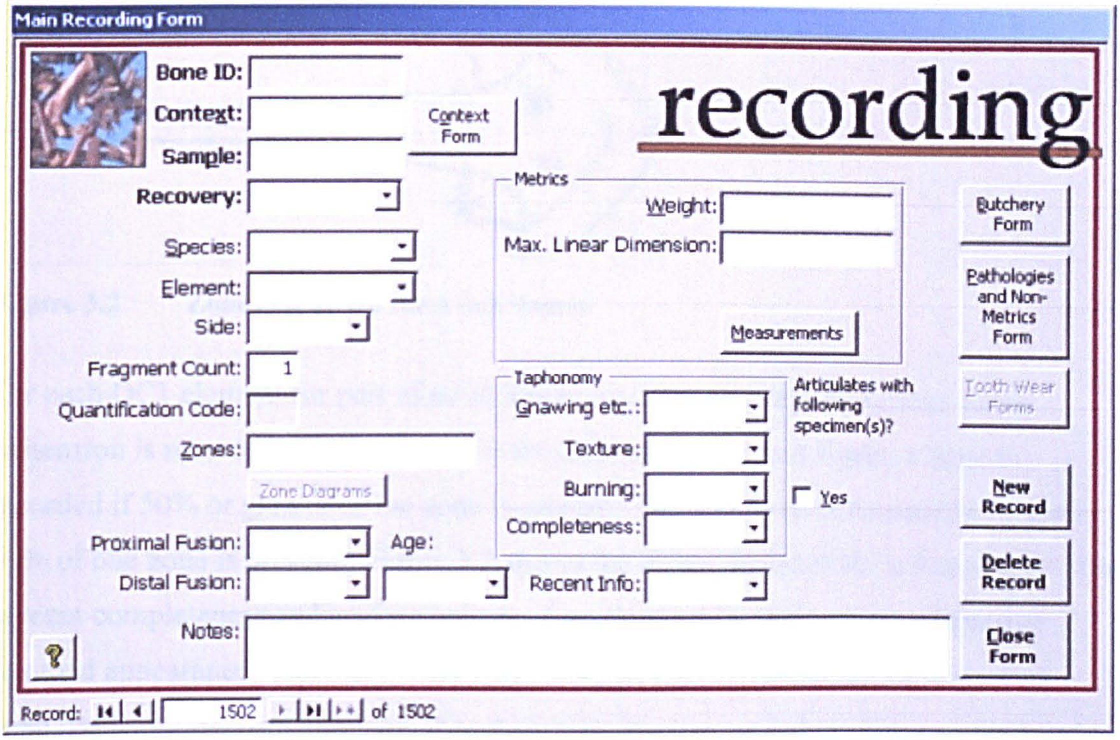


Figure 3.1 York system recording form (Harland *et al.*, 2003)

In addition to the York system, Outram's Freshness Fracture Index (FFI) was used. This is a method developed by Outram (2001) to assess the extent of bone fat or grease extraction from mammal bone.

3.3.2 York Protocol

The York system is based on two earlier recording protocols, one used at the former Environmental Archaeology Unit, University of York (Dobney *et al.*, 1999) and on FISH 1.1 a recording system used at the *fishlab* also at the University of York (Barrett, 2001). Mammal and bird bone measurements taken follow (von den Driesch, 1976) and the fish measurements Morales and Rosenlund (1979). The York system uses quantification codes to place elements into four categories, each category is defined and the criteria recorded listed.

Quantification code 1 (QC1): a subset of diagnostic elements that are typically identifiable to species. There are 17 mammal, 8 bird and 18 fish QC1 elements (Table 3.2). These elements are weighed individually and fully recorded and measurements taken where appropriate.

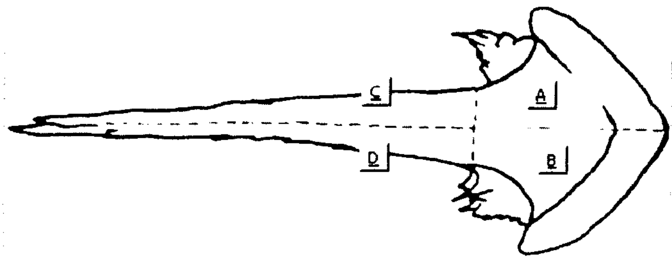


Figure 3.2 Zones recorded for a fish vomer

For each QC1 element (or part of an element), species, side and maximum linear dimension is recorded. Each element is divided into a series of zones; a zone is recorded if 50% or greater of the zone is present. The specimen is recorded if at least 50% of one zone is present. Figure 3.2 shows the zones recorded for a fish vomer. The percent completeness and surface texture of an element is noted, as is a charred or calcined appearance. Butchery marks and other modifications to the surface of the bone, such as carnivore gnawing or root etching are also recorded. For mammal and bird bone fusion data is recorded and an estimation of age given (immature, juvenile, sub-adult and adult). An estimation of fish total length is recorded in the following categories; tiny 0-150mm, small 151-300mm, medium 301-500mm, large 501-800mm, extra large 801mm-1m and extra extra large >1m. Total length is defined as the length from the tip of the snout to the end of the tail (Wheeler and Jones, 1989, 139).

Quantification code 2 (QC2): fish vertebrae, fully recorded as above but no measurements taken or element zone recorded. Specimens may be weighed in groups. Vertebrae are divided according to their place along the vertebral column as first, abdominal, caudal, penultimate or ultimate vertebrae. Gadidae vertebrae are further divided into abdominal group1, 2 or 3 and caudal group 1 or 2 (as defined in (Barrett, 1997)). This additional division stems from gadids having been commercially important fish through time in the British Isles and the presence or absence of certain groups of vertebrae (in addition to appendicular elements) have been used to determine butchery and preservation practices. With hindsight mammal vertebrae and ribs should also have been recorded and their place in the body noted; this omission has hampered full interpretation of the Sand mammal remains (Chapter 4).

Quantification code 4 (QC4): elements that are not part of the QC1 subset but may be of special zooarchaeological interest in some way. These elements are fully recorded.

Fish QC4 elements include the otolith, dermal denticle and otic bulla (for herring fishes). The mammal QQ4 element of most relevance here is antler. There are no bird QC4 elements. Quantification code 0 (QC0): unidentified bone, all fragments are counted and weighed (bones can be grouped to weigh). This includes both truly unidentifiable fragments and those which could be identified but do not form part of the QC1 subset. Evidence of burning is noted. There is no quantification code 3, this was a category previously used in the FISH 1.1 protocol but not used in the York system.

Mammal	Bird	Fish	'other'
Calcaneum	Carpometacarpus	Articular	Atlas
Femur	Coracoid	Basioccipital	Carapace
Humerus	Femur	Ceratohyal	Dentary
Lateral phalanx (pig only)	Humerus	Cleithrum	Femur
Mandible (incorporating dP4, P4, M1/M2, M1, M2, M3)	Scapula	Dentary	Fibulare
Metacarpal	Tarsometatarsus	Hyomandibular	Frontal
Metacarpal 2	Tibiotarsus	Infrapharyngeal	Frontoparietal
Metacarpal 3	Ulna	Maxilla	Humerus
Metacarpal 4		Opercular	Ilium
Metacarpal 5		Palatine	Maxilla
Metapodial		Parasphenoid	Orbitosphenoid
Metapodial 2		Posttemporal	Parietal
Metatarsal		Premaxilla	Plastron
Metatarsal 2		Preopercular	Prootic-exoccipital
Metatarsal 3		Quadrate	Radioulna
Metatarsal 4		Scapula	Sacral vertebra
Metatarsal 5		Supracleithrum	Scapula
Pelvis		Vomer	Scapulocoracoid
Phalanx			Tibiale
Phalanx 1			Tibiofibula
Phalanx 2			
Phalanx 3			
Radioulna			
Radius			
Scapula			
Skull			
Tibia			
Ulna			

Table 3.2 Elements recorded as QC1 in the York system

3.3.3 Fracture Freshness Index

The Fracture Freshness Index (FFI) was developed by Outram (2001, 2002, 2003) at the University of Durham and latterly at the University of Exeter. It was first applied to a highly fragmented Mediaeval Norse assemblage from a site called Sandnes in Greenland. Insect remains (Buckland *et al.*, 1996) from the deposit pointed to a near complete lack of fat on the bones indicating that bone fats had been extensively extracted. Outram's methodology, therefore, was designed to assess the degree of bone fat extraction.

There are two types of bone fat. Bone marrow can be extracted relatively easily whilst the bone is still fresh from within the medullary cavities of, for example, limb bones and the mandible. Bone grease is extracted from the cancellous bone of epiphyses and axial elements and is much harder to extract. To render (extract) the grease the bone needs to be fragmented, heated in water and then, as the water cools the fat scraped from the surface (Outram, 2003, 122). These different methods of bone fats extraction leave distinctive patterns of fragmentation and fracture. Ethnographic accounts, previous fats extraction work and Outram's own experimental work gives the overall pattern of bone marrow extraction as undamaged epiphyses, axial elements and diaphysis bone with helical fractures. Whereas the pattern from grease extraction is small fragments of cancellous bone and larger helical shaft splinters.

In order to assess the fragmentation and fracture patterns of an archaeological assemblage the first stage of Outram's methodology is to categorise bone into marrow or grease bearing bones (or fragments of) and into various size class. The second stage uses a scoring system to characterise the fracture types present and their frequency in the assemblage. This combines aspects of previous work by (Johnson, 1985) and (Villa and Mahieu, 1991) into a method that allows quick recording of large assemblages.

3.3.4 Application of FFI to Sand

Few complete elements were recorded at Sand. In order to assess the role marrow and grease extraction may have had on mammal bone fragmentation the FFI was applied to mammal bone from the >4mm fraction from the main shell midden layer.

Since Outram's FFI was developed the method appears to have been applied to few published assemblages. Its application at Sand, therefore, also provides the chance to see if any meaningful information, beyond that already recorded in the York system, can be gleaned where supporting environmental evidence (as for Sandnes) is lacking.

3.3.5 Fracture Freshness Index Methodology

Bone fragments were separated into the following classes; <20mm, 20-29mm, 30-39mm, 40-49mm, 50-59mm, 60-69mm, 70-79mm, 80-89mm, 90-99mm, 100+mm, part bone and whole bone. In this instance a part bone is defined as a bone that is not whole but that represents whole units that could have been exploited but that weren't broken up. This includes entire epiphysis and complete vertebral centra. A whole bone is simply a complete bone.

All fragments were sorted into cancellous bone (can) and cortical bone (cor) and recorded by size class (by placing on drawn out concentric circles to determine size class). All fragments were counted and weighed in their respective size classes. Where possible, for the larger size classes fragments were further categorised into cranial bone (cran), rib fragments (rib), other (?) axial cancellous bone (ax), appendicular cancellous bone (appen) and diaphysis bone (sha). Two additional categories not in Outram's original FFI methodology were used; antler (ant) and unknown (unid).

The second stage of Outram's method is to assess all shafts greater than 30mm according to the fracture freshness index. Three criteria are used to assess fracture type: fracture outline (shape); fracture angle to cortical surface; and fracture texture (rough or smooth). For each, a score from 0-2 based is given, based on certain characteristics as shown in Table 3.3. The total overall fragment score can range between 0-6. Fragments with eroded edges and unclear fracture features weren't given an FFI score.

Criterion	Score range	Characteristic
Fracture angle	0-2	
	0	<10% of surface at right angles to cortical surface
	1	10-50% at right angles to cortical surface
	2	>50% at right angles
Fracture surface texture	0-2	
	0	surface entirely smooth apart from stress relief features
	1	some roughness but texture mainly smooth
	2	largely rough edges
Fracture outline	0-2	
	0	only helical breaks
	1	mixture of fragment outlines
	2	absence of helical outline
Total overall fragment score	0-6	

Table 3.3 Summary of the FFI scoring system

3.3.6 Oronsay re-recording Cnoc Sligeach

Wilkinson originally recorded much of the fish bone from the Oronsay sites but an archive was never produced. In his thesis limited raw data is available. Element distribution is provided but only for saithe; the other species are quantified in terms of their relative abundance (Wilkinson, 1981, 207 table 4). The otolith measurements, used to reconstruct season of capture (Mellars and Wilkinson, 1980), are not given in their raw form but in half millimetre increment groupings, this makes it very difficult to re-calculate estimates of fish total length. In order to better compare the fish remains with those from Sand and to investigate if re-analysis of all the material would be worthwhile, re-analysis of the fish from one site, Cnoc Sligeach, was undertaken. Following the recording procedure in the York system, all material greater than 2mm was recorded. Otoliths were also recorded from the greater than 1mm fraction.

3.4 Quantification

The advantages and disadvantages of various methods of zooarchaeological quantification have been well discussed (for example, Grayson, 1984, Reitz and Wing, 1991, Lyman, 1994, O'Connor, 2000, O'Connor, 2001, Lyman, 2008) but as definitions can vary it is necessary to be explicit and a brief summary is provided here.

The number of identified specimens (NISP) may be used as a count of identified specimens and as a relative measure of taxonomic abundance. Here specimen refers to an identified whole element or part of an element. Identification may be to species, family or a more general taxonomic group. Another commonly used method of assessing taxonomic abundance is the minimum number of individuals (MNI). MNI provides a conservative estimate of the least number of the individuals required to account for the specimens identified for a certain species or taxonomic group by context or site. At its simplest the number of identified specimens of a given element is divided by the number of times the element occurs in the body. For example, as the femur occurs twice in the body the total number of femora for a given taxa would be divided by two. A further step is to take into account the number of left and right sided elements, for example, in Table 3.4 a minimum of 11 individuals would account for the specimens present.

Red deer	NISP	Left	Righ	MNI
Femur	6	3	3	3
Humerus	12	5	7	7
Metacarpus	14	11	3	11
Scapula	7	1	6	6
Tibia	11	4	7	7

Table 3.4 Example of MNI

This calculation of MNI does not, however, take into account male or female or juvenile versus adult specimens (Lyman, 2008). The unit of analysis chosen can have a large impact on the MNI estimate. For example, if the 3 left femora from table Table 3.4 were deposited in pit A and the 3 right femora were deposited in pit B and MNI were calculated for both pits 6 rather than 3 individuals could be deemed to be present. MNI can overinflate the importance of an infrequently occurring taxon at a site as even a taxon which is only represented by one specimen will have a MNI of one (Reitz and Wing, 1991).

The minimum number of elements (MNE) offers a method to estimate the number of elements, as opposed to individuals, in a given context or larger unit of analysis, and takes into consideration the parts of elements represented. In the York system zones are recorded for QC1 elements for all classes of animal. The MNE can then be calculated by counting how many times a zone of an element occurs Table 3.5. This does not take the side of an element or part of an element into consideration, nor age or sex, but offers a simple estimate of how many elements may have been present.

Saithe	A	B	C	D	MNE
Vomer	16	18	15	21	21
Cleithrum	2	1	5	3	5
Basioccipital	22	23	14		23

Table 3.5 **Example of MNE**

Both NISP, MNI and MNE are affected by how readily identifiable to species an element is and how fragmented the material is (Reitz and Wing, 1991, 191-194). Given all the caveats of MNI it is not used as a method of quantification in this thesis, NISP is used and as 'raw data' it is important for NISP to be available for comparison with other sites. MNE estimates are useful when looking at skeletal element patterning and are provided but it is stressed that these are still only a relative means of quantification.

3.5 Calculation of fish size

Fish continue to grow throughout their lives it also follows that the older a fish the longer it is. The habitat of some fish species varies markedly with age. This applies to saithe, one of the principal species from the two largest assemblages; Sand and Oronsay. Knowing the length of the fish, therefore, helps inform interpretation.

A first year fish is one in the first year of growth, the start of that year is typically classes January as this coincides with when many species spawn, although there will be variation. All of the fish in a particular age cohort should be a similar size and between age cohorts there is a one year gap (Wooton 1998, 115). When the total length of the fish are plotted the age classes should be distinguishable as different modes. Distinction is less clear as fish get older and growth slows and if, for example, the first year fish grow at a faster rate than the second year fish and 'catch up'.

An estimation of fish total length, based on comparison with modern reference specimens, is routinely recorded for fish QC1 and QC4 elements as described in Section 3.3.2. A less qualitative estimate of fish size can be calculated using a linear regression equation. This uses the biometrical principle that there is a relationship between the size of a given element and the animal, in this case fish, from which it comes (Reitz and Wing, 1991, 70, Barrett, 1993, Desse and Desse-Berset, 1996, 176, Leach and Davidson, 2001). Measurements taken on a fish bone can, therefore, be used to calculate the total length of the fish.

To calculate a linear regression equation modern reference skeletons of known total length are required. The measurements taken on a given element are then plotted against the total lengths and a regression equation determined (using a statistical package like, for example SPSS). As the growth of animals is allometric the relationship between individual element and overall size (in this case total length) is best expressed logarithmically (using $\log_{10}$).

Cod family fish were of economic importance in late prehistoric and early historic Northern Scotland (Barrett *et al.*, 1999, for example) and regression equations exist for selected measurements. Regression equations as defined by Jones (1991, 164) were applied to the otolith width measurements of specimens recorded as *Pollachius* (saithe or pollack) from Sand to provide an estimate of fish total length. The equation used was: **total fish length ($\log_{10}$) = 1.59+1.54 x otolith width ($\log_{10}$)**

These estimates are then plotted as histograms to show the distribution of fish size. Wrasses (the other principal fish family from Sand) have not been as commercially important and few equations exist for British waters (but have been successfully calculated elsewhere, see (Leach and Davidson, 2001). In addition, with reference to Ballan wrasse, (Dipper *et al.*, 1977) state the fish's slow and irregular growth rate may have contributed to the lack of work.

Although a regression equation can provide a closer estimation of total length it is still an estimate. Fish growth is complicated, factors include the quality and quantity of food and temperature, which can affect food metabolism and consumption. When measured on a yearly basis the growth curve of a fish is generally smooth; the long-term timescale masks shorter term variability. However, when measured on a shorter timescale, the growth curve will reflect short-term variations (Wooton, 1998). Seasonal growth is a feature for many species that live in temperate environments; growth is slow in winter and rapid in spring and summer. Saithe follow this seasonal pattern and species-specific growth data is discussed in chapter 4.

A further method for calculation fish age and season of capture, but not employed in this thesis, is to examine in thin section the growth annuli of elements such as scales and otoliths. This is a standard method used in fisheries research and has been applied archaeologically. For gadids the otolith is often used. Otoliths are the earstones of bony fish. There are 3 pairs of otoliths, of which the sagittae are generally the largest and most diagnostic (Harkonen 1986, Wheeler and Jones 1989). In this thesis otolith hereafter refers to the sagittal otolith. Otoliths are mostly composed of aragonite (crystalised calcium carbonate) (Campana 2004). The otolith's chemical composition is key to preservation. In laboratory tests otoliths survived well in dry alkaline conditions but even slightly acidic conditions will result in poor preservation (Campana 2004, 3). Ageing is based on the principal that within the annual pattern of growth there are seasonal variations. In otoliths this is a sequence of alternation concentric zones; opaque in period of rapid growth and hyaline (translucent) in periods of slow growth. In fish from temperate zones fast growth is typically in spring and summer and slow growth in winter (Wooton 1998, 110). An opaque and hyaline zone, therefore, corresponds to one year's growth. The most recent edge of the otolith should be able to indicate the season of capture based on type and on measurement of the most recent increment of growth.

Van Neer *et al.* (2004) have questioned the validity of applying this method to archaeological otoliths for recreating season of fishing. They looked at large modern samples of plaice and haddock thin-sectioned otoliths of known catch dates. They concluded that there are two requirements for season of capture to be determined with any confidence. The first is if the fish are caught during a period of rapid growth, especially at the start of a new growth season when incremental growth patterns are clearly distinguishable. The second is that if the fish remains come from a context that represents a single deposition, for example, the discard of fish processing waste from one catch, or, if the remains are the result of a short seasonal event that has been repeated year after year. Even with these factors taken into consideration the area of sea fished and the age of fish may still influence interpretation. They also stress that it is not possible to determine season of capture on one otolith alone and large sample sizes are advantageous. Whilst the Sand assemblage provides a large sample the fish remains are not from contexts that meet the requirements of Van Neer *et al.* (2004).

Chapter 4 Sand

4.1 *Introduction*

In this chapter results from analysis of the mammal, bird, small mammal, amphibian and fish bone from Sand are presented. Prior to this thesis I undertook preliminary recording and analysis of a subset of material from Sand in fulfilment of an MSc (Gamble, 2002). This pilot study allowed limited comparison of the mammal and fish (excluding otoliths) from a main shell midden context and from the organic rich layer.

In total, 113,994 bone fragments were recorded from Sand, 16,589 of which were diagnostic as defined in the York system (Harland *et al.*, 2003 and see Chapter 3). Bone was recovered from all context types, the main shell midden yielded the largest number of specimens; mammal, bird, fish, small mammal and amphibian remains were all recovered. A substantial assemblage was also recovered from the undated topsoil and turf contexts. Mammal, bird and fish bone measurements are provided in Appendices 1, 2 and 3. Latin species names are provided in Appendix 4.

At the beginning of analysis it was hoped that comment could be made on both the zooarchaeological assemblage as a whole and also from individual contexts. However, the use of the broad context descriptions rather than numbers used in this thesis reflects the ambiguity over context numbering as discussed in Chapter 2. Discussion is focused primarily on the main shell midden and organic rich layer; these are dated to the 7th millennium and 6th millennium respectively.

Class	Recovery	Topsoil	Main shell midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Mammal											
Diagnostic	4 mm	66	137		2	72	3	9		3	292
	Hc	1	2								3
Unidentified	4 mm	13601	13025	81	1473	6645	2521	5618	24	438	43426
	Hc	59	1								60
Subtotal		13718	13165	81	1475	6717	2524	5627	24	441	43781
Bird											
Diagnostic	4 mm	307	810		38	88	17	25	2	3	1290
Unidentified	4 mm	3608	7953	8	549	2375	206	325	9	18	15051
Subtotal		3915	8763	8	587	2463	223	350	11	21	16341
Fish											
Diagnostic	2-4 mm	2817	6582	2	66	348	169	311	1	80	10376
	4 mm	1015	3089		46	191	86	116	1	34	4578
Unidentified	2-4 mm	7992	21747	3	285	2669	694	1268	2	231	34891
	4 mm	844	2609		29	244	44	63		19	3852
Subtotal		12668	34027	5	426	3452	993	1758	4	364	53697
Small mammal and amphibian											
Diagnostic	2-4mm	13	18				1	1			33
	4mm	5	10				1	1			17
Unidentified	2-4mm	16	63		1	8	4	23			115
	4mm		13			1					14
Subtotal		34	104		1	9	6	25			179
Total diagnostic		**4224**	**10648**	**2**	**152**	**699**	**277**	**463**	**4**	**120**	**16589**
Total number of bones		**30344**	**56059**	**94**	**2489**	**12641**	**3746**	**7760**	**39**	**826**	**113994**

Table 4.1 Number of identified specimens from Sand by method of recovery. 'Unidentified' includes truly unidentifiable specimens and specimens not routinely recorded under the York system. Hand collected (hc), wet sieved greater than 4mm fraction (4mm), wet sieved greater than 2mm fraction (2-4mm)

4.2 *Mammal bone*

A total of 43,781 mammal bone specimens were recovered from all context types at Sand (Table 4.1). Despite the high number of specimens recovered fewer than 300 diagnostic specimens were recorded. A small amount of mammal bone (3 diagnostic specimens and 60 unidentified specimens) was recovered by hand collection on site. Due to this small number the hand collected material was combined with that from the >4mm fraction for analysis.

4.2.1 Mammal bone preservation

Preservation of QC1 diagnostic elements was gauged on two criteria, surface texture and percent completeness (Table 4.2 and Table 4.3). From the main shell midden and topsoil the majority of specimens had either a good or fair surface texture. From the organic rich layer the sample is much smaller but the majority are fair to poor. From other contexts there are too few specimens to discuss in detail. The percent completeness of an element gives an indication of the level of fragmentation. If fragmentation is low then high percentage completeness would be expected. From the main shell midden and topsoil over half of the specimens were less than 40% complete indicating a high level of fragmentation. But, some near complete (81-100%) elements are also present. Similarly, from the organic rich context the majority of elements were less than 40% complete. As the lower organic rich deposit may be mixed with slumped midden material the similarity in preservation is not surprising. Again, the other contexts had few mammal QC1 specimens.

Turning to all specimens, including unidentified, a total of 12,370 specimens across all contexts showed signs of burning, either being calcined white or charred brown or black (Table 4.4). From the sandy soil, which contained several heat cracked stones, nearly 40% of specimens showed evidence of burning. From the main shell midden just over 25% were burnt, 13% from the organic rich layer and nearly 30% from the lower shell midden. Specimens with carnivore gnawing damage were few (total of 22) and were found in the topsoil, main shell middden, organic rich layer and shell midden. Carnivore activity can be very destructive and have an impact on elements, or parts of, present (Payne and Munson, 1985). Fox and dog or wolf remains were present at the site but it is impossible to know if the gnawing took place whilst people were still using the site or when the site was abandoned. Rodent gnawing was observed on two specimens from the main shell midden. Root damage on the bones was also minimal. One antler fragment from the main shell midden showed signs of ungulate gnawing, presumably by deer (Figure 4.1). It is interesting to note the same fragment had also been worked and this is discussed further with the other worked bone.

Figure 4.1 Antler specimen from the main shell midden at Sand with evidence of ungulate gnawing. Bar scale represents 10cm

Texture	Topsoil	Main shell midden	Organic rich	Shell midden	Sandy soil	Unprov	Total
Excellent			1				1
Good	21	57	3	1	2	1	85
Fair	20	36	7	1	3	1	68
Poor	4	3	9		1		17
Total	45	96	20	2	6	2	171

Table 4.2 Surface texture of mammal QC1 elements. Assessment of surface texture based on the following criteria (Harland *et al* 2003) Excellent - majority of surface fresh or even slightly glossy; very localized flaky or powdery patches. Good - lacks fresh appearance but solid; very localized flaky or powdery patches. Fair - surface solid in places, but flaky or powdery on up to 49% of specimen. Poor - surface flaky or powdery over >50% of specimen

Element completeness	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Unprov	Total
0-20%	15	25		10		3		53
21-40%	13	35	1	7	1	2	1	60
41-60%	2	12		1	1		1	17
61-80%	1	4						5
81-100%	12	16		2		1		31
Total	43	92	1	20	2	6	2	166

Table 4.3 Percent completeness of mammal QC1 elements

Modification	Topsoil	Main shell midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Carnivore gnawing	6	9			6	1				22
Rodent gnawing		2								2
Root etching	4	5			3	1				13
Root etching & carnivore gnawing		2								2
Ungulate gnawing		1								1
Calcined	1139	666	9	81	292	205	1086	1	29	3508
Charred	3289	2869	10	218	644	522	1132	4	174	8862
Burning total	4428	3535	19	299	936	727	2218	5	203	12370
% burnt of total specimens	32%	26%	23%	20%	13%	28%	39%	20%	46%	28%

Table 4.4 **Modification of mammal bone (identified and unidentified) by context**

4.2.2 Taxonomic abundance

The mammal assemblage from Sand is dominated by wild, almost exclusively terrestrial taxa (Table 4.5). From the site as a whole red deer, *Cervus elaphus*, is most abundant (108 specimens) followed by wild boar, *Sus scrofa* (40 specimens). The *Sus* specimens are assumed to be wild boar rather than domestic pig, based on a qualitative assessment of size and tooth cusp pattern and are referred to as wild boar hereafter. From the main shell midden layer in addition to red deer and wild boar, roe deer, fox (*Vulpes vulpes*), dog or wolf and otter were present. Identification between domestic dog and wolf can be problematic especially where elements are fragmented or poorly preserved and distinguishing traits such as small body size become more pronounced in later periods (Pluskowski, 2006 and references therein).

From the organic rich layer the only other positively identified species other than red deer or wild boar was badger (*Meles meles*). Only two specimens of marine mammal were recovered. From the topsoil layer a seal first phalanx unidentifiable to species and an unidentified whale element from the main shell midden. Following the York recording protocol (Harland *et al.*, 2003) mammal elements not identifiable to genera were recorded as either 'large mammal', 'medium mammal 1' or 'medium mammal 2'. Large mammal was used to describe specimens that could have been red deer, cattle or large wild boar. Medium mammal 1 was used for specimens the size of small cervids and wild boar, and medium mammal 2 for taxa such as otter, badger and canids.

Red deer are a large deer, adults weighing 150-200kg are typically known today. Antlers are shed from March onwards but young stags may not shed antlers until August or September. Rutting takes place early September to November but can be variable; young are usually born the following May or June (Southern, 1964, 412-416).

Taxon	Topsoil	Main shell midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Whale sp.		present								
Dog or wolf		2								2
Fox		1								1
Dog family	1									1
Badger					present					
Otter		present								
Seal sp.	1									1
Wild boar	8	29			1		2			40
Red deer	30	49		1	22	2	2		2	108
Roe deer	1	5								6
Deer family	3	2								5
***Bos* sp.**	4	1			1		1			7
Sheep	3						1			4
Sheep or goat		1								1
Large mammal	8	8			3	1	3			23
Medium mammal	3	6			2					11
Unidentified	13660	13026	81	1473	6645	2521	5618	24	438	43486
QC1 subtotal	62	104		1	29	3	9		2	210
QC4 subtotal	5	35		1	43				1	85
Total	13727	13165	81	1475	6717	2524	5627	24	441	43781

Table 4.5 Number of identified mammal specimens by context

Roe deer are much smaller than red deer, weighing approximately 20kg. They are selective feeders, but due to a lower body mass do not need a large home range (Putman, 1988, 36). They are mostly solitary or occur in small family groups. Rutting takes place in late July or early August; young deer are then born the following May or June (Ratcliffe and Mayle, 1992).

Red deer and roe deer are known to occupy the same area in the wild today (Ratcliffe and Mayle, 1992, 1). Both are primarily woodland animals, with a preference for the dense cover of the inner rather than edges of a wood. They will feed in more open habitat and as for red deer in Scotland today, can adapt to a more open habitat (Putman, 1988, 19).

True wild boar (from which all domesticated pigs are descended) are extinct now in Britain, although there are localised feral populations and wild populations do still exist in continental Europe. They live in small social groups and prefer broad-leaved deciduous woodland (Clutton-Brock, 1999).

Fox belong to the same family as dog and are highly adaptable in terms of habitat and prey choice (Southern, 1964). Prey can include small mammals, birds, fruit, insects and remains of larger mammals. Otters are found along freshwater water courses as well as coastal waters. Otters feed primarily on fish; diet will vary with locality. Even if they are predominantly coastal they need access to freshwater to clean the saltwater from their coats (The Mammal Society 2009). Badgers are found in a wide variety of habitats but typically sets are made in woods. Their diet is broad and can include mice, rats, voles, slugs, amphibians, beetles, fruit, acorns and earthworms (Southern, 1964, 377-380). Two seal species are common in British waters today, common seal (*Phoco vitulina*) and grey seal (*Halichoerus grypus*).

A total of 36 specimens of possible domestic taxa, including non-diagnostic elements not routinely recorded, were found throughout the shell midden (Table 4.6). Eighteen specimens of probable domestic *Bos* sp. were recorded from the topsoil, main shell midden, organic rich layer and sandy soil layer. These included isolated teeth, a navicular-cuboid and one axis. The axis is clearly intrusive due to a metal cut mark but it is unclear if the other elements are also intrusive. Few measurable elements were recovered. Measurements were taken from the navicular-cuboid from the main shell midden and a mandibular first molar from the topsoil (Appendix 2). The small number of measurements makes it difficult to assess if the *Bos* sp. specimens are wild aurochs or domestic cattle. Based on qualitative assessment the latter seemed probable (O'Connor *pers comm.*) but, small aurochsen specimens are known (as discussed in Chapter 2). Direct dating and mtDNA analysis of the Sand specimens is required.

A small number of sheep specimens were recovered including a pelvis from the sandy soil layer and a metatarsal from the main shell midden. A calcaneum and isolated teeth identified to either sheep or goat were recorded from the main shell midden. The colour and texture (very well preserved with green surface colour in contrast to the rest of the material) of the metatarsal suggests it was probably intrusive. It is likely that all the sheep or goat specimens and a result of movement within the midden, direct dating is necessary, however, would be advantageous to confirm their date.

Taxon	Element	Topsoil	Main shell midden	Organic rich	Shell midden	Sandy soil	Total
Bos sp.	mandibular premolar	2					2
	mandibular molar	2	1	1		1	5
	axis		1				1
	navicular cuboid		1				1
	Incisor	1	5				6
	isolated teeth		1				1
	maxillary molar		1	1			2
Subtotal		**5**	**10**	**2**		**1**	**18**
Sheep	mandibular deciduous premolar	2					2
	metatarsal		1				1
	pelvis					1	1
	maxillary molar		1				1
	isolated teeth					2	2
Subtotal		**2**	**2**			**3**	**7**
Sheep or goat	calcaneum		1				1
	isolated teeth	5		1	1	1	8
	maxillary molar		1		1		2
Subtotal		**5**	**2**	**1**	**2**	**1**	**9**
Total		12	14	3	2	5	36

Table 4.6 Possible domestic mammalian taxa recorded (all specimens)

4.2.3 Element representation

In the York recording system elements are categorised by a 'quantification code'. The quantification code system was detailed in the methodology chapter but to summarise quantification code 1 (QC1) is a suite of 29 mammal elements, typically identifiable to species level. Elements that are not QC1 but are of special interest, such as antler, are recorded as QC4. Elements that do not fall into either of these categories are recorded as unidentified (QC0), this category also includes truly unidentifiable specimens.

Out of a total of 43,781 specimens from the site 295 QC1 and QC4 elements, or parts of, were recorded. Focusing just on the QC1 elements (table 4.7), the majority were recovered from the topsoil, main shell midden and organic rich deposits, the latter two are considered here. From the main shell midden QC1 elements were recorded for, in order of numerical abundance, red deer, wild boar, roe deer, dog or wolf, fox, *Bos* sp., sheep and either sheep or goat. From the organic rich layer QC1 elements were recorded, in order of numerical abundance, for red deer, wild boar and *Bos* sp..

Taxon	QC	Element	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Unprov	Total
Dog or wolf	1	scapula		1						1
		ulna		1						1
Fox	1	scapula		1						1
Dog family	1	metacarpal	1							1
Seal	1	phalanx1	1							1
Wild boar	1	astragulus	1							1
		calcaneum	1	1						2
		metacarpal3		1						1
		metacarpal4		1						1
		metapodial	1	5						6
		metatarsal				1				1
		metatarsal3		1						1
		metatarsal4		1						1
		mandible	1	1				1		3
		phalanx1		3						3
		phalanx2	3	6				1		10
		phalanx3	1	2						3
		radius		2						2
		ulna		5						5
	4	canine		1					1	2
Red deer	1	astragulus	4			1			1	6
		calcaneum	2	1		1				4
		femur		2						2

Taxon	QC	Element	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Unprov	Total
		humerus	2	1	1	3				7
		metapodial	2	7		5				14
		metatarsal		2						2
		mandible	6	4		5		1		16
		pelvis		1		1			1	3
		phalanx	2	2						4
		phalanx1	4	9		2	1			16
		phalanx2	2	5		1		1		9
		phalanx3	1	7		1				9
		radius	3	3						6
		radius/ulna	1							1
		scapula		1		1	1			3
		tibia	1	3						4
		ulna		1		1				2
	4	antler	3	26	1	41				71
Roe deer	1	mandible	1	1						2
		metapodial		2						2
		pelvis		1						1
		scapula		1						1
Deer family	1	metacarpal		1						1
		metapodial	1	1						2
		phalanx1	1							1
		radius	1							1
	4	antler	2	8		2				12
Bos sp.	1	mandible	4	1		1		1		7

Taxon	QC	Element	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Unprov	Total
Sheep		mandible	2							2
		metatarsal	1							1
		pelvis						1		1
Sheep or goat	1	calcaneum		1						1
Large mammal	1	humerus		2						2
		metapodial	5	1		3		1		10
		metatarsal		1						1
		mandible					1			1
		pelvis		1						1
		phalanx	1					2		3
		phalanx3	1							1
		scapula	1	3						4
Medium mammal 1	1	astragulus	1							1
		humerus				2				2
		metapodial	2	1						3
		mandible		2						2
		phalanx		3						3
Total			67	139	2	72	3	9	3	295

Table 4.7 Mammal QC1 and QC4 element representation

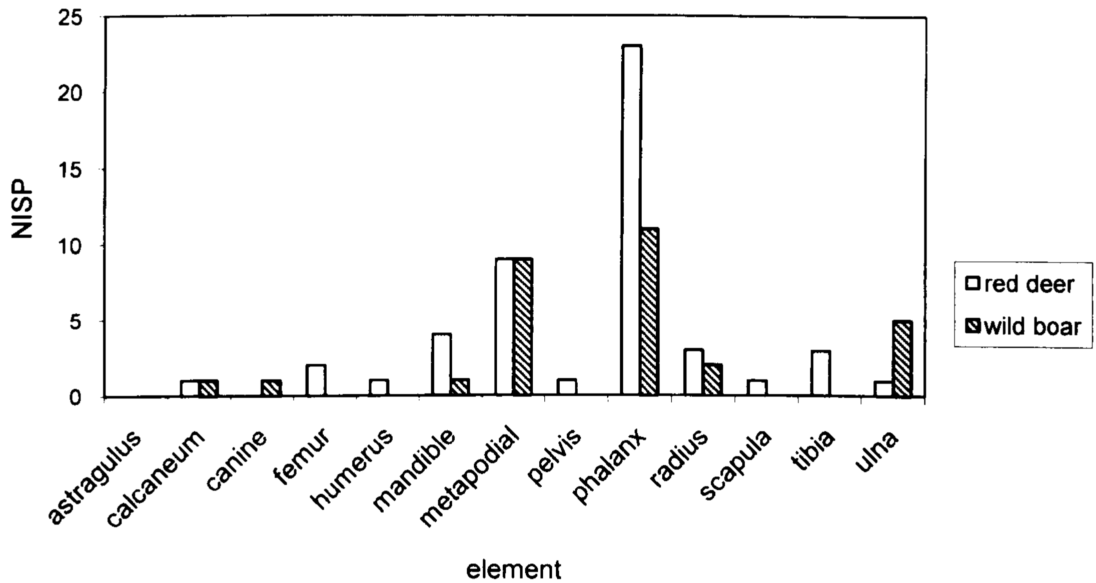


Figure 4.2 Red deer and wild boar QC1 element distribution from the main shell midden (metapodial includes specimens recorded as metatarsal and metapodial)

The most striking observation for both the red deer and wild boar QC1 element representation from the main shell midden is the apparent lack of meat-bearing bones, such as the femur, humerus and scapula and comparatively high number of terminal appendicular elements such as phalanges and metapodials (Figure 4.2). However, both the ratio that these elements occur in the body and the parts of elements present need to be taken into consideration. The count of mandibles is inflated due to a number of loose mandibular teeth. In the York system loose mandibular teeth are recorded in the same form as mandibles. No complete mandibles were recorded; 2 fragments of red deer, 1 of roe deer and 2 of wild boar were recorded from the main shell midden.

The minimum number of elements (MNE) uses the zones recorded in the York system to provide an estimate of the numbers of elements present as opposed to number of elements identified Table 4.8. This is an estimate as a zone is only recorded if 50% or more of the zone is present. Figure 4.3 shows the element distribution of red deer this time using the MNE calculation. The pattern is similar, with metapodia and phalanges still most abundant.

element	red deer MNE main shell midden	red deer MNE organic rich	wild boar MNE main shell midden
astragulus		1	
calcaneum	1		1
femur	1		
humerus	1	2	
metatarsal	5		
metapodial	1	3	
pelvis	1	1	
phalanx	1		
phalanx 1	5	1	2
phalanx 2	5	1	2
phalanx 3	7	1	2
radius	2		1
scapula	1	1	
tibia	1		
ulna			1

Table 4.8 **Red deer and wild boar minimum number of elements**

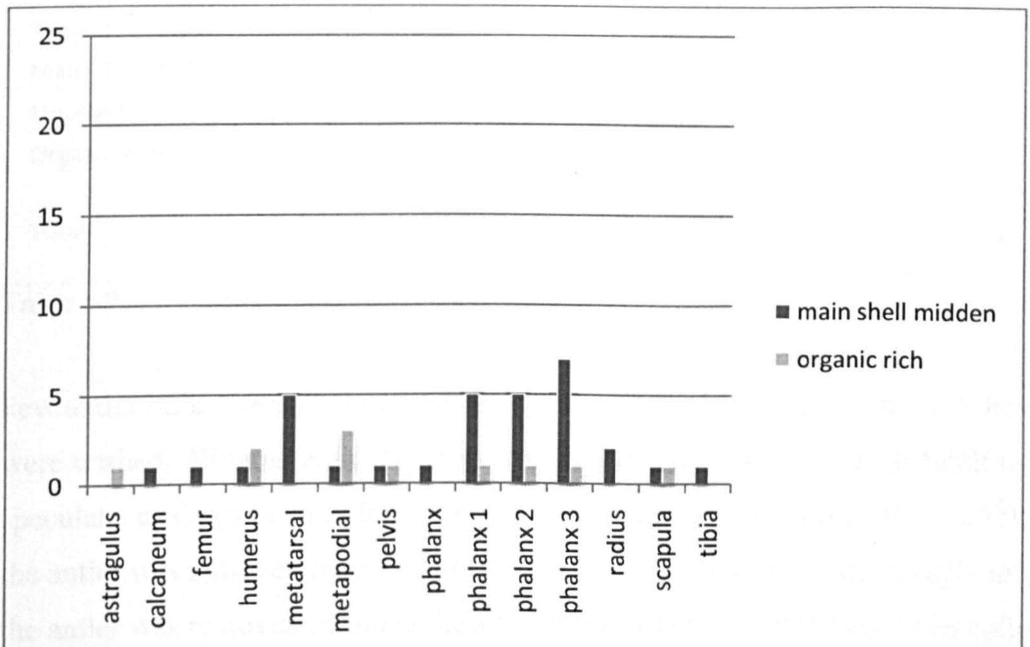
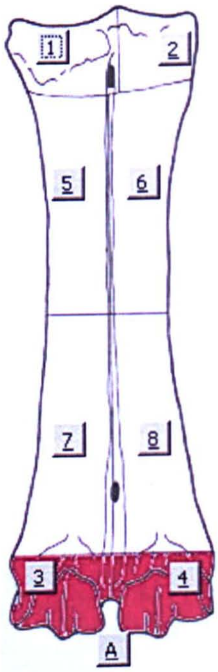


Figure 4.3 **Minimum number of elements for red deer from the main shell midden and organic rich layer**



From the main shell midden most of the metapodia are represented by unsided distal condyles (Figure 4.4). MNE provides a conservative estimate of the numbers of elements present. These could represent a couple of individuals and the element pattern seems to represent how frequently an element occurs in the body rather than a real tendency towards terminal appendicular elements.

Turning to the antler from the site 83 specimens were recovered from the site (Table 4.19). The majority of these specimens were tine ends or small fragments and from the main shell midden and organic rich deposit.

Figure 4.4 Red deer metatarsal: most frequently occurring zones from the main shell midden

Whilst antler appears numerically abundant when compared to other red deer elements, this number may be inflated by a high degree of fragmentation.

Context	NISP	Unshed	Worked?	Worked
Topsoil	5			
Main shell midden	34		2	2
Slopewash	1			
Organic rich	43	2		1
Total	83	2	2	3

Table 4.9 Antler specimens from Sand

Few antler bases were recorded, two specimens from the organic rich layer, however, were unshed. Without antler bases as a means of quantification it is difficult to speculate, as Grigson and Mellars were able to argue at Cnoc Coig (1987, 252), whether the antler was removed from a whole carcass, or head, before being brought to site or if the antler was removed *in situ* at the site. Shed antler may also have been collected and brought to the site. The antler specimen with working and gnawing (Figure 4.1) suggests this may account for some of the antler at Sand; for the antler to have been gnawed it has to have been shed and on the ground.

4.2.4 Butchery evidence

From the site as a whole 56 mammal specimens were recorded as having evidence of cut marks or some form of working (Table 4.10). Largely this consisted of fine cut marks or the bevelling of ends of bone. Despite there being 83 specimens of antler only three specimens had clear evidence of working and a further two had more ambiguous marks. On the specimen with ungulate gnawing cut marks were also visible at the base and at the tip of the tine (Figure 4.5). These cut marks were typical of the type observed on the mammal bone.

Figure 4.5 Example of antler working from main shell midden scale represents 10cm

Bone id	Taxon	Element	Modification	Notes
Topsoil				
SFS4-148	unidentified	unidentified	cut	series fine parallel cut marks along length of frag
SFS4-147	unidentified	unidentified	cut & worked	fine irregular cut marks & striations visible at rounded end
SFS4-19	unidentified	unidentified	worked	bevel-ended
SFS4-2065	wild boar	calcaneum	cut?	possible small parallel cuts above distal end
SFS4-15726	unidentified	unidentified	worked?	possible flaking of end of fragment
SFS4-166	unidentified	unidentified	worked?	possible rounded end
SFS4-4	unidentified	unidentified	worked	bevel-ended
SFS4-3614	unidentified	unidentified	cut	three cut marks
SFS4-22	unidentified	unidentified	worked	bevel-ended
SFS4-3268	unidentified	shaft	cut	small medio-lateral cut mark across shaft
SFS4-3257	unidentified	unidentified	cut	
SFS4-203	unidentified	unidentified	worked?	possible striations & slight bevelling at one end of frag
Main shell midden				
SFS4-6	unidentified	unidentified	cut & worked	rounded at both ends, shallow cut marks on one side
SFS4-393	large mammal	metapodial	worked	bevelling at one end, working to point at other
SFS4-149	unidentified	unidentified	worked?	slightly abraded at tip
SFS4-6993	*Bos* sp.	axis	cut	metal cut mark on condyle and chop
SFS4-3193	large mammal	shaft	worked	rounded at end
SFS4-13877	unidentified	shaft	cut	2 parallel cut marks
SFS4-574	unidentified	unidentified	worked?	possible working
SFS4-418	unidentified	unidentified	worked?	bevel-ended but striations ambiguous
SFS4-193	unidentified	unidentified	worked	rounded end
SFS4-16	red deer	antler	worked?	some abrasion but unclear if from human use
SFS4-394	unidentified	shaft	worked	bevel-ended
SFS4-3188	large mammal	shaft	worked	bevel-ended
SFS4-3172	red deer	antler	worked	evidence of use at end of tine - shine & abrasion

Bone id	Taxon	Element	Modification	Notes
SFS4-25	unidentified	unidentified	worked	bevel-ended both ends
SFS4-3189	large mammal	shaft	worked	roughly bevel-ended, looks worked as for lithic
SFS4-3190	large mammal	shaft	worked?	possibly broken to point
SFS4-20	red deer	metatarsal	cut	series fine medio-lateral cut marks at proximal end
SFS4-379	red deer	phalanx 2	cut	small but clear dorsal-ventral cut mark at proximal end
SFS4-1884	red deer	antler	worked	tips of antler worked and also at base
SFS4-3179	unidentified	unidentified	cut	
SFS4-151	unidentified	unidentified	cut	cut across length of frag
SFS4-23	large mammal	scapula	cut	
SFS4-23	large mammal	scapula	cut	fine cut marks over curve of blade edge
SFS4-7	red deer	radius	chop?	chop/split towards proximal epiphysis on posterior side
SFS4-3185	large mammal	shaft	worked	bevel-ended
SFS4-3194	large mammal	shaft	worked	bevel-ended
SFS4-3186	large mammal	shaft	worked	bevel-ended
SFS4-400	unidentified	unidentified	worked	bevelled at both ends
SFS4-13879	unidentified	unidentified	cut	6 parallel cut marks
SFS4-15	unidentified	unidentified	worked	bevel-ended, striations visible
SFS4-14	red deer	antler	worked?	abrasion at tine tip possibly from use
SFS4-13	unidentified	unidentified	worked	rounded abraded end
SFS4-12	red deer	metapodial	chop?	
SFS4-3538	red deer	pelvis	cut	3 fine cut marks across ventral surface, zone 5
SFS4-573	unidentified	unidentified	worked	small frag worked to cylindrical shape and point
Organic rich				
SFS4-401	red deer	antler	worked	bevel-ended
SFS4-399	unidentified	unidentified	worked	bevel-ended
SFS4-3250	red deer	phalanx 3	cut?	possible dorsal-ventral cut mark/carnivore gnaw on medial side, zone 1

Bone id	Taxon	Element	Modification	Notes
Shell midden				
SFS4-3763	unidentified	unidentified	worked	bevel-ended
Sandy soil				
SFS4-3764	unidentified	unidentified	worked?	high degree of polish but unclear if worked
SFS4-3191	large mammal	metapodial	worked	roughly bevel-ended, looks worked as for lithic
SFS4-3221	unidentified	shaft	worked	bevel-ended
SFS4-3213	unidentified	shaft	worked	bevel-ended
Unprov				
SFS4-6969	unidentified	rib	cut	deep cut mark towards articular end of rib

Table 4.10 Mammal butchery and working evidence

4.2.5 Age at death and season of capture

The practice of estimating the age at death of an individual and the season of capture is a well-established one within zooarchaeology. For mammals, typical methods for estimation of age at death and season of use include the comparison of epiphyseal fusion of long bones, tooth eruption and tooth wear patterns with reference to specimens of known age in addition to known ethological behaviour such as seasonal migration patterns (O'Connor, 2000, Reitz and Wing, 1991, Hillson, 2005).

When juvenile specimens are present estimating the age of death with the known time of year for breeding, can enable an estimate of the time of year the animal was killed. For example, wild boar give birth in the spring. Rowley-Conwy's reanalysis of the wild boar specimens at the southern Swedish Late Mesolithic site of Skateholm combined metrical data from the juvenile wild boar remains with this biological behaviour (1998). Rowley-Conwy calculated that the animals were killed in the winter. At the Mesolithic site of Star Carr in North Yorkshire Carter used radiographs to calculate the stages of tooth development, and estimate season of death, of Mesolithic roe deer and red deer from Star Carr (Carter 1997;1998).

From the mammal bone assemblage there is a paucity of this type of data to shed light on the time of year Sand was in use and the age of the animals targeted. The only potential seasonal indicator is the red deer antler. Deer antler growth is seasonal and red deer antler is typically shed from late March onwards and completely shed by June but there is variation in timings (due for example, to age of animal, herd density). By the time of the rut around August and September antlers are fully regrown (Clutton-Brock *et al.*, 1982). In order to gauge if antler is shed or not antler bases are required. A shed antler could be collected at any point during the year, an unshed antler base can only be removed from a dead animal with antlers. Two unshed antler bases were recovered from Sand in the organic rich layer deposit. Assuming that in the past the cycle of antler growth and loss was similar the animal (s) these are from must have been killed before shedding in late March. As only the bases survive and not the full antler it is difficult to ascertain if the antler was fully grown, was the animal killed during the summer during a period of antler growth or in late summer or autumn during the rut when the antler would be at its largest size. It is really only possible to say when the animal (s) from which the unshed bases were *not* killed; the spring as at this point the antlers would be shed. However, this does not preclude the use of Sand at other times of year as the antler fragments in the assemblage could represent collected shed antler.

4.2.6 Bone fragmentation

Several taphonomic pathways can cause high fragmentation of bone and at Sand it is unclear if this is a result of post-depositional factors such as trampling or deliberate cultural activity. Fragmentation may be caused by the extraction of bone marrow and grease (Lyman, 1994); tool manufacture is another activity to be considered (Hardy, 2009b). Outram's Freshness Fracture Index method postdates the creation of the York system and was not applied during initial analysis. The greater than 4mm mammal bone from context 13 (as defined before any square renumbering) from the main shell midden was later reassessed using the FFI method. In order to assess the degree of bone fragmentation Outram's methodology relies on the survival of a reasonable number of shaft fragments greater than 30mm in length. The highly fragmented nature of the Sand assemblage is further highlighted as very few fragments (15%) over 30mm were recorded in the sample used for the FFI. A total of 49 shaft fragments were recorded, 19 of which had helical fractures (Table 4.11). Of all fragments over 70% were from cortical bone; very few whole or part (as defined in Outram, 2001) were recorded and no points of impact observed. A bias towards cortical bone is to be expected, as this is the predominant type of bone in the skeleton. The paucity of shaft fragments makes it difficult to interpret the FFI scores. Some helical fractures were recorded, and a range of scores were represented. This suggests that bone was broken in both a fresh and dry state.

Bone type	<20mm	20-29mm	30-39mm	40-49mm	50-59mm	60-69mm	70-79mm	80-89mm	90-99mm	100+mm	Ttotal
Cortical bone											
Shaft		23	12	25	10	2	2	2	3		79
Other cortical	4286	427	85	24	12	2	2			1	4839
Cortical subtotal											4919
Cancellous bone											
Appendicular cancellous	11	21	18	5	12	2	1	2	1		73
Axial cancellous	2	9	12	5	5	1	1				35
Rib	7	24	18	9	7	7	3	1	1		77
Other cancellous	1326	99	30	1	1	2					1459
Cancellous subtotal											1644
Cranial fragments	3	3	7	3	1	3	1	1			22
Unidentified & antler	4	10		1						1	16
Total	5639	616	182	73	48	19	10	6	5	2	6600

Table 4.11 Fracture freshness index fragments by size class and type

Bone grease and marrow extraction is not the only human activity that could have been responsible for the high degree of fragmentation. As bone tools were recovered from Sand it is possible that fragmentation is due to tool manufacture. Experimental tool manufacture by Birch (2003) found fresh bone difficult to work with due to the remains of flesh and sinew. Birch found that although bone that was two years old was initially difficult to break in to a uniform shape it was easier to work when shaping a tool than fresh bone. The FFI methodology was applied to the debris from Birch's experimental tool manufacture on red deer metapodia. The waste from 12 tools was examined as shown in Table 4.12. FFI scores of 2 and 3 were predominant and despite the bone not being fresh 19 of the 49 shaft fragments greater than 30mm had helical fractures.

FFI score	Shaft with helical fracture	Total
0	1	1
1	7	10
2	3	8
3	5	5
4	3	7
5		10
6		7
Total	19	49

Table 4.12 Fracture freshness index scores for Birch's experimental work. FFI scores only given to fragments greater than 300mm (Outram, 2002)

The cause of fracture bone from archaeological sites has long been debated, particularly with reference to the deliberate breaking by early hominids (Lyman, 1994). Simpson commented in 1895 that the larger mammal bones from MacArthur's Cave, Oban, had been broken to extract marrow (Simpson in Turner, 1895, 433). At Sand the small number of shaft fragments make it difficult to assess if the fragmentation is due to a specific cultural or post-depositional process based solely on the FFI. Although helical break is typically formed when fresh bone is broken, such breaks were also noted during Birch's experimental work on 2 year old bone. In addition, a range of taphonomic processes can create helical fractures, including trampling, carnivore gnawing and the dropping of a carcass from a distance (Lyman, 1994, 324). Bone marrow extraction at Sand remains a possibility as does fragmentation for tool manufacture and there appears to be no reason why fragmentation for marrow extraction and tool manufacture could not have taken place simultaneously.

4.3 *Small mammal and amphibian bone*

The majority of small mammal and amphibian remains (179 of which 51 were diagnostic) were recovered from the topsoil and main shell midden deposits (Table 4.13 and Table 4.14). These included shrew and vole species, wood mouse and common frog. Many of these taxa burrow or make use of burrows and given the unconsolidated nature of the midden it is likely that all are intrusive.

Taxon	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Total
Common shrew	2	2					4
Pygmy shrew	2						2
Shrew sp.	2						2
Bank vole	4	3				1	8
Field vole	1						1
Vole sp.		2				1	3
Wood mouse		4					4
Wood mouse?		2			1		3
Wood or yellow-necked mouse	4	5					9
Mouse sp.		1					1
Vole or mouse	3	3					6
Small mammal	1	4			1		6
Common frog		2					2
Unidentified	15	76	1	9	4	23	128
QC1 subtotal	18	28			2	2	51
total	34	104	1	9	6	25	179

Table 4.13 **Number of identified small mammal and amphibian specimens (Latin species name is provided in Appendix 1)**

Taxon	Element	Topsoil	Main shell midden	Shell midden	Sandy soil	Total
Common shrew	mandible	2				2
	pelvis		1			1
	tibia		1			1
Pygmy shrew	humerus	1				1
	mandible	1				1
Shrew sp.	mandible	2				2
Bank vole	mandible	3	3		1	7
	ulna	1				1
Field vole	mandible	1				1
Vole sp.	mandible		2		1	3
Wood mouse	femur		2			2
	pelvis		1			1
	ulna		1			1
Wood mouse?	femur		2			2
	mandible			1		1
Wood or yellow-necked mouse	humerus	1				1
	mandible	1	4			5
	pelvis	1				1
	tibia	1	1			2
Mouse sp.	mandible		1			1
Vole/mouse	femur		1			1
	humerus	2				2
	pelvis		1			1
	tibia	1	1			2
Small mammal	femur		2	1		3
	Metapodial		1			1
	mandible	1				1
	tibia		1			1
Common frog	radio/ulna		2			2
Total		18	28	2	2	51

Table 4.14 Small mammal and amphibian QC1 element representation

4.4 *Bird Bone*

A total of 16, 341 bird specimens were recorded from Sand. This number includes a smaller subset of 1290 identified specimens. The remaining 15,051 unidentified specimens includes both truly unidentifiable specimens and elements not routinely identified under the York system.

4.4.1 Preservation

Surface texture and percent element completeness were recorded for QC1 elements and give a quick indication of the state of preservation of the assemblage. A well preserved specimen would be expected to have an excellent surface texture and be complete. Across all contexts most specimens had either a good or fair surface texture, in total just under half had a good surface texture (Table 4.15). Few specimens were complete or near complete but the majority were greater than 20% complete (Table 4.16). In terms of bone modification (all specimens) under 2%, 267 specimens, were either burnt black or calcined white. From the main shell midden contexts 10 specimens showed signs of root etching and 2 of carnivore gnawing. A single specimen from the topsoil had been gnawed by a rodent (Table 4.17).

Texture	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Nnatural	Uunprov	Ttotal
Excellent	1	8			1				10
Good	207	596	4	21	2	4		3	837
Fair	97	193	34	65	13	19	2		423
Poor	1	7		2	1	2			13
Total	306	804	38	88	17	25	2	3	1283

Table 4.15 Surface texture of bird QC1 elements. Assessment of surface texture based on the following criteria (Harland *et al* 2003) :Excellent - majority of surface fresh or even slightly glossy; very localized flaky or powdery patches. Good - lacks fresh appearance but solid; very localized flaky or powdery patches. Fair - surface solid in places, but flaky or powdery on up to 49% of specimen. Poor - surface flaky or powdery over >50% of specimen

Element completeness	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
0-20%	64	112	10	10	1	4			201
21-40%	167	414	21	52	9	16	2	2	683
41-60%	56	189	7	21	5	2			280
61-80%	12	53		3		3			71
81-100%	7	38		2	2			1	50
Total	306	806	38	88	17	25	2	3	1285

Table 4.16 Percent completeness of bird QC1 elements

Modification	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Total
Carnivore gnawing		1		1			2
Rodent gnawing	1						1
Root etching		10					10
Calcined	1	3		1		1	6
Charred	92	85	1	22	4	57	261
Burning total	93	88	1	23	4	58	267

Table 4.17 Modification of bird bone (identified and unidentified)

4.4.2 Taxonomic abundance

From across all context types the bird bone assemblage is made up almost exclusively of seabirds, in particular species belonging to the auk family (Alcidae) (Table 4.18). Razorbill and guillemot are alcids and are most common in the assemblage. They have a very similar skeletal morphology and distinction beyond 'razorbill or guillemot' identification was only possible on a limited range of elements. Razorbills are generally slightly smaller than guillemots but the two species do overlap so size alone is not a reliable criterion (Cramp, 1985, 170). Distinction between the two was possible on well preserved distal humerii. Eleven specimens of the much larger and now extinct great auk were identified from the assemblage. The University of York does not have a great auk reference specimen so identification was based on comparison with drawings by Cohen and Serjeantson (1996). Of the other alcid species one little auk specimen was identified and two possible puffin specimens.

The habitat of razorbills and guillemots overlaps and they commonly associate with each other and puffins. Razorbills and guillemots are diving seabirds and much of their time is spent at sea, coming inland only to breed (Cramp, 1985). Guillemots are found in and by offshore and inshore waters and prefer to breed on rocky cliffs, stacks or islets with ledges. Breeding colonies are large and densely packed; eggs are laid from late April onwards and hatch between 28-37 days later. Razorbills have similar breeding habits but breed in less dense colonies and eggs hatch between 29-32 days after being laid. After breeding, adult guillemots stay close in shore near the colony; many may be present all year round whilst the younger birds spend all year at sea. Razorbills and guillemots feed mostly on fish but their diet also includes some invertebrates. In winter razorbills have been observed feeding in large flocks (Snow and Perrins, 1998, 806-810 and 812-814). Puffins nest in burrows along coasts and islands facing the sea (Snow and Perrins, 1998, 821-825).

A small number of shag or cormorant specimens were identified. These species present a similar identification problem to razorbill and guillemot; cormorant is the larger of the two but they are very similar osteologically. Identification was not attempted to species level. As for guillemot and razorbill the habitat of cormorants and shags can overlap, but unlike the alcids they rarely share breeding sites. Shag is an exclusively marine bird but cormorant will nest inland as well as along the coast. Both have a diet of fish. In terms of season of breeding both species nest from around March and eggs take approximately 30 days to hatch (Snow and Perrins, 1998, 80-86). Shag and cormorants are currently resident around the British coastline. The only non-seabird taxa recorded from the site were three specimens of thrush and chat family, this includes species such as the blackbird and wheatear.

Taxon	Topsoil	Main shell midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Shag or cormorant	1	6								7
Razorbill	2	16			1					19
Guillemot	18	58		1	2					79
Razorbill or guillemot	241	645		35	69	10	19	2	3	1024
Little auk		1								1
Puffin?	2									2
Great auk	4	5			1	1				11
Auk family	39	76		2	15	6	6			144
Thrush & chat family		3								3
Unidentified	3608	7953	8	549	2375	206	325	9	18	15051
Auk family subtotal	306	801		38	88	17	25	2	3	1280
QC1 subtotal	307	810		38	88	17	25	2	3	1290
Total	3915	8763	8	587	2463	223	350	11	21	16341

Table 4.18 Bird number of identified specimens from Sand

4.4.3 Element representation

In the York recording protocol 8 bird 'QC1' diagnostic specimens are routinely recorded; carpometacarpus, coracoid, femur, humerus, scapula, tarsometatarsus, tibiotarsus and ulna. QC1 elements were recorded from all context groups. From the main shell midden contexts QC1 elements were recorded for shag or cormorant, razorbill, guillemot, little auk, great auk and the thrush or chat family. Table 4.19 shows the elements recorded from the site and Table 4.20 shows the MNE estimate (minimum number of elements as discussed in the methodology chapter) for the same elements from the main shell midden and organic rich contexts for razorbill or guillemot and shag or comorant.

Figure 4.6 shows the distribution of the razorbill and guillemot elements from the main shell midden contexts. All QC1 elements are present in the main shell midden contexts with a bias towards the pectoral and wing elements such as the coracoid, humerus and ulna. Wing and leg elements are both robust in alcids, therefore, this pattern is unlikely to be a preservational bias. The pattern is most marked when the carpometacarpus, an element from the distal end of the wing and the tarsometatarsus (from the distal end of the leg) are compared. Whatever processing of the razorbills and guillemots took place it meant that roughly two thirds fewer legs than wings ended up in the midden. The scapula also appears underrepresented when compared the numbers of coracoids and humeri.

Taxon	Element	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Shag or cormorant	coracoid	1	3							4
	femur		2							2
	humerus		1							1
Razorbill	coracoid		5							5
	humerus	2	11		1					14
Guillemot	carpometacarpus	1	8							9
	coracoid	1	6							7
	femur		1							1
	humerus	15	39	1	2					57
	scapula		1							1
	tarsometatarsus		1							1
	ulna	1	2							3
Razorbill or guillemot	carpometacarpus	33	88	5	10	3	4	1		144
	coracoid	71	159	15	17	3	3		1	269
	femur	20	34	1	4					59
	humerus	45	137	8	19	1	3			213
	scapula	16	46		7		5			74
	tarsometatarsus		6							6
	tibiotarsus	13	41		2	1	3		1	61
	ulna	43	134	6	10	2	1	1	1	198

Taxon	Element	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Little auk	tarsometatarsus		1							1
Puffin?	coracoid	1								1
	humerus	1								1
Great auk	carpometacarpus	1								1
	coracoid	2				1				3
	humerus	1	3		1					5
	scapula		1							1
	ulna		1							1
Auk family	carpometacarpus	6	2	1			1			10
	coracoid	4	22	1	6	1	3			37
	femur	2	9							11
	humerus	17	27		6		1			51
	scapula	5	4		1	1	1			12
	tarsometatarsus	2	2			1				5
	tibiotarsus	2	5			3				10
	ulna	1	5		2					8
Thrush and chat family	coracoid		1							1
	humerus		2							2

Taxon	Element	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Total		307	810	38	88	17	25	2	3	1290

Table 4.19 Element representation of bird specimens from Sand

	Razorbill or guillemot		Shag or cormorant
Element	Main shell	Organic rich	Main shell
Carpometacarpus	62	6	
Coracoid	101	10	2
Femur	24	3	2
Humerus	93	9	1
Scapula	46	7	
Tarsometatarsus	5		
Tibiotarsus	27	1	
Ulna	87	7	

Table 4.20 Minimum number of elements for razorbill or guillemot from the main shell midden and organic rich and shag or cormorant from the main shell midden

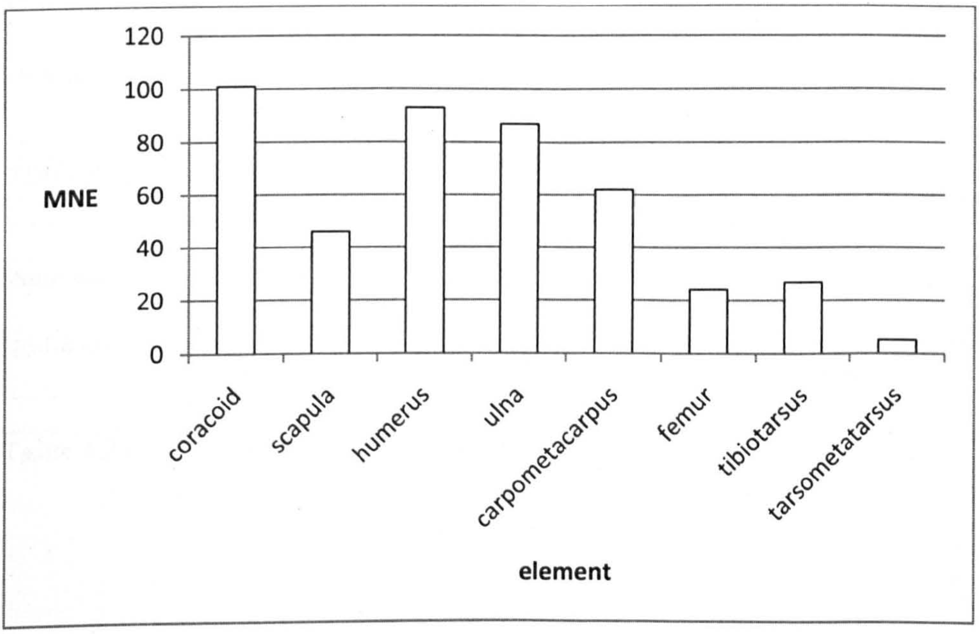


Figure 4.6 Combined razorbill or guillemot minimum number of elements from the main shell midden contexts

4.4.4 Butchery evidence

Four cut marks were recorded on the bird bone, all on wing elements, 2 of which were on specimens from the main shell midden contexts (Table 4.21). All of the cut marks are very similar, a series of short parallel cuts. The cut marks on the humerus are below or on the head of the proximal end and may be consistent with wing removal. The marks on the bone shafts may be a result of cleaning the bone. Ethnographic and ethnohistoric evidence from Greenland and Scotland shows that auks provide many potential resources. This includes marrow, meat, skins and feathers (as discussed in Baldwin, 1974, Gotfredsen, 1997, Serjeantson, 1997).

Bone id	Taxon	Element	Modification	Notes
Topsoil				
SFS4-4120	razorbill or guillemot	humerus	cut	medio-lateral cut mark below proximal head, fine scratches visible over entire shaft
Main shell midden				
SFS4-5052	razorbill or guillemot	humerus	cut	medio-lateral cut mark c.2 mm on medial surface of shaft & 2 parallel cut marks on head
SFS4-4282	razorbill or guillemot	ulna	cut	4 very fine, sporadic cut marks, approx medio-laterally, along shaft
Slopewash				
SFS4-4328	razorbill or guillemot	humerus	cut?	possible cut mark below crista lateralis of proximal head

Table 4.21 Bird butchery evidence from Sand

4.4.5 Bird age and season and method of capture

Based on the surface texture consistent with immature bones, 15 juvenile alcid QC1 elements were recorded Table 4.22. Ageing of alcid bones is typically carried out on skull development; changes in bone fusion is observable into a bird's third year of age (Van Peer, accessed 13.7.2012). It is unclear at what age the bones in the rest of body have an adult appearance.

Taxon	Element	Topsoil	Main shell midden	Organic rich	Total
Razorbill or guillemot	Carpometacarpus		1		1
	Coracoids		2		2
	Humerus		1		1
	Ulna	1			1
Auk family	Coracoids		2		2
	Femur		1		1
	Humerus	2	3	1	6
	Scapula	1			1
Total		4	10	1	15

Table 4.22 Juvenile bird specimens recovered from Sand

Serjeantson has argued that there is a restricted period of time when certain seabirds are readily available to catch (1988, 24). For razorbills and guillemots this is either during the breeding season or during the post-breeding moult. Razorbills and guillemots often form colonies together and prefer steep, rocky, sea-facing cliffs. The two species generally breed in May and June and brood for around 34 days. The breeding season offers one opportunity for birds to be taken from the cliffs. Adult birds rather than young birds were targeted at breeding sites in recent centuries (Serjeantson 2001). Hand nets and rods, with a snare at the end, were used to catch sitting birds and birds in flight (Figures 4.7 and 4.8).

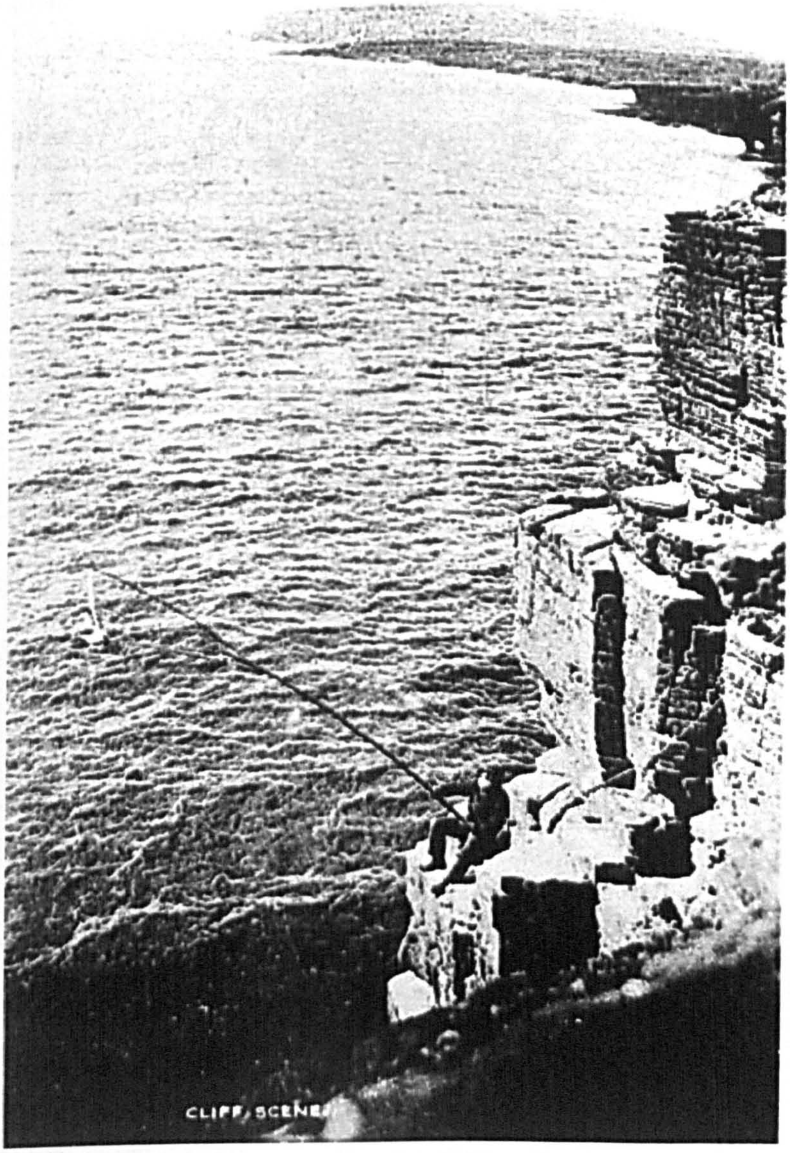


Figure 4.7 Hunting auks at Westray, Orkney Isles, early 20th century. Image source: SCRAN

The second period of potential capture is in late summer and into autumn when adult birds have a complete post-breeding moult at sea. From late July to November the birds are flightless for 45-50 days until their primary feathers grow back (Cramp, 1985, 171-178, Serjeantson, 1988, Serjeantson, 2001). Rafts of flightless, moulting birds can be seen today in the Inner Sound and Loch Snizort during August and September (Yoxon and Yoxon, 1990, Steven Birch pers comm.). Similar equipment to the snares and nets in the figures shown in this section were also used to take birds from the water in the historically recent past (Baldwin 1974).

Figure 4.8 **Auks caught by net at Westray, Orkney, in the early 20th century. Image source: SCRAN**

Recent research by McSorley *et al.* has demonstrated that during the breeding season aggregations of alcids are found in waters within approximately 1km of the colony and the highest densities typically within 200m. This provides an additional season of capture from water to the two identified by Serjeantson. In addition to feeding and cleaning, large numbers of birds were recorded sitting on the sea doing nothing (McSorley et al., 2003). Taking this and the post-moult into consideration the period that birds could be taken from the water could run from May until September. If the assumption is made that the behaviour of razorbills and guillemots was similar in the past when Sand was in use, this is potentially a 5 month period of capture. It is difficult to say if the small number of juvenile bones reflects hunting during the late summer and autumn moult when fewer juveniles would be present, or, if it is the product of a targeting of only adult birds, thereby largely excluding juveniles. However, given that the post-breeding moult in late summer and early autumn would offer large numbers of readily accessible birds to be taken from the water by boat it is reasonable to conclude that if razorbills and guillemots were targeted in a large number at any one time August and September during this moult would be the most likely period of time. Shags and cormorants are resident all year round and their capture would not be seasonally restrictive. They may have been taken from the coastline at any point during the year, but the main season of fowling based on the auk evidence is late summer and into autumn.

4.5 *Fish bone*

From Sand 53,697 fish bones were recovered, of which 14, 954 were identified. In the York recording protocol (detailed in the methodology chapter), a set of 18 diagnostic elements are recorded in full (QC1 elements); vertebrae (QC2) and elements such as otoliths (QC4) are also recorded. Unidentified specimens represent elements not classified as either QC1, 2 or 4 and truly unidentifiable specimens

4.5.1 Preservation

Preservation of the fish remains from all contexts, based on the surface texture of QC1 elements, was generally good to fair (Table 4.23). Percentage completeness of the same elements was more variable (Table 4.24). Less than 2% of fish bone was burnt, the majority charred black rather than calcined white (Table 4.25).

Texture	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Unprov	Total
Excellent	22	20		1	1	5		49
Good	141	535	1	20	9	17	2	725
Fair	111	352	2	25	16	16	3	525
Poor	21	49	2	10	3	1		86
Total	295	956	5	56	29	39	5	1385

Table 4.23 **Surface texture of fish bone.** Assessment of surface texture based on the following criteria (Harland *et al.*, 2003) Excellent - majority of surface fresh or even slightly glossy; very localized flaky or powdery patches. Good - lacks fresh appearance but solid; very localized flaky or powdery patches. Fair - surface solid in places, but flaky or powdery on up to 49% of specimen. Poor - surface flaky or powdery over >50% of specimen

Element completeness	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Unprov	Total
0-21%	37	132		8	3	5		185
21-40%	94	281	4	24	12	11		426
41-60%	78	184		3	9	8		282
61-80%	40	189		8	2	9	3	251
81-100%	46	164	1	13	3	6	2	235
Total	295	950	5	56	29	39	5	1379

Table 4.24 **Element completeness of fish bone**

Six specimens, 4 from the topsoil contexts and 2 from the main shell midden contexts showed evidence of crushing whilst the bone was fresh (Table 4.25); an additional specimen showed signs of acid etching. Both of these modifications are consistent with mastication (Jones, 1991). Crushing is also a feature of otter spraint. However, at Sand no concretions were found on the bone which is another common feature of spraint (Nicholson, 2000). The lack of concretions, small number of crushed specimens and the presence of burnt material discounts otter spraint at Sand.

Modification	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Unprov	Total
Acid etched		1						1
Crushed	4	2						6
Calcined	6	42		6	2	1		57
Charred	172	475	1	59	11	16	3	737
Burning total	178	517	1	65	13	17	3	794

Table 4.25 Fish bone modification (all specimens)

4.5.2 Taxonomic abundance

The assemblage from Sand is dominated by two families, the cod family (Gadidae) and wrasse family (Labridae) (Table 4.26). Saithe and pollack were the most common gadid species recorded at Sand. The two species have a similar anatomy and due to the small size of the specimens distinguishing between the two was sometimes problematic. Specimens which had the characteristics of saithe or pollack but could not positively be identified were left at genus level and recorded as *Pollachius*. Distinction between saithe and pollack otoliths is especially problematic (Harkonen, 1986, 100) and identification beyond *Pollachius* was not attempted. Saithe and pollack vertebrae recorded during the MSc were only identified to genus level. The habitats of the species are similar, the young are common inshore fish in northern waters, however, saithe form shoals and pollack do not.

The wrasse family is a very large family of fishes. In northern European waters seven species are known, many of which inhabit the shallow water of rocky coastlines (Wheeler, 1969, 361-372). The most abundant species from Sand is ballan wrasse; cuckoo wrasse, corkwing wrasse and goldsinny were also identified. Labrids were identified to species were possible. Identification to 'ballan or cuckoo wrasse' was necessary especially for some vertebrae. Similarly, some specimens were identified to 'corkwing wrasse or goldsinny'.

Apart from saithe, pollack and the wrasses there were few other taxa recorded in any great number. The taxa list is long but other than herring, cod and Atlantic mackerel, many fish are represented by fewer than 20 specimens. Herring are mainly found in offshore waters, from the water surface down to 200m. First and second year herring, however, stay in shallow water and may be found close to where they were spawned. Typically at one year herring are 7-9cm, and in their second year around 16-18cm but there is much regional variation (Wheeler, 1969). Atlantic mackerel is a common catch off the coast in summer and autumn (Wheeler, 1969). Large cod inhabit deep water but the fish from Sand are small (section 4.6.4) and such specimens can be found close to the shore. Specimens recorded as *Gadus/Pollachius* had characteristics of cod, saithe or pollack.

Taxon	Topsoil	Main shell midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Tope		1								1
Dogfish families	1	12								13
Ray family	4	1				1				6
Elasmobranch	1	3								4
Herring	73	87		1	11	9	8		10	199
Eel	3	10					1			14
Conger eel	1									1
Salmon family	1						3			4
Rockling sp.	2	1								3
Saithe	186	275		6	2	9	23		8	509
Pollack	39	101			1	3				144
Saithe or pollack	710	1487	1	12	22	44	21		26	2323
Cod	26	99		3	1	1	6			136
Cod, saithe or pollack	397	1309		13	17	9	35		6	1786
Haddock	4	3			1					8
Whiting	4	3			1					8
Poor cod		3								3
Norway pout, bib or poor cod	5	1		1		1				8
Cod family	616	993	1	36	137	37	83		8	1911
Gurnard family	2									2
Sea scorpion family		3								3
Atlantic horse mackerel	2	15								17
Sea bream family		1								1
Sea bream family?							1			1
Corkwing wrasse	29	48		1	2	1	1		3	85
Goldsinny	1	1								2
Corkwing wrasse	29	37				2	10			78

Taxon	Topsoil	Main shell midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
or goldsinny										
Ballan wrasse	110	246		1	15	20	11		2	405
Cuckoo wrasse	2	16								18
Ballan or cuckoo wrasse	741	808		29	36	50	125	1	8	1798
Wrasse family	817	3922		8	286	66	93	1	38	5231
Eelpout									1	1
Butterfish		17		1						18
Sandeel family	1	4								5
Atlantic mackerel	23	159			7	1	5		4	199
Perch order	1									1
Plaice						1				1
Plaice family	1	4					1			6
Flatfish order		1								1
Unidentified fish	8835	24356	3	314	2913	738	1331	2	250	38742
Cod family subtotal	1989	4275	2	71	182	104	168	48		6839
Wrasse family subtotal	1729	5157		39	339	139	240	2	51	7696
Identified fish subtotal	3832	9671	2	112	539	255	427	2	114	14954
Total fish	12668	34027	5	426	3452	993	1758	4	364	53697

Table 4.26 **Fish number of identified specimens from Sand**

4.5.3 Element representation

The main shell midden contexts (list the numbers) produced 9671 diagnostic elements; 960 QC1 elements, 7910 QC2 elements and 801 QC4 elements. A smaller assemblage was recorded from the organic rich layer: 57 QC1, 466 QC2 and 416 QC4 elements. From the topsoil layer a sizeable amount of diagnostic material was also recorded; nominal numbers of diagnostic specimens were recorded from other contexts (Table 4.27). From the main shell midden contexts almost the full range of QC1 elements is present for the gadid and labrid families (Figure 4.9) but, the relative abundance of different elements is highly variable.

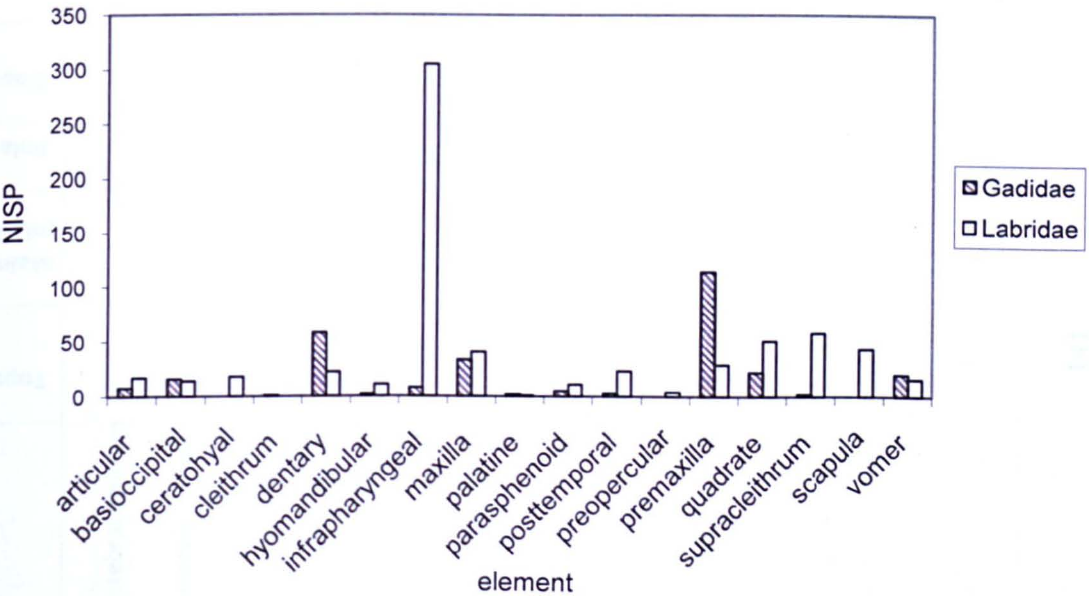


Figure 4.9 Gadid and labrid element representation, main shell midden contexts

For the wrasse family the most abundant element is the infrapharyngeal. As this is a very robust element with a distinctive morphology (Figure 4.10) it is likely that taphonomic and identification biases may have exaggerated its abundance, or rather other elements may be underrepresented.

Figure 4.10 Fish bones from Sand. Many of these bones are wrasse infrapharyngeals, the clearest example is at the bottom right

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Black mouthed dogfish	2	mineralised vertebral centrum		1								1
Dogfish families	2	mineralised vertebral centrum	1	12								13
Ray family	4	dermal denticle	4	1				1				6
Elasmobranch	2	mineralised vertebral centrum	1	3								4
Eel	1	basioccipital		1								1
		quadrate		1								1
		vomer		1								1
	2	abdominal vertebra	3									3
		caudal vertebra		7					1			8
Conger eel	2	caudal vertebra	1									1
Herring	2	abdominal vertebra	45	44			5	5	6		8	113
		abdominal vertebra3		1								1
		caudal vertebra	25	29		1	6	4	2		2	69
		caudal vertebra2		1								1
		first vertebra	2									2
		penultimate vertebra		1								1
		ultimate vertebra	1									1
		vertebra		11								11
Salmon family	2	caudal vertebra	1						1			2
		vertebra							2			2

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Rockling sp.	2	abdominal vertebra	1									1
		abdominal vertebra1	1									1
		caudal vertebra1		1								1
Saithe	1	basioccipital	4	4					1			9
		dentary	3	11								14
		hyomandibular	2	1								3
		infraphryngeal	1	1								2
		maxilla	6	7				2	1			16
		palatine	2	1				1				4
		parasphenoid		2								2
		posttemporal	1	1								2
		premaxilla	15	30					1			46
		quadrate	8	9								17
		supracleithrum	2									2
		vomer	5	3								8
	2	abdominal vertebra	2									2
		abdominal vertebra1	25	45		2	1	3	6			82
		abdominal vertebra2	21	30		2	1	1	5		1	61
		abdominal vertebra3	35	50				1	5		1	92
		caudal vertebra	4	1								5
		caudal vertebra1	24	53		2			2		2	83
		caudal vertebra2	23	21				1	1		3	49
		first vertebra	3	5					1		1	10
Pollack	1	articular		1								1

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
		basioccipital		3								3
		dentary		6								6
		maxilla		3								3
		premaxilla		13								13
		quadrate		1								1
	2	abdominal vertebra		1								1
		abdominal vertebra1	7	5								12
		abdominal vertebra2	2	5				1				8
		abdominal vertebra3	16	39			1	1				57
		caudal vertebra	2									2
		caudal vertebra1	7	14				1				22
		caudal vertebra2	5	10								15
Saithe or pollack	1	articular					1					1
		basioccipital		2								2
		cleithrum		1								1
		dentary	3	12								15
		hyomandibular						1				1
		infraphryngeal		5								5
		maxilla	4	6		1		1				12
		palatine	1									1
		parasphenoid		2								2
		posttemporal	3									3
		premaxilla	10	24			1					35
		quadrate		1				1				2
		supracleithrum	2	1								3
		vomer	1	6								7

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
	2	abdominal vertebra	9	282				4				295
		abdominal vertebra1	60	56		7	4	5	5		2	139
		abdominal vertebra2	36	24		1	1	3	1		1	67
		abdominal vertebra3	46	71		1	2	1	3		3	127
		caudal vertebra	15	298			2					315
		caudal vertebra1	31	27							2	60
		caudal vertebra2	39	29		2		2	2			74
		first vertebra	6	24								30
		penultimate vertebra		2								2
		vertebra		1								1
	4	otolith	444	613	1		11	26	10		18	1123
Cod	1	basioccipital		1								1
		dentary		6								6
		hyomandibular	1									1
		maxilla		1								1
		parasphenoid				1						1
		posttemporal	1									1
		premaxilla		4					1			5
		quadrate	2	4								6
		vomer	2	1								3
	2	abdominal vertebra	1	13								14
		abdominal vertebra1	3	5		1	1					10
		abdominal vertebra2	1	2					1			4
		abdominal vertebra3	5	3					2			10
		caudal vertebra		41								41
		caudal vertebra1	1	1		1			1			4

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
		caudal vertebra2		5								5
		first vertebra	3	1					1			5
	4	otolith	6	11				1				18
Cod, saithe or pollack	1	articular		2								2
		basioccipital		1								1
		dentary	6	8								14
		hyomandibular		1								1
		infraphryngeal	2	1								3
		maxilla	2	7								9
		posttemporal	1									1
		premaxilla	7	14					4			25
		quadrate	2	1								3
		vomer		6								6
	2	abdominal vertebra	22	412		3	7		1		1	446
		abdominal vertebra1	87	49		1		2	11		1	151
		abdominal vertebra2	26	33					4			63
		abdominal vertebra3	51	114		6		1	1		2	175
		caudal vertebra	46	373		1	7	2	3			432
		caudal vertebra1	89	133				2	8		2	234
		caudal vertebra2	26	48		2	1	1	3			81
		first vertebra	3	15			2					20
		penultimate vertebra	1	1								2
		ultimate vertebra		1								1
		vertebra	1	67								68
	4	otolith	25	22				1				48

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Haddock	1	parasphenoid					1					1
		posttemporal		1								1
	2	abdominal vertebra1		1								1
		caudal vertebra	2									2
		caudal vertebra1	1									1
		caudal vertebra2	1									1
	4	otolith		1								1
Whiting	1	premaxilla		1								1
	2	abdominal vertebra	3	2								5
		caudal vertebra	1				1					2
Poor cod	4	otolith		3								3
Norway pout, bib or poor cod	2	abdominal vertebra	1			1						2
		abdominal vertebra1	1									1
		caudal vertebra1	1									1
	4	otolith	2	1				1				4
Cod family	1	articular	3	5			1					9
		basioccipital	1	5					1			7
		dentary	6	15			1	1				23
		hyomandibular	1									1
		infraphryngeal		1								1
		maxilla	3	9					1			13
		palatine	2	1								3
		parasphenoid	1	1								2

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
		posttemporal	2	1			1					4
		premaxilla	20	28		1	7	3	2			61
		quadrate	2	6			1		1			10
		supracleithrum	1	1								2
		vomer	1	4					1			6
	2	abdominal vertebra	48	199	1	2	68	8	9			335
		abdominal vertebra1	74	87		5	6	7	6			185
		abdominal vertebra2	9	15		1			1			26
		abdominal vertebra3	37	43			3		13		1	97
		caudal vertebra	126	232		6	38	11	9		2	424
		caudal vertebra1	37	59		1	1		8			106
		caudal vertebra2	21	15		1	2		8		1	48
		first vertebra	18	22		1	2	1			1	45
		penultimate vertebra	1				1					2
		vertebra	64	98		15		1	12		2	192
	4	otolith	138	146		3	5	5	11		1	309
Gurnard family	1	premaxilla	1									1
	2	abdominal vertebra	1									1
Sea scorpion family	2	abdominal vertebra		1								1
		first vertebra		1								1
		ultimate vertebra		1								1
Atlantic horse mackerel	2	abdominal vertebra	1	6								7
		caudal vertebra	1	6								7
	4	otolith		3								3

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Sea bream family	2	caudal vertebra		1								1
		vertebra							1			1
Corkwing wrasse	1	infraphryngeal	6	23			1	1			3	34
		premaxilla		1								1
		preopercular		4								4
		quadrate		2								3
		vomer	2						1			3
	2	abdominal vertebra	14	8			1					22
		caudal vertebra	7	8		1						16
		vertebra		2								2
Goldsinny	1	infraphryngeal	1	1								2
Corkwing wrasse or goldsinny	2	abdominal vertebra	23	15				1	2			41
		caudal vertebra	6	18				1	8			33
		caudal vertebra2		4								4
Ballan wrasse	1	articular	9	8			3	1			1	22
		basioccipital		2								2
		ceratohyal	1	7			1	1	1			11
		dentary	3	6							1	10
		infraphryngeal	13	46			1		1			61
		maxilla	2	8								10
		palatine	1						1			2
		parasphenoid	1	3								4

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
		posttemporal	1	6			2	1	1			11
		premaxilla		3				1	1			5
		quadrate	4	12			1	1				18
		supracleithrum	3	8				1	4			16
		scapula		1								1
		vomer		4								4
	2	abdominal vertebra	51	94		1	4	11	1			162
		caudal vertebra	18	26			3	1				48
		first vertebra	3	8				2	1			14
		penultimate vertebra		1								1
		ultimate vertebra		3								3
Cuckoo wrasse	1	infraphryngeal		3								3
		posttemporal	1									1
		quadrate		1								1
		supracleithrum		2								2
		vomer		2								2
	2	abdominal vertebra	1	2								3
		caudal vertebra		5								5
		first vertebra		1								1
Ballan or cuckoo wrasse	1	basioccipital		1								1
		infraphryngeal	2	8				2				12
		maxilla	1	2				1				4
		opercular	1									1
		palatine	1									1
		parasphenoid		1								1

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
		posttemporal	1									1
		quadrate		1								1
		supracleithrum	3									3
		scapula		3								3
		vomer		1								1
	2	abdominal vertebra	401	396		22	24	35	85	1	5	969
		abdominal vertebra1		1								1
		caudal vertebra	300	379		6	10	10	29		3	737
		first vertebra	22	13		1	2	2	9			49
		penultimate vertebra	9						2			11
		ultimate vertebra		2								2
Wrasse family	1	articular	2	9			1					12
		basioccipital	6	11				2	1			20
		ceratohyal	2	11			3		2			18
		cleithrum	1									1
		dentary	7	16			5					28
		hyomandibular	6	11				1	1			19
		infraphryngeal	30	224		1	9	1				265
		maxilla	9	30			5	2	4			50
		palatine	4	1								5
		parasphenoid	1	7								8
		posttemporal	5	17			1	1				24
		premaxilla	3	25			1	1	2			32
		quadrate	4	35			5	1	3			48
		supracleithrum	7	48		1	2	1				59
		scapula	4	39			1		3			47

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
		vomer	5	9			1					15
	2	abdominal vertebra	361	1615		5	129	29	47	1	19	2206
		caudal vertebra	295	1535			96	20	23		16	1985
		caudal vertebra1									2	2
		first vertebra	41	122		1	22	5	5		1	197
		penultimate vertebra	23	42			4	1	2			72
		ultimate vertebra	1	20			1					22
		vertebra		95				1				96
Eelpout	2	abdominal vertebra									1	1
Butterfish	2	abdominal vertebra		13								13
		caudal vertebra		4		1						5
Sandeel family	2	abdominal vertebra	1	4								5
Atlantic mackerel	2	abdominal vertebra	4	67			1		1		1	74
		abdominal vertebra3	2									2
		caudal vertebra	16	85			6	1	4		3	115
		vertebra	1	7								8
Perch order	1	parasphenoid	1									1
Plaice	2	abdominal vertebra						1				1
Plaice order	2	abdominal vertebra		2								2
		caudal vertebra	1	2					1			4

Taxon	QC	Element	Topsoil	Main midden	Palaeo	Slopewash	Organic rich	Shell midden	Sandy soil	Natural	Unprov	Total
Flatfish order	2	vertebra		1								1
Total			3832	9671	2	112	539	255	427	2	114	14954

Table 4.27 Fish element representation from Sand

When the minimum number of elements is calculated (MNE) the labrid infrapharyngeal is still represented by a much higher number of elements than any other single element (Table 4.28). In wrasse the infraphryngeal is a midline element that only occurs once in the body. Its distinct morphology may have made it readily visible to sample sorters and the robustness will have increased the chance of identification. Although this may appear to skew any skeletal element patterning it may actually provide a reasonable estimate of the number of fish present. It also highlights how underrepresented other elements are. Preservation and post-excavation bias may also have influenced the element distribution of the gadids as the most abundant element, the premaxilla, has a robust and distinctive articular end.

Element	Gadidae	Labridae
Basioccipital	15	14
Parasphenoid	4	6
Posttemporal	3	20
Vomer	13	15
Premaxilla	98	20
Maxilla	29	26
Dentary	53	15
Articular	4	15
Quadrate	21	48
Palatine	2	1
Ceratohyal		15
Hyomandibular	2	10
Cleithrum	1	
Supracleithrum	2	56
Infrapharyngeal	4	188

Table 4.28 Gadidae and labridae minimum number of elements for the main shell midden

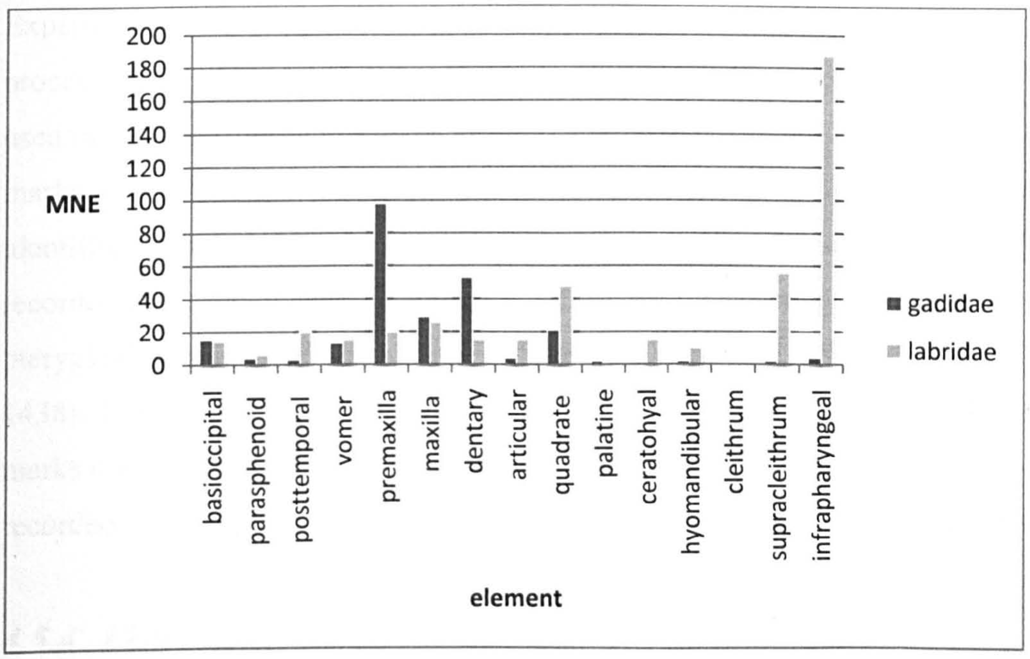


Figure 4.11 MNE distribution for combined cod family fish and wrasse family fish from the main shell midden contexts

The lack of gadid appendicular elements such as the cleithrum, supracleithrum and scapula could be interpreted as a butchery pattern. In the classic stockfish pattern (albeit from a much later period) these elements are sometimes left in dried fish after removal of the head and are taken away from the catch site (for example, Barrett, 1997). Dried fish production also leads to vertebrae to be underrepresented and in Norse and later period assemblages often leaves strong cut mark evidence (Barrett, 1999). However, at Sand cod family abdominal and caudal vertebrae are both abundant (Table 4.28) and only one possible cut mark was recorded on fish bone; a ballan wrasse caudal vertebrae (SFS-6028).

The over-abundance of gadid premaxillae and wrasse infraphryngeals seems more likely a factor of preservation and identification biases rather than a specific processing pattern. A lack of clear processing pattern does not mean that the fish were not processed; clearly the fish carcasses were discarded, and a fish can be filleted and few bones removed. Fillets of fish could then be eaten fresh or dried or smoked to preserve. In Scotland the air drying of fish is known from ethnohistorical sources (Saville, 2004) It is difficult to assess if the bones represent fish that had been caught then eaten fresh or the processing of fish for storage (or both).

Experimental work by (Willis *et al.*, 2008) examined the cut marks left by fish processing. Various methods based on ethnographic and modern fish accounts were used using stone tools and a metal knife 37 fish were butchered. They found that cut marks were left but that they frequently occurred on elements that are not typically identified, or not identified to specific taxon, by zooarchaeologists. Cut marks were recorded on vertebral neural and haemal spines, the transverse processes of vertebrae, pterygiophores, ribs and other bones generally not identified. (Willis *et al.*, 2008, 1438). Due to their occurrence on non-diagnostic bones the authors suggest that cut marks may be overlooked during analysis. The bones they list are not routinely recorded in the York system and indeed may have been overlooked during my analysis.

4.5.4 *Fish size*

Based on comparison with reference specimens of known total length (TL), the majority of fish bones at Sand, came from small (151-300mm TL) and medium (301-500mm TL) sized fish (Table 4.29).

Size	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Unprov	Total
Very large (801-1000mm)	1							1
Large (501-800mm)	7	30	1	4	1			43
Medium (301-500mm)	108	239		14	8	14	1	384
Small (151-300mm)	167	606	3	33	20	20	4	853
Tiny (<150mm)	8	56	1	2		4		71
Total	291	931	5	53	29	38	5	1352

Table 4.29 **Fish size**

In Table 4.30 the size of fish is shown for the wrasse family and cod family fish are broken down by species. Wrasse are small to medium fish; ranging from the ballan wrasse at an average total length of 300-500 mm TL to the goldsinny at around 100-140 mm TL that are found along the west coast today (Sayer and Treasurer 1996, 3-7). Wrasses are not commercially exploited for food but goldsinny, rock cook and corkwing are used as cleaner fish in the salmon farming industry to control sea lice infestations (Sayer *et al.*, 1996). Research into growth rates is limited and is largely a response to the emergence of this commercial, albeit small, fishery and the impact this may have on population and social structure (Treasurer, 1994). The effectiveness of various capture techniques has also been studied by Treasurer (1994; 1996; 2000). Baited and unbaited creels and traps were successful, although larger species such as ballan and cuckoo wrasse were underrepresented (probably due to the small apertures of the fishing gear). Perhaps of most relevance here are the by-catches found associated with these wrasse fishing techniques: saithe, pollack, cod, conger eel, scorpion fish, rockling, flatfish and dogfish (Treasurer, 1996, 75). All of these taxa are represented at Sand, with saithe and pollack particularly abundant.

Taxon	**Size**	**Topsoil**	**Main shell midden**	**Slopewash**	**Organic rich**	**Shell midden**	**Sandy soil**	**Unprov**	**Total**
All wrasse family subtotal	large	1	2		1				4
	medium	50	142		10	3	11	1	217
	small	98	468	2	28	16	11	4	627
	tiny	4	38		2		3		47
Saithe	large	1	2			1			4
	medium	20	23			1	1		45
	small	27	39			1	2		69
	tiny	1	6						7
Pollack	large		4						4
	medium		14						14
	small		8						8
	tiny		1						1
Saithe or pollack	very large	1							1
	large	1	4	1	1				7
	medium	11	20		1	2			34
	small	11	32			1			44
	tiny		1						1
Cod	large	1	5						6
	medium	2	5				1		8
	small	3	6	1					10
	tiny		1						1
Cod, saithe or pollack	large	1	1						2
	medium	6	15						21
	small	13	21				4		38
	tiny		3						3

Taxon	Size	Topsoil	Main shell midden	Slopewash	Organic rich	Shell midden	Sandy soil	Unprov	Total
Haddock	medium		1		1				2
Whiting	tiny		1						1
Cod family	large	2	10		2				14
	medium	17	19		2	2	1		41
	small	15	32		5	2	3		57
	tiny	3	4	1			1		9
All cod family subtotal	very large	1							1
	large	6	26	1	3	1			37
	medium	56	97		4	5	3		165
	small	69	138	1	5	4	9		226
	tiny	4	17	1			1		23

Table 4.30 **Size of fish: wrasses and cod family fish by species based on QC1 elements**

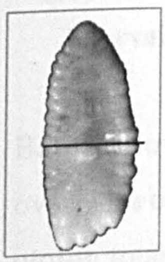
From Sand the majority of gadids (including saithe and pollack) based on estimate of total length were medium (301-500mm total length) or small (151-300mm total length). Both saithe and pollack are found in the waters surrounding the west coast of Scotland and local fishermen attest to the abundance of pollack (which are known locally as *lythe*) around the coast of the Applecross Peninsula today. The behaviour of saithe would make them more likely to be caught in greater abundance, as they form small shoals throughout the year. Only sexually mature, adult pollack, shoal during the spawning period. However, the fish are often found in numbers on reefs, with young pollack found closer to the shore than adults, and today are a common catch of anglers (Wheeler, 1969, 272-273, Whitehead *et al.*, 1986). The adult size of saithe and pollack is much larger than that of wrasse and they can reach lengths of over 1 m (Wheeler, 1969, 167-275).

Turning first to saithe, they have a consistent growth pattern in the first 3 to 4 years, growing approximately 150mm each year. First year fish, therefore, are generally around 150mm and second year fish around 300mm total length. Saithe spawn in offshore deep water and today spawning typically takes place between January and April but the timings of this are largely dependent on geographic location (Bertelsen 1942, Wheeler 1969). To begin with the young fry live near to the surface of the water but by mid-summer are found close inshore and they remain so for at least a year

(Wheeler, 1969, Bertelsen). In Scottish waters the second year fish continue to live along the shoreline until migrating offshore into deeper water in spring. In late summer and autumn young saithe (presumably first and second years) are found in large numbers in Scottish and Norwegian coastal waters (Scottish Government: Marine and Fisheries website).

Less is known about pollack as they have not been as commercially important as saithe. Both young (first and second year fish) and older fish are found inshore, the adults more so in summer and they are a common catch of anglers today. Pollack do not shoal unless spawning, although small groups may gather within certain areas, typically around reefs. Wheeler notes the fish are less common around the northern British coastline. As for saithe, spawning takes place between January and April. The growth rates of pollack are less well known than that of saithe. Wheeler reports estimates of total lengths of 13.5-17cm in the first year, 26-31cm in the second year, 37-40 cm in the third year and 45-48cm in the fourth year but cautions that these lengths are based on small sample sizes (Wheeler, 1969, 272-273, Whitehead *et al.*, 1986).

From the estimated fish total length categories (Table 4.30) it is not possible to see *where* within the size brackets specimens are from; are there two clear size groupings or are most fish around 300mm length.



A more accurate estimate of fish total length can be calculated using a regression equation. The otolith width measurement of saithe, pollack and specimens identified as *Pollachius* (specimens identified as saithe or pollack) gave the largest sample of measurements from Sand (Appendix 5).

Figure 4.12 Modern saithe otolith with width measurement shown

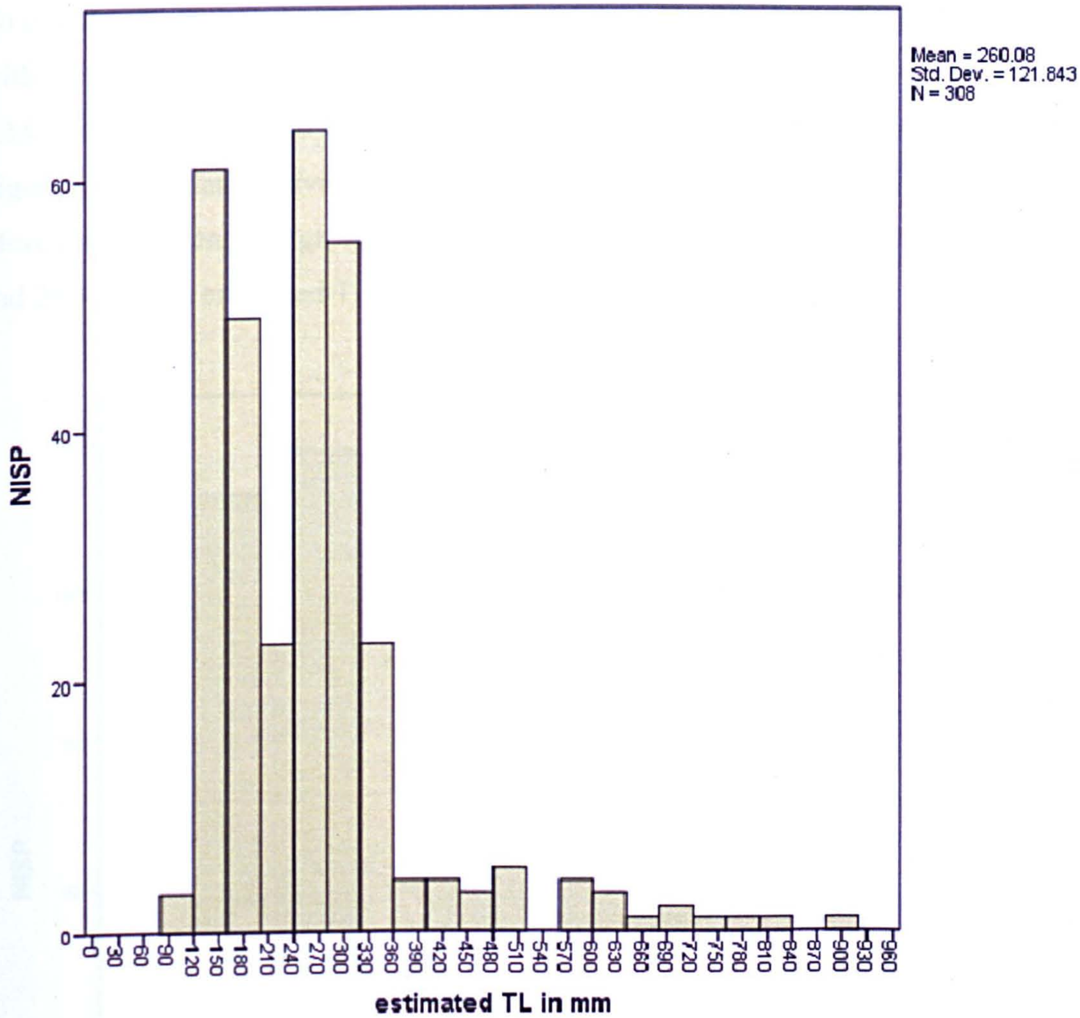


Figure 4.13 ***Pollachius* total length estimates from the main shell midden contexts (25 intervals on the x-axis)**

Based on over 300 measurements of otolith width from the main shell midden contexts over 90% of specimens were under 400mm total length. When plotted, the estimated otolith total lengths form a bimodal distribution (Figure 4.13) with a peak at 120mm-200mm and another at 240-320mm. One mode is centered around total lengths consistent with first year fish and the second with total lengths of second year fish. The fish of greater than 360mm is likely to represent third year and older fish. The implication of this distribution for season of capture is discussed further in Section 4.5.6 but a note on the appearance of the histogram is necessary. Both left and right otoliths are included, this will duplicate some of the measurements. Within SPSS, the statistics package used to generate the histogram in Figure 4.13, the division of lengths, or number of intervals on the x-axis has a default setting but can also be defined by the user and in this way the distribution 'tweaked' by the analyst.

To a large extent the range of lengths in the modes are subjective. The same dataset but with the data in different intervals along the x-axis is shown in Figures 4.14 and Figure 4.15. In both there is still a bimodal distribution but the peak in total lengths differs. In Figure 14.4 the data is divided into fewer intervals than Figure 4.13, 10 rather than 25. More measurements are grouped together and the peaks span 100-200mm estimated TL and 200-300mm estimated TL.

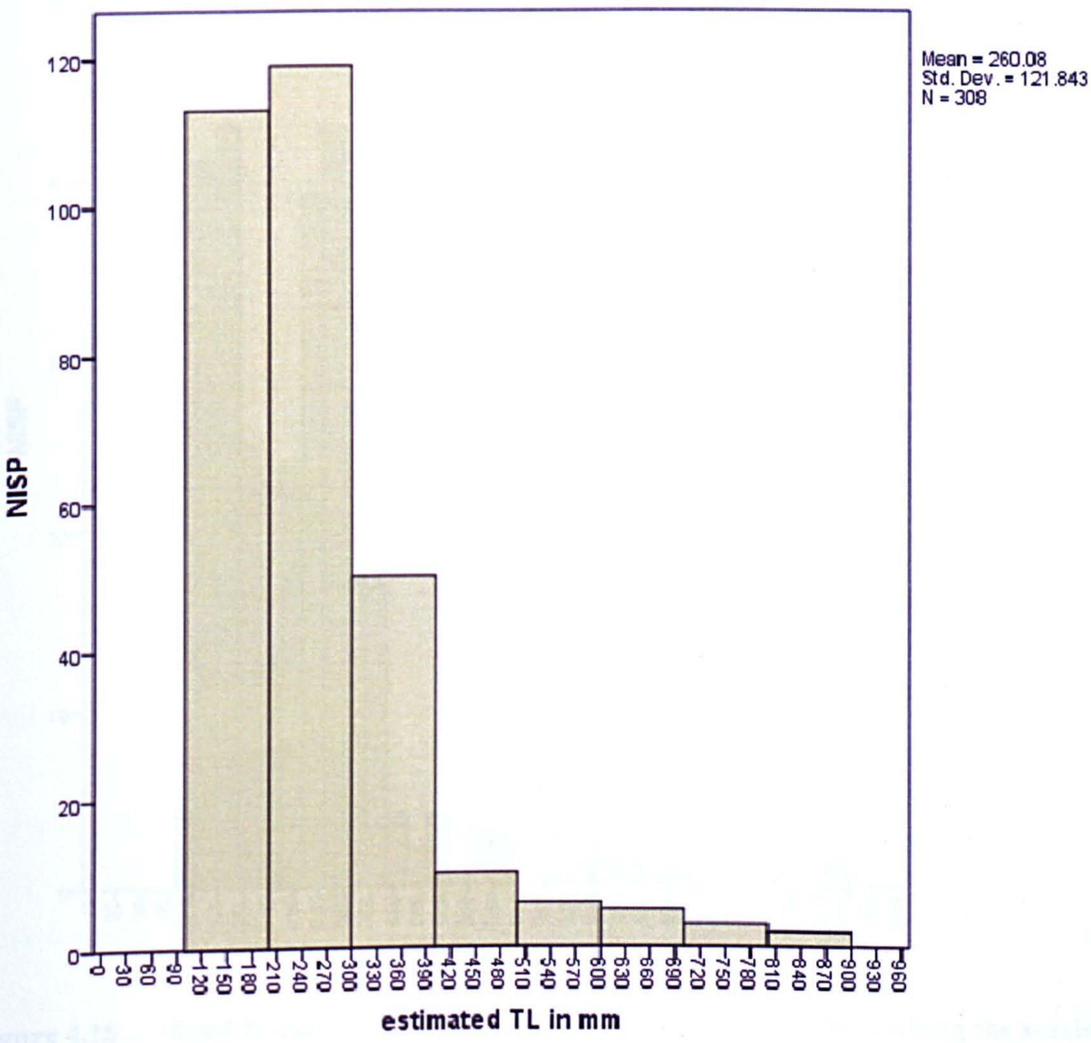


Figure 4.14 Sand *Pollachius* otolith total length estimates 40 intervals along the x-axis

In Figure 4.15 forty intervals along the x-axis gives a finer division of the dataset; there are peaks in total length estimates of 120-180mm and 250-300mm. On the first peak specimens up to 200mm TL are also well represented, on the second peak specimens up to 330mm could be included. Figure 4.13 with 25 intervals seem to provide a good intermediate. By comparing the differently presented histograms it is clear that rather than representing *the* distribution of lengths they are a useful visual interpretation of the data. They have allowed resolution of the broad size data from Sand (ie. small, medium) based on visual sizing of QC1 to be refined and two size groups, and therefore ages of fish has been identified.

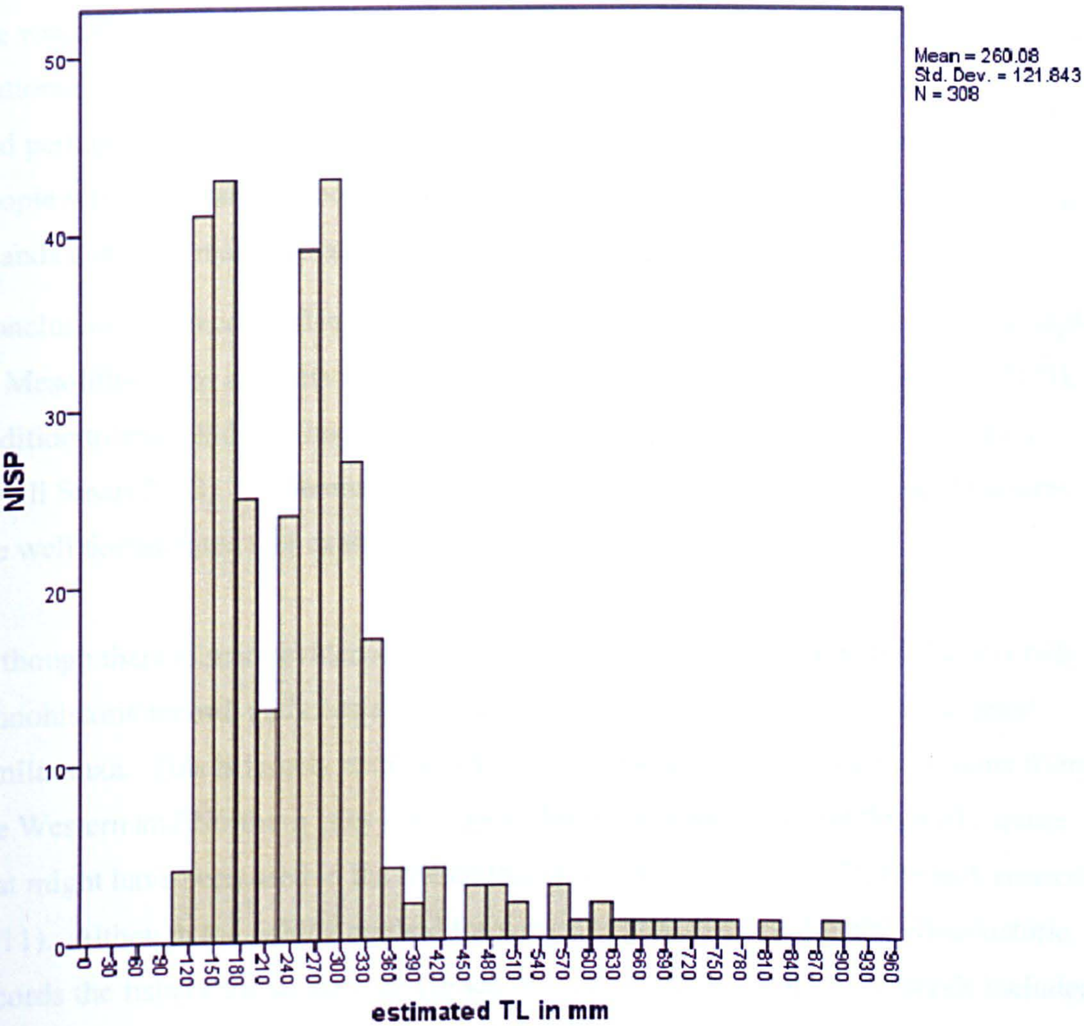


Figure 4.15 Sand *Pollachius* otolith total length estimates 40 intervals along the x-axis

4.5.5 Method of fishing

Although there is a wide species range from Sand all are littoral zone fish, and could have been caught from, or, close to, the shore. The lack of large fish does suggest that deep-sea fishing methods were not used, however, a lack of deep-sea fishing does not exclude the use of boats. Despite a wide species range, only a few; saithe, pollack and the wrasses, were caught in any number. Two main fishing methods can be considered; stationary traps and nets and more mobile methods using equipment such as nets, hooks and perhaps bait from the shore or boats in inshore waters. We know that Mesolithic people were familiar with boats as the movement of Rhum bloodstone to surrounding islands and local mainland attests (Wickham-Jones, 1990).

Conclusive evidence for fishing gear is missing from Mesolithic Scotland, but examples of Mesolithic traps and nets are known from Ireland (McQuade and O'Donnell 2009), in addition to traps and nets hooks are also know from the continent and Scandinavia (Quill Smart 2003). In Denmark large scale, permanent Mesolithic fishing structures are well documented (for example, Fischer, 2007).

Although there is scant evidence of Mesolithic fishing gear Scotland does have a rich ethnohistoric record, and coastal communities in the relatively recent past targeted similar taxa. This is largely restricted to late 19th and early 20th century accounts from the Western and Northern Isles but it does illuminate some of the methods of capture that might have been used in the Mesolithic (Low 1813; Fenton 1973, Cerón-Carrasco 2011). Although the fishing method for wrasse is little discussed in the ethnohistoric records the fishery for saithe is discussed in detail. Principal capture methods included rod and line and craig fishing with nets, both of which could be conducted from the shore or from inshore boats. Craig fishing in Orkney involved the mashing up of limpets (by chewing), throwing them into the water and then scooping up the swarms of fish attracted by the bait in a net (Figure 4.16, Figure 4.17).

Anderson (1895, 227) describes another method of fishing for saithe with limpet used as bait observed by Martin Martin on Skye:

" The Grey Lord, alias Blackmouth, a fish of the size and shape of the salmon, takes the limpet for bait. There is another way of angling for this fish, "by fastening a short white down of a goose behind the hook, and the boat being continually rowed, the fish run greedily after the down and ure easily caught. The Grey Lord swims on the surface of the water, and then is caught with a spear, a rope (line) being tied to the further end of it and secured in the fisherman's hand."

Anderson writes :

"Unfortunately, Martin has omitted to describe the precise kind of-spear by which the natives of Skye were accustomed to catch the greylord (which I take to be the saithe or coal-fish) when swimming on the surface ; but there is little doubt that this spearing of sea fish in 1700 on the West Coast was a direct survival of the ancient custom, and not a new invention."

Figure 4.16 Craig fishing for sillocks (first year saithe) image source: SCRAN

Figure 4.17 Rod fishing for saithe. Image source: SCRAN

Stationary traps are also known historically from Scotland, known colloquially as *yairs* (on the east) and *cairidhs* (on the west coast). Examples are recorded all around the Scottish coastline (Canmore accessed 29.10.13), including two at Applecross Bay, just south along the coast from Sand. *Cairidh* is a broad term that describes a stone fish trap, few have been dated and they are generally assumed to be less than 300 years old (Martin 2008). The entire trap may have been made of stone, creating a wall that prevented fish from escaping on the retreating tide, or a base of stone may have supported stakes and nets. From survey work by Hale around the Beauly and Cromarty Firths and Martin in Argyllshire the stone remains of traps that are still visible today also appeared on maps in the 1800s (Hale 2005, Martin 2008) and there is no reason to doubt the tradition is a long one. Despite a wide distribution of fish traps, those that have a known recorded use generally tend to have been river or estuarine and targeted salmon, the construction, other than the stone base of ones like at Applecross is unknown, as is the species of fish it would have targeted.

The shore at Sand would have been rocky during the Mesolithic, not the large sandy bay that is present today. Hale notes that along exposed coastlines traps may have been less permanent and designed to be removed easily (Hale 2005). If traps were used semi-permanent traps may have been more appropriate, especially if targeting fish at certain times of the year, as discussed below.

So, which method of fishing would the assemblage from Sand be most consistent with? The catch of small sized saithe, pollack, wrasse, and indeed most other taxa from Sand, is broadly comparable with the Danish Mesolithic site of Maglemosegård, where most fish were less than 500mm in total length (Enghoff, 1994, 75). Although the principal species was cod, at this and other coastal sites, Enghoff found that the same cluster of small specimens was replicated for several coastal taxa. She proposed an indiscriminate 'catchall' method of fishing, probably using stationary traps or nets (1994, 83-84). It is possible that a similar interpretation may be appropriate for Sand especially when the by-catch evidence from the experimental wrasse capture methods (discussed above) is considered. However, only a catch-all method of fishing does not seem a satisfactory explanation for Sand, because here, despite the species range, fishing appears highly targeted for wrasse and *Pollachius*. The method of fishing was also highly targeted in terms of size, both taxa with small maximum total lengths (wrasse) and taxa with large maximum lengths (saithe and pollack) were targeted.

If traps and nets were used, given the rocky nature of the Sand coastline, gear that could be left out and then easily retrieved may have been more appropriate. The aperture of traps would exclude fish beyond a certain size, in this case the majority of fish, regardless of taxa are under 500mm. The size of a hook used can also affect the size of fish caught. At the Swedish site of Dammen *Pollachius* was a key taxa and small bone fish hooks were amongst the finds. Whilst hook and line would have been appropriate for catching *Pollachius*, a combination of fishing methods must have been used as herring were also important at Dammen yet they are more suited to net fishing, (Schaller Ahrberg, 2007).

If traps were the sole method of fishing at Sand we might expect to see larger quantities of the less numberically abundant taxa and indeed it may be that one fishing method alone is an inadequate interpretation; perhaps traps were used for wrasses and for the shoaling saithe (and some pollack) rod and line or nets akin to craig fishing, either from the shore or in boats.

4.5.6 Fish season of capture

As to *when* in the year the fish may have been caught there are several strands to explore; the biological behaviour of the fish, ethnohistoric accounts, and the fish size estimates. Turning first to the biological behaviour of the fish, as discussed in the previous section, in Scotland saithe are known to be most abundant in the late summer and autumn with 2nd-3rd year fish moving into deeper water in the winter. Much less is known of the seasonal movements of wrasses. Anecdotal accounts by modern anglers suggest low numbers during winter and that ballan wrasse hibernate or move offshore through the winter whilst others contradict this asserting that larger wrasse can be caught during winter. Fisheries research into 3 species used as cleaner fish on salmon farms (goldsinny, rock cook and corkwing wrasse) found no offshore migration (Sayer, Reader et al. 1996) but did find the fish were less active during winter, with some for example, hiding in crevices.

Low, writing in 1813 about the fishing for saithe in Orkney says that by August the young fish (born earlier that year) began to be fished with rods in small numbers. But he continues: "*but still this is nothing to the shoals that set in towards winter, when the sea begins to grow stormy; then the harbour of Stromness especially, and many other places, are quite filled with them, and thus they continue for the whole winter." About this time they measure from six to ten inches, and are very much esteemed". (Sillucks).* These fish (between around 15cm to 25cm) were caught in large quantities using a rod and line both from piers and small boats in the harbour. Low goes on to describe how in March the shoals move to deeper water, this is consistent with modern fisheries evidence for offshore migrations in the spring. In May, when the fish are 15 inches (c.38cm and consistent with fish in their third year of growth) they are also caught. Low describes the winter fishery in some detail but it is unclear if the fishing in May is also from the harbours.

Although saithe appear to be super-abundant at certain times of the year, Fenton describes fishing at different times of the year at different islands around the Northern Isles (Fenton 1978), to fit in with other activities (for example, winter fishing for saithe in Bressay, summer and autumn fishing at Holm, all year round fishing at Orphir). Historic accounts, therefore, also reflect when the fish were caught due to seasonal resource scheduling rather than just periods of abundance.

Low's account provides anecdotal evidence of the length of fish but the exact time of year is vague; we know that sillucks (also spelt sillock and typically used to describe a fish in second year of growth) are between about 15-25cm at some point after August, 'towards winter' and before March. Data on saithe length throughout the year for young fish is limited. A problem with modern fisheries data is that the fishing method used, trawling, targets larger, mature fish and commercial fishing does not take place inshore. For example in extensive sampling of saithe aboard the commercial vessel 'Farnella' in north Scottish waters fish caught were primarily older than 3 years (Enerver 2009).

Sources of fish length and growth data for Saithe include Wheeler (1969), Bertelsen (1942) and Wilkinson (1981, 1980). Wheeler's data is minimal, only that for the first three years of life a fish increases by 15cm each year. It is unclear if this a maximum length reached shortly before the fish would be classed as 2nd year fish (so in December). Based on the measurement of over 50,000 specimens of saithe from Danish Fisheries Research Vessels in Faroese waters Bertelsen's paper from the 1940s is the most comprehensive numerically. He found that although in Faroese waters the annual increase in total length of saithe was around 130mm for each of the first three years of life there was variability in the rate of growth (Bertelsen 1942). Fish increased rapidly in length following spawning but that growth slowed during mid-summer then increased again during September. He found that some first year fish were 20cm in September. Consequently, he found that the range in fish length was greatest during the summer and decreased during the winter. Bertelsen noted that the average length of first year fish was affected by abnormally cold or mild winters.

The shortcomings of existing saithe growth data prompted Wilkinson to conduct a small scale study of fish growth as part of his PhD research (1981), although his focus was primarily on the change in otolith length his research is of most relevance here. Wilkinson caught fish from around the coast of Colonsay and Oronsay over various periods in the 1970s in order to investigate the relationship between the time of year and otolith length (Wilkinson 1981). Wilkinson collected two datasets; otolith lengths and fish fork lengths. The otolith lengths were measured to 0.05mm and although fork lengths were recorded they do not appear in Wilkinson's published work or his PhD thesis. Wilkinson demonstrated that over one year the ranges of otolith length for fish caught in June, August, September, November and December were statistically different to each other (a Mann-Whitney test in Minitab by the author confirms this) and went on to correlate archaeological otolith lengths with specific seasons of capture, discussed in the next chapter. If the fish total lengths and otolith measurements were both known a regression equation could be calculated, as it is it is very difficult to compare Wilkinson's data with other datasets. During the recording of the Sand otoliths I found that often the tip of the otoliths was broken and the majority of measurements taken were maximum otolith *width* the Sand data is, therefore, not suitable for a direct comparison with the existing Oronsay otolith data.

With reference just to the Sand otolith data, primarily two lengths, and, therefore, ages of fish are represented. One group at around 120mm-200mm estimated total length and another at 240-320mm estimated total length. When compared with Wheeler, Bertelsen and Low's fish lengths these broadly accord well with both first year and second year fish being exploited. As first year fish are known to migrate from spawning grounds to the inshore from late summer it is likely that the first size cohort was caught from then onwards. Second year fish may have been caught at the same time or later in the year.

The range of total lengths within the bimodal distribution can be interpreted as fishing repeatedly throughout the period when saithe are abundant (whilst acknowledging the caveat that this relies on fish behaviour being the same in the past as today). If fishing had only been the result of a fishing at the same time each year (over several weeks each time say) more narrow peaks in the bimodal distribution might be expected Within this broad seasonal period fishing may not have been continuous, semi-permanent use of the site from late summer into autumn and winter is **not** being suggested here.

If distinct contexts of fish discard had been identified in the midden then the season of capture may been narrowed by analysis of otolith thin sections. Thin section analysis examines the differing growth sequence produced by seasonal slow then rapid growth. However, the contexts from Sand do not meet the requirements of the Van Neer *et al.* paper of closely dated, controlled contexts representing discreet dumps of fish discard (Van Neer et al., 2004).

4.6 *Summary of faunal remains at Sand*

The zooarchaeology of Sand is characterised by the use of a relatively narrow suite of taxa. Red deer, wild boar and roe deer were the most abundant mammal taxa. There is little reliable season of capture evidence for these species. The bones are highly fragmented but the application of Outram's Fracture freshness failed to provide conclusive evidence of fragmentation due to tool manufacture versus marrow extraction, indeed there seems no reason why they should be mutually exclusive. Fowling for seabirds was highly targeted for razorbills and guillemots and to a lesser extent great auk. A focus on these taxa suggests, and the small number of juvenile bones suggests they were exploited during the moult of primary feathers in the late summer and autumn, rather than during the breeding season. Fishing primarily targeted two families of fish; cod family fishes, primarily saithe and pollack and the wrasse family, predominantly ballan wrasse. A wide range of other fish taxa were caught, but in low numbers, which suggest that the fishing gear used was not exclusively selective for the main taxa; a combination of hook and line and nets or traps may have been used. Two sizes (and therefore ages) of saithe were caught, a seasonal fishery to take advantage of the abundance of fish in late summer and autumn seems likely and would have coincided with the birding for razorbills and guillemots.

Chapter 5 Oronsay results

5.1 *Introduction*

The Oronsay middens have largely crept into the literature as a good example of a Scottish Mesolithic faunal assemblage (for example, Schulting and Richards, 2002) but the mammal, bird and fish bone have not been discussed together. The mammal bone report (Grigson and Mellars, 1987) and a small part of the fish bone analysis is published (Mellars and Wilkinson, 1980). The mammal report was intended as a precursor to a more detailed report that was to incorporate results from various PhD theses connected with the sites including Nolan's 1986 thesis on spatial analysis at Cnoc Coig. The bird bone, identified by Bramwell, remains unpublished but the bone from Cnoc Coig is included in Nolan's thesis. The paper on fish is concerned solely with season of capture and discussed only saithe otoliths; the remainder of the fish bone work is in an unpublished PhD thesis (Wilkinson, 1981) and is rarely mentioned. The published paper on the saithe season of capture concludes that at each site on the island fishing occurred at a different time of year and subsequently a semi-permanent occupation of the island has been suggested (Mellars, 2004). That each site on a small island should have a different season of fish capture is, if the case, remarkable.

The various sources of zooarchaeological data from Oronsay have not been brought together before and it makes comparison with other sites difficult. This chapter, therefore, aims to combine Nolan's spatial work on the mammal remains with the data from Grigson and Mellars' animal bone; to review the bird bone from Cnoc Coig and to re-evaluate the fish bone evidence so that the material can be used as comparative datasets. In addition to the extraction of raw data from Wilkinson's thesis one site, Cnoc Sligeach, was chosen for re-recording of the fish bone. The aim of this reanalysis was to see how much additional data could be gleaned to assess if reanalysis of all the sites would further interpretation and to provide comparative otolith raw data for total length estimation to Sand.

5.2 *Summary of mammal remains from 1970s excavations*

Grigson's mammal bone report was published in the 1987 Oronsay site volume (Grigson and Mellars, 1987). Mammal bone was analysed from 4 small trenches at Caisteal nan Gillean II, from 1 small trench at Priory Midden and from several trenches and open area excavation at Cnoc Coig. The largest assemblage was from Cnoc Coig and this site was, therefore, considered in most detail.

As the Cnoc Coig report was intended as a general and preliminary account, ahead of more detailed spatial and stratigraphic analysis (Nolan, 1986) the bones from all contexts at Cnoc Coig are treated as one unit. Grigson is explicit that the quantification of MNI and the interpretations of butchery and consumption patterns may, therefore, subsequently change (Grigson and Mellars, 1987, 247). NISP is the main method of quantification with MNI used to complement analysis of bone element representation. In order to compare the actual elements represented at the site with the expected number if a whole animal was present the minimum number of each bone (MNB) was also calculated. Grigson gives the example that if a left proximal and left distal end of a humerus from a given species were present then this would be counted as one because they could potentially be from the same animal (Grigson and Mellars, 1987, 248). This is akin to the minimum number of elements quantification (MNE) method used at Sand. Due to the small assemblage sizes NISP and MNB only are provided for the sites other than Cnoc Coig.

5.2.1 Preservation and bone modification

Grigson gives a general note that the preservation of the bones from the sites was relatively good. Only from certain areas of Cnoc Coig was it noted that the material was less well preserved often from near the surface of the midden (Grigson and Mellars, 1987, 247). No dog gnawed specimens were recorded (Grigson and Mellars, 1987, 284). Burnt specimens of red deer, wild boar, grey seal and otter were recorded from Cnoc Coig. The percentage of total identified specimens burnt for red deer and grey seal is nominal. For wild boar burning occurred on around 15% of total number of identified specimens and was restricted primarily to the femur, tibia and phalanges. It is only for otter where burning on specimens appears common (just over 40% of total identified specimens) and burning is present throughout the body. Grigson and Mellars also note that generally whole bones show signs of burning (1987, 277).

From Caisteal nan Gillean II (CNGII) few burnt specimens were recovered; two red deer phalanges (out of 29 identified specimens) and two otter metapodials were burnt (out of a total of 13 identified specimens). From Priory Midden no burnt specimens were recovered (Grigson and Mellars, 1987, tables 15.18-15.20, p280-282). It is unclear what proportion of unidentified material from the sites was burnt.

5.2.2 Taxonomic abundance; Cnoc Coig, Caisteal nan Gillean II and Priory Midden

Table 5.1 summarises the number of identified specimens (as recorded by Grigson and Mellars) by species and site. The range of taxa is quite narrow, restricted to red deer (*Cervus elaphus*), wild boar (*Sus scrofa*), otter (*Lutra lutra*), grey seal (*Haliochoerus grypus*), small amounts of common seal (*Phoca vitulina*) and cetacea.

Taxon	Cnoc Coig NISP	CNGII NISP	Priory Midden NISP
red deer	70	29	1
wild boar	56		
Otter	123	13	3
grey seal	360	22	11
common seal	3		
large cetacean			2
small cetacean	9		
total number of specimens	621	64	17

Table 5.1 Summary of mammal assemblage from Cnoc Coig, Caisteal nan Gillean II (CNGII) and Priory Midden (Grigson and Mellars, 1987, 279, table 15.17)

Just over 600 identifiable bones were recorded from Cnoc Coig. Grey seal was the most numerically abundant (360), followed by otter (123 specimens), red deer (70 specimens excluding antler), wild boar (56 specimens) and common seal (3 specimens). The 3 common seal specimens include a pelvis, proximal phalanx and a rib. In addition a small number of vertebrae and rib fragments belonging to most likely common porpoise or common dolphin (cetacean) were recorded.

From Caisteal nan Gillean the assemblage is much smaller and red deer is most numerically abundant (29 specimens) followed by grey seal (22 specimens) and otter (13 specimens). At Priory Midden, in addition to red deer (1 specimen), otter (3 specimens) and grey seal (11 specimens) 2 fragments of rib from a whale were recorded. This was tentatively identified as from a common rorqual and showed evidence of working (as discussed in 5.2.4).

Nolan's 1986 PhD thesis examined spatial variation within the Cnoc Coig midden by using various statistical plotting methods. Nolan's work is a useful adjunct to Grigson's as in the initial bone report no context information is discussed. Nolan used Grigson's identifications and using the '*in situ*' specimens divides the mammal remains into spatially associated groups which he believes could represent 10 or 12 major depositional episodes (Nolan, 1986, 413C-D). Nolan stresses that each episode may not represent separate 'occupation', more than one episode may have taken place during an 'individual occupation'; what is meant by an occupation is not explained.

The majority of mammal bone was dumped, specimens closely associated with hearths and high clustered were interpreted as food refuse (1986, 428-429). Seal, otter and pig *in situ* remains were highly clustered, some red deer was highly clustered, other dispersed (1986, 416).

5.2.3 Cnoc Coig element representation

Grigson used the following element categories: antler, cranium, maxilla, mandible, loose teeth, atlas, axis, cervical vertebrae, dorsal vertebrae, lumbar vertebrae, sacrum, sternebrae, ribs (articulations and fragments), scapula, humerus, ulna, radius (proximal, distal and shaft fragments), carpals, pelvis, femur (proximal, distal and shaft fragments), patella, tibia (proximal, distal and shaft fragments), fibula, astragalus, calcaneum, other tarsals, metacarpal (proximal, distal, shaft fragments), metatarsal (proximal, distal, shaft fragments), metapodial (proximal, distal, shaft fragments), phalanges (various categories depending on species) and sesamoids. The elements recorded are broadly similar to the York system QC1 recording protocol used to record the Sand mammal bone assemblage but ribs, vertebrae and carpals are recorded. The element representation of red deer, wild boar, grey seal and otter are provided in Table 5.2. The red deer and wild boar assemblages are relatively small with fewer than 100 identified specimens.

		red deer	wild boar	grey seal	otter
skull (petrous) seal only				17	
cranial fragments				5	5
Antler base (unshed)		5			
Cranium		1			
Maxilla			2*	5	2*
Mandible		2*	1*	10	9
Loose teeth		7	9	14	16
Atlas				3	1
Axis			1	1	2
cervical vertebrae				7	1
dorsal vertebrae				21	
lumbar vertebrae		2		3	1
sacral vertebrae				1	
caudal vertebrae				6	2
Uncertain vertebrae				29	10
Sacrum					1
Sternebrae		1		11	3
ribs	Articulations			28	4
	Fragments	3		18	
Scapula		1		4	1
Humerus					
	Complete			2	1
	Proximal			1	1
	Distal			3	
	shaft fragments			4	3
ulna	Complete				4
Ulna	Proximal		3	4	4
	shaft fragments			2	
Radius	Complete			2	1
Radius	Proximal	1	1		2
	Distal	1			2
	shaft fragments	1		2	3
Carpals		7	3	13	2
Pelvis		1	1	4	
Femur	Complete			3	
Femur	Proximal		1	1	2
	Distal	1	1	1	2
	shaft fragments	1		3	
Patella		1			
Tibia	Complete			1	2
Tibia	Proximal	1	1	1	
	Distal	3	4		2
	shaft fragments		1	4	
Fibula	Complete			1	
Fibula		1			
	Distal		2	1	1
	shaft fragments			1	

Astragalus			3		1
Calcaneum			1		3
Other tarsals		1	2		1
Tarsals				13	
Metacarpal	complete			9	5
Metacarpal	proximal	4		5	1
	Distal			2	12
	shaft fragments	1		1	
Metatarsal	complete			5	
Metatarsal	proximal	5		4	
	Distal	2		6	
	shaft fragments	4		1	
Metapodial	Proximal	1	1		
	Distal	1	2		
	shaft fragments	3			
proximal phalanges		5	6	38	6
middle phalanges		1	9	30	6
Distal phalanges		1	3	19	
Phalanges					
Sesamoids		2	2		
Total		70	57	370	123

Table 5.2 **Cnoc Coig element distribution.** Grey seal total includes specimens identified as probable grey seal. An * indicates an estimated total based on loose teeth and is not included in the total of identified specimens

5.2.4 Red deer

Grigson and Mellars outline three main features of the red deer element distribution

- Strong representation of antler
- Small quantity of meat bearing bones such as the femur, scapula and humerus
- Strong representation of terminal elements such as metacarpals and metatarsals

Five unshed antler bases (the antler is still attached to the skull when the animal dies) and 11 shed bases were recorded. The authors state that based on the number of left or right unshed specimens at least four individuals are represented. In addition to the antler bases, 71 smaller fragments of antler, not included in their element representation table, were quantified (Grigson and Mellars, 1987, 254). The majority of these (64 fragments) were tines or tips of the antler. The shed antler must have been collected and brought to the site. The unshed antler bases, however, show access to at least 4 whole animals. The numbers of teeth and other skull parts are less well represented than antler. Grigson and Mellars suggest two scenarios; the antler was removed from the skull and then brought to site or, the antlers were detached at the site and the other skull parts taken away. In addition to the four males, two females, based on two small right magna, brings the estimated red deer MNI to six. Based on measurements of elements and the size of antler Grigson and Mellars suggests that two populations of red deer might have been targeted; one island population (possibly neighbouring Colonsay) and one mainland population (1987, 254-262).

Grigson and Mellars suggest that only specific parts of the body of the red deer were brought to the site, not the whole animal. They note that worked bone tools common on the Oronsay sites are often made from metapodials. Based on the small number of red deer bones and these three features the authors conclude that only specific parts of the red deer was brought to Cnoc Coig. Further, whilst some meat-bearing bones are present body parts seem to have been chosen primarily for their value as a raw material for tool manufacture rather than food-stuff.

Nolan's spatial analysis confirms Grigson and Mellars' interpretation. Nolan identified 7 groups of red deer specimens, scattered widely around the site with less clustering than seal or otter. Nolan notes that two of these groups were quite large. These were not associated with hearths and contain more meat-bearing bones, Nolan suggests these bones were mainly food waste. Groups 3-7 have 5 or fewer bones, typically metapodials and adjoining bones and are generally close to stratigraphically related hearths. Nolan interprets these as dumped waste material from tool manufacture (1986, 242-247).

5.2.5 Wild boar

It appears, as Grigson and Mellars note, the wild boar element distribution pattern is similar to that of red deer because few meat-bearing bones are present whilst lower limb bones and phalanges are present (Grigson and Mellars, 1987, 263-265). There is not, however, the same strong representation of metapodials. The authors also comment on the under representation of parts of the skull and teeth and based on four left distal tibiae a minimum of four wild boar are represented (Grigson and Mellars, 1987, 262).

Nolan noted that a limited number of occupational episodes (between 3 to 7) could account for the wild boar bones.

5.2.6 Seal

Grey seal is the most numerically abundant species from Cnoc Coig with 360 identified specimens of these 271 were aged as either juvenile (between 1-3 years old) or adult (over 3 years old). Seventy specimens were aged as young pups (up to approximately 4 to 5 weeks old) (Grigson and Mellars, 1987, 266, Table 15.12). The remaining specimens could not be confidently aged. In terms of minimum numbers of individuals at least 6 older animals and 3 very young seals are represented, based on the number of petrous bones.

Recovery and preservation are suggested as key factors affecting the element distributions; the c.6mm mesh size used on some areas of the site may have missed some of the smaller bones, in particular those from very young animals. Most parts of the body of the older seals (animals older than 1 year) are present. The authors do note that small carpals and tarsals and terminal phalanges appear to be underrepresented, perhaps due to recovery method. The petrous part of the skull, the humerus, ulna, femur and tibia are relatively well represented but it is suggested this is a result of differential preservation as these are all robust bones (Grigson and Mellars, 1987, 269-271). *In situ* decay of seal bones was reported in some parts of the midden, for example where groups of mandibular teeth survived but the mandibles themselves did not (Grigson and Mellars, 1987, 270). Very young seals would have small and less robust bones than the older animals. Poor bone preservation coupled with recovery bias against small bones is likely to have affected the element distribution of these very young animals. Grigson and Mellars attribute the low number of ribs and small tarsals and carpals to these factors (Grigson and Mellars, 1987, 271).

Eleven main groupings of seal bones were identified by Nolan. Group size ranged from over 60 *in situ* specimens, made up of more than one individual to groups containing fewer than 10 *in situ* specimens. Based on these groups Nolan suggests the overall minimum number of depositional events for seal (grey and common) is 12 with 6 of these being very small or part of a larger group. The largest groups are not spatially associated with hearths and appear to have been dumped (1986, 212-232).

From his spatial analysis Nolan highlights that despite seal being the most common mammal at the site the overall amount of food represented is still quite small, especially when the potential temporal range of the midden is considered (1986, 232-234). He suggests three scenarios;

1) The site was not occupied regularly as part of an annual round
2) Seals were not intensively or regularly exploited
3) Seals were butchered and processed elsewhere

Nolan concludes *'despite the relatively large numbers of seal bones in Cnoc Coig, these remains do not appear to indicate a large-scale, regular (annual) exploitation of seal over a period of many years. The defined seal bone groupings at Cnoc Coig could all be accounted for by a small number of occupations.'* (1986, 234)

5.2.7 Otter

Most parts of the body of otter are represented with the exception of smaller elements such as phalanges, carpals and tarsals (Table 5.2). Rather than this being the result of a particular butchery or skinning practice (otters could have been caught for their fur and, or meat) Grigson and Mellars suggest that this is more likely to be the result of these smaller bones not recovered by the c.6mm mesh size used on some areas of the site. They warn that due to recovery method the number of identified specimens of 123 should also be regarded as a conservative estimate (Grigson and Mellars, 1987, 274-277). They also state that burning may have affected the skeletal element patterning, decreasing the survival of the vertebrae, ribs, pelvis and scapulae.

When the MNI is calculated 6 or 7 animals can account for the bones present, including at least 5 adults (based on 5 right mandibles) and one or two juveniles. The authors discuss that one or two concentrations of otter bones may represent the whole animal and that whole otter carcasses may have been brought to the site for skinning.

Half of the otter specimens from the site were recovered *in situ* and based on spatial association Nolan grouped the specimens into five groups. The largest group contained over two thirds of the *in situ* specimens at the site. Based on these groupings (and subgroups) 6 depositional events are believed to have taken place. The groupings tend to be small and scattered around the site, generally within 1.5m of the nearest stratigraphic hearth and Nolan suggests bones were discarded by dropping or tossing. From the amount of otter and number of groupings Nolan concludes that otters are only likely to have been caught on a few occasions rather than large-scale or regular exploitation (Nolan, 1986, 235-240).

5.2.8 Bone and antler working, all Oronsay sites

One of the whale rib bone fragments from Priory Midden, identified as possible common rorqual, showed a series of deep indentations which the authors suggested was perhaps from the use of the bone as an anvil or similar function (Grigson and Mellars, 1987, 273 figure 15.15). According to Grigson and Mellars nearly every fragment of antler from Cnoc Coig showed signs of deliberate working.

The quantification of the antler is unclear. The worked material was to be discussed in a subsequent publication but the authors do refer to over 400 limpet scoop types of tool, fragments from at least 10 antler mattock heads and a variety of antler awls, pins (Grigson and Mellars, 1987, 254). The 71 pieces of antler appear to only be those fragments that could be placed along the antler (fork, tine, base). Further confusion as regards quantification of the various tool types is caused as the authors refer to illustrations of worked antler in chapter 8 of the 1987 volume, but not all the illustrations show fragments from Cnoc Coig. For example, red deer antler mattocks are illustrated from Priory Midden (1987, 123, Figure 8.8). It is unclear if the 400 limpet scoops and 10 antler mattocks referred to by Grigson and Mellars are a total for all the Oronsay sites combined or just Cnoc Coig. However, regardless of this point, the amount of antler at Cnoc Coig, when compared to other elements, still indicates specialised antler working. Grigson and Mellars also note that large fragments of antler and finished tools were scarce (Grigson and Mellars, 1987, 254). It is suggested that the lack of large fragments in particular indicates that antler was not an abundant resource.

5.2.9 Age of animals and season of death, all sites

The vast majority of red deer, wild boar and otter specimens from Cnoc Coig were from adult animals. The small number of unfused specimens recorded are detailed in Table 5.3. In terms of more closely ageing the season of death the red deer antlers provide most detailed information. One antler was in the process of being shed which places the time of death of that animal in the spring, Grigson and Mellars suggest April. The unshed antlers came from animals killed between August and March. The shed antlers were perhaps most likely to have been collected soon after they were shed late spring.

Element		**red deer**	**wild boar**	**otter**
Cranium		1		
caudal vertebrae				2
uncertain vertebrae				
Sacrum				1
Pelvis		1		
Femur	Proximal		1	
	Distal	1		1
Tibia	Proximal	1	1	
	Distal		1	
calcaneum				2
metapodial	Distal	1		
middle phalanges				1
phalanges			6	
Total		5	9	7

Table 5.3 Red deer, wild boar and otter unfused specimens from Cnoc Coig

For the wild boar, one unerupted mandibular first molar was most likely from an animal less than 5 months old (Grigson and Mellars, 1987, 262). Grigson and Mellars estimate the season of death was April-July. Based on teeth at various stages of eruption one otter could be aged to around 6 months old. However, as the breeding pattern of otters is not highly seasonal this does not provide an estimate of season of death (Grigson and Mellars, 1987, 275).

The very young seal remains were estimated to be from animals up to 4 or 5 weeks old. Assuming that grey seal bred at the same time of year in the Mesolithic as modern British colonies such young seals must have been caught in early autumn (September to October). According to Grigson and Mellars modern colonies on Oronsay calve the first week in October (Grigson and Mellars, 1987, 268). Grigson and Mellars suggest that the breeding season is also the most likely time of year when the adult seals were exploited. Both males and females come ashore immediately before calving and for a few weeks after but the authors note that the number of females is much higher than males. At Cnoc Coig similar numbers of male and female seals are represented. Grigson and Mellars suggest that to achieve this ratio males must have been positively selected (Grigson and Mellars, 1987, 268). In addition to the breeding season adult grey seals could have been taken during their spring moult from (Grigson and Mellars, 1987, 268). For females this would have been March to May and for males January to March. Outside of this and the breeding season seals would have to have been taken from boats at sea.

From Caisteal nan Gillean II and Priory Midden the only species from which an estimate of season of death could be gleaned was the grey seal. As for Cnoc Coig, the presence of very young animals indicated the season of death of those animals as early autumn.

5.3 *Cnoc Coig bird bone*

The bird bone was identified by D.Bramwell but no report was published, nor does a site archive exist. Some raw data is available, however, in Nolan's unpublished PhD thesis which used Bramwell's identifications (1986). No preservation information is given but tables of taxa, elements present and a calculation of the minimum number of individuals (MNI) are included. Where possible all bird bone at Cnoc Coig was recorded three-dimensionally *in situ*. *In situ* bones refers to those discovered when trowelling and from areas included in Nolan's spatial study. It should be noted that the number of *in situ* bones is very small, only 9 taxa have more than 5 *in situ* bones. Nolan acknowledges the small sample size, his tables show both the *in situ* specimens and those specimens not recorded *in situ* and defined as 'other'.

5.3.1 *Taxonomic abundance and age*

The tables given in this section are based on tables 6, 7, 8 and 29 of Nolan's thesis (1986, 91-98, 296). A total of 465 identified specimens were recovered from the midden, no separate context information is given (Table 5.4). Fifty-two taxa were recorded, (42 species), an impressive number given the relatively small size of the assemblage. Most of the taxa, however, are only represented by only a few bones. Eleven have 10 or more bones; great auk, razorbill, black guillemot, guillemot, gannet, cormorant, shag, Bewick's swan, goose sp., teal and eider duck, with the auk family (Alcidae) the most abundant.

Taxa		In situ	Other	Total
Great northern diver	*Gavia immer*		1	1
Fulmar	*Fulmarus glacialis*	5	3	8
Manx shearwater	*Puffinus puffinus*	3		3
Pelicaniformes		1	2	3
Gannet	*Sula bassana*	10	6	16
Cormorant	*Phalacrocorax carbo*	14	6	20
Shag	*Phalacrocorax aristotelis*	4	4	8
Anatidae			1	1
Bewick's swan	*Cygnus columbianus*	29		29
Whooper swan	*Cygnus Cygnus*	5	1	6
Goose sp.		7	5	12
Greylag goose	*Anser anser*	4	5	9
Duck sp.		4	5	9
Teal duck	*Anas crecca*	12	2	14
Mallard	*Anas platyrhynchos*		2	2
Long-tailed duck	*Clangula hyemalis*	2		2
Velvet scooter	*Melanitta fusca*	1		1
Common scooter	*Melanitta nigra*	1	2	3
Eider duck	*Somateria mollissima*	9	7	16

Shelduck	*Tadorna tadorna*		2	2
Sparrowhawk	*Accipter nisus*	1	1	2
Buzzard	*Buteo buteo*	1	8	9
Quail	*Cotunix cotunix*	3	8	11
Crane	*Grus grus*	1		1
Corncrake	*Crex crex*		2	2
Spotted crake	*Porzana porzana*		3	3
Water rail	*Rallus aquaticus*		1	1
Rail or wader sp.			3	3
Curlew	*Numernius arquata*	5	3	8
Black-tailed godwit	*Limosa limosa*	1		1
Greenshank	*Tringa nebularia*	1		1
Sandpiper sp.	*Tringa sp.*	1		1
Snipe	*Gallinago gallinago*		3	3
Woodcock	*Scolopax rusticola*	3	1	4
Knot or Sandwich tern?	*Calidris canutus or Sterna sandvicensis*		1	1
Gull sp.	*Larus sp.*		2	2
Herring or Lesser black-backed gull	*Larus argentatus or Larus fuscus*	2	2	4
Common gull	*Larus canus*		1	1
Great black-backed gull	*Larus marinus*		3	3
Black-headed gull	*Larus ridibundus*		1	1
Sandwich tern	*Sterna sandvicensis*		1	1
Alcidae		3	1	4
Greak auk	*Alca impennis*	46	12	58
Little auk	*Alle alle*		1	1
Razorbill	*Alca torda*	12	24	36
Guillemot	*Uria aalge*	14	25	39
Black guillemot	*Cepphus grille*	4	1	5
Razorbill or black guillemot	*Alca torda or Cepphus grille*		9	9
Razorbill or guillemot	*Alca torda or Uria aalge*	1	1	2
Puffin	*Fratercula arctica*	2	9	11
Passeriformes			1	1
Turdidae			1	1
Blackbird or Ring-ouzel	*Turdus merula or Turdus torquatus*		3	3
Redwing	*Turdus iliacus*		1	1

Redstart	*Phoenicurus phoenicurus*	1		1
Raven	*Corvus corax*	3		3
Unidentified bird		28	34	62
Total		244	221	465

Table 5.4 Cnoc Coig bird number of identified specimens

Based on Nolan's spatial analysis, curlew, Bewick's swan and teal are believed to be at the site due to natural causes which reduces the number of species present to 38. The majority of specimens were from adult birds. Single juvenile specimens of Manx shearwater, crane, a specimen identified to passeriform, and 4 specimens identified only to bird were recorded.

5.3.2 Element representation

The element distributions of the taxa with 10 or more specimens are discussed here, the *in situ* bones present are shown in (Table 5.5). In terms of element distribution for the *in situ* bones there seems to be no distinct pattern. This may simply be a factor of sample size but it should be noted that for great auk, which has most specimens, most areas of the skeleton are represented.

Element/taxa	Great auk	Razorbill	Guillemot	Gannet	Cormorant	Bewick's swan	Teal	Eider duck
Skull								
Maxilla			1					
Mandible	2							
Quadrate	3			1				
cerv vert	3		1				1	
Furcula	2	2	1			1	1	
Coracoids	3		1	3		1	2	2
Scapula	4		3			1	1	2
sternebrae & ribs	3	1	1	1	1		1	
dorsal vert	3				1			
Synsacrum	1							
pelvic bones	1						1	
caudal vert	1							
Vert								
Humerus	5	5	5	1	2	2	2	3
Radius	2		1		2	2		
Ulna	3	1		2		3		1
Femur	2	2			1		1	
Fibula								
Tibiotarsus	3			1	2			1
long bones								
radiale & ulnare				1		2		
Carpometacarpus	1					1		
Tarsometatarsus	4	1			2		1	
Phalanges							1	
wing phalanges					3	2		
foot phalanges								
Subtotal 'in situ' bones	46	12	14	10	14	14	12	9
Total specimens recorded	58	36	39	16	20	29*	14	16

Table 5.5 Cnoc Coig bird element representation (Nolan, 1986, 91, Table 8) *The 15 indeterminate age Bewick's swan bones are not included in Nolan's element representation table

5.3.3 Nolan's bird spatial analysis

For his spatial analysis of the *in situ* bones, Nolan discussed taxa which are represented by at least 2 bones. These were then divided into 3 categories based on their distribution with the midden (Table 5.6).

- Category 1 – birds with a dispersed distribution within the midden
  Raven, woodcock, whooper swan, long-tailed duck, Manx shearwater, herring or lesser black backed gull, puffin and black guillemot
- Category 2 – birds with a clustered distribution within the midden
  Goose, eider duck, gannet, shag, cormorant, fulmar, guillemot, razorbill, great auk
- Category 3 – birds with a highly clustered distribution at the base of the midden
  Curlew, quail, Bewick's swan and teal

Taxa	*In situ* MNI	Total MNI	MNDE
Category I			
Raven	3	3	1
Woodcock	1	1	1
Whooper swan	1	1	1
Long-tailed duck	1	1	1
Manx shearwater	1	1	1
Herring gull or Lesser black-backed gull	1	1	1
Puffin	2	3	1
Guillemot	1	1	1
Category II			
Greylag goose or goose sp.	2	2	2
Eider duck or duck sp.	2	2	2
Gannet	2	2	2
Shag	2	2	2
Cormorant	1	2	1
Fulmar	1	1	1
Guillemot	3	5	3
Razorbill	3	4	1
Great auk	4	4	3
Total	31	36	25

Table 5.6 Bird taxa by spatial category and minimum number of depositional events

The division into categories 1 and 2 is rather arbitrary it is based on numbers of *in situ* bones, both have specimens scattered around the site, and Nolan concludes that this distribution, based on the proximity to hearths, can be explained by either tossing remains from the hearth area or dropping of the bones rather than specific dumping. The third category are represented by compact clusters of bones lying at the bottom of the midden on the basal sand, many of these bones Nolan notes appear to have been articulated when deposited. The curlew, Bewick's swan and teal are not found anywhere else in the midden and based on this Nolan believes were not deposited by humans. As quail does have a few bones scattered within the midden Nolan suggests that humans were probably responsible for this species being at the site.

5.4 *Fish bone 1970s excavations: Priory Midden, Caisteal Nan Gillean I, Caisteal Nan Gillean II, Cnoc Coig and Cnoc Sligeach*

As detailed in the methodology chapter, fish bone was recovered from the sites from both column samples and excavation; selected sub-samples of the column samples were analysed (Table 3.1 in Chapter 3 details the samples Wilkinson analysed). Column samples from the 1970 season at Cnoc Sligeach were identified by Wheeler (1970). As these are not listed separately, it is assumed that they are amalgamated with Wilkinson's own data.

Element distribution tables for the principal species from the site, saithe are given by Wilkinson. For the other minor species the relative abundance by site is given. The measurements for saithe otoliths only are given but in size cohorts rather than the actual measurements. For all species a 'relative abundance' and number of fish per species per sample is given.

5.4.1 Preservation and bone modification

Wilkinson reported that most of the fish bone was well preserved with the material from Cnoc Sligeach less well preserved than the other sites (Wilkinson, 1981, 75). He also found that bone from deposits of sand within and below the midden was better preserved than in the shell matrix, but it is unclear if this comment only refers to Cnoc

Coig. The degree of fragmentation is not explicitly discussed but is implied in his discussion of problems with quantification.

The number of burnt bones is not given but Wilkinson does say that 'a proportion' showed signs of burning and that all parts of the skeleton were affected (Wilkinson, 1981, 80). As for preservation, it is unclear, however, if this relates to bone from all sites or just Cnoc Coig. There is no mention of the presence or absence of carnivore gnawing. No butchery marks were recorded. The only modification other then burning recorded is 'some' (no quantification given) distorted vertebrae from Cnoc Coig. Wilkinson describes this distortion as "the caudal central, which have been compressed along the anterior-posterior vertical axis, and the thoracic centra that shows traces of distortion along the anterior face." (Wilkinson, 1981, 80). Wilkinson's interpretation considers this may be the result of human activity or pathological. Without a drawing or photograph it is difficult to offer further interpretation but partial digestion can alter the appearance of bone (Jones, 1991). He does not state explicitly that the vertebrae were saithe, but as the majority of the assemblage was saithe it can be assumed he is referring to this species. The possibility does remain, however that the vertebrae were from a different species, the posterior caudal vertebrae of ling, for example, have a 'squashed' appearance.

5.4.2 Taxonomic abundance

Table 5.7 shows known species present at the site, by recovery method when known, based on the 1970s excavations (Wilkinson, 1981, 206 table 3). From the five sites combined dogfish, monkfish, thornback ray, eel, conger eel, pollack, saithe, hake, ling, red sea bream, ballan wrasse, shanny, eelpout, sea scorpion and a member of the flatfish family thought to be flounder were recorded to species level. In addition, specimens belonging to the ray, shark or ray and salmon families were identified to family level. This includes taxa recovered by all methods of recovery (hand collection during excavation, sieving following excavation, and from column samples and fish bone concentrations sieved to 1mm and 2mm). The ling and hake from Cnoc Coig were only recovered by hand collection (in this table trench recovery and 1/8 sieving are listed separately so it seems that hand collected material was bagged separately from the material sieved after excavation but from the same contexts). Similarly, at Caisteal nan

Gillean I conger eel was only recovered from the material sieved to 1/8 inch after excavation. Wilkinson focused on the fish from the column samples and fish bone concentrations and these larger species are largely excluded from subsequent tables and discussion.

Taxa		Cnoc Sligeach	Caisteal nan Gillean I	Caisteal nan Gillean II	Cnoc Coig	Priory Midden
Dogfish	*Scyliorhinus caniculus*	*				
Monkfish	*Squatina squatina*	*	*			
Shark or ray sp.		*	2mm, 1mm	⅛, 2mm	hc, ⅛, 2mm	*
Thornback ray	*Raja clavata*			*	*	
Ray sp.		*	*	*	*	*
Salmo sp.		*			*	
Eel	*Anguilla anguilla*	*	2mm, 1mm	⅛, 2mm	2mm	*
Conger eel	*Conger conger*	*	hc	⅛, 2mm	hc, ⅛, 2mm	
Pollack	*Pollachius pollachius*	*			*	*
Saithe	*Pollachius virens*	*	hc, ⅛, 2mm	⅛, 2mm	cc, ⅛, 2mm	*
Hake	*Merluccius merluccius*				hc	
Ling	*Molva molva*	?			hc	
Red sea bream	*Pagellus bogaraveo*	*	hc, ⅛, 2mm			
Ballan wrasse	*Labrus bergylta*	*	hc, ⅛, 2mm	⅛, 2mm	hc, ⅛, 2mm	*
Shanny	*Lipophrys pholis*	*	2mm, 1mm	⅛, 2mm	⅛, 2mm	*
Eelpout	*Zoarces viviparous*	*	2mm, 1mm		2mm	*
Sea scorpion	*Taurulus bubalis*				⅛, 2mm	*
Flatfish cf. Flounder	*Platichthys flesus*	*	*			

Table 5.7 Species recorded by Wilkinson and by recovery method where known

That the material wet-sieved to 2mm does not contain the larger species is puzzling as there should be no size bias in the material. It may be that the samples are simply too small for anything other than the most common species to be picked up. Alternatively, and importantly, the 2mm fraction may actually be only the greater than 1mm but less than 2mm, rather than everything greater than 2mm. This would not only affect the species present but would directly affect the size of the elements (and therefore size of fish) present. Larger elements even if present in the sample would be excluded. This would then have a knock on effect for the seasonality histograms because larger otoliths would be excluded. Unfortunately, it is unclear if this was the case.

5.4.3 Wilkinson's quantification methodology

The method of quantification has a direct bearing on the calculation of taxonomic abundance and of interpretation of element tables. Wilkinson used two methods of quantification that he calls 'relative' and 'absolute abundance'. By both methods saithe was by far the most abundant species at the sites. It occurs in all sub-samples analysed from each site as Table 5.8 shows and is also numerically abundant. All other species recorded (sea bream, eel, shark or ray, eelpout, monkfish, wrasse, shanny, ray, conger and flatfish) are not abundant and are rarely represented by more than one individual. The number of fish recorded as unidentified is not given at any point by Wilkinson.

Taxa	Cnoc Sligeach	Priory	CNG II	Cnoc Coig
Saithe	100%	100%	100%	100%
Shanny	40	100	21.4	48
Eel	100	51.5	14.3	18
Eelpout	80	36.4		6
Shark or ray	100	9.1	14.3	
Wrasse	60	27.3	14.3	
Sea scorpion		18.2		6
Sea bream	100			
Monkfish	80			
Ray	40			
Conger eel	20		7.1	
Flatfish	20			
Number of samples	**5**	**11**	**14**	**50**

Table 5.8 **Relative abundance of fish species** . Cnoc Sligeach, Priory, Caisteal nan Gillean II (CNG II) and Cnoc Coig (taken from Wilkinson, 1981, 207 table 4). *Please note that Caisteal nan Gillean I was not included in the original table*

To calculate the absolute abundance the most common element for each species was counted for Priory Midden (Table 5.9), CNGII (Table 5.10), Cnoc Coig (Table 5.11) and Cnoc Sligeach (Table 5.12). It isn't clear from Wilkinson's original table what (+) means and why 0.5 is used. Paired elements were not divided into left and right instead the total number was divided by two. In a precursor to recording element zones Wilkinson only recorded a fragment of an element when a certain diagnostic feature was present. He does not state which feature he used for each element. The most common saithe element was mostly the otolith, sometimes the basioccipital or one of the very anterior vertebrae. The quadrate was the most common shanny element, the dentary for wrasse, posttemporal for sea bream and preoperculum for sea scorpion. The remaining species (eel, eelpout, shark or ray, monkfish, ray, conger eel and flatfish) were represented in small numbers by elements such as vertebrae and denticles and were marked as present. Wilkinson describes the resulting figures as absolute abundances, which are in effect a form of MNE.

Sample Priory	Saithe 2mm	Saithe 1mm	Shanny	Eel	Eelpout	Wrasse	Sea scorpion	Shark or ray
1	12	0.5	0.5	+	+	(+)		
2	46.5	0	(0.5)					
3	40.5	0.5	(+)					
4	3		(+)	+	+			
5	0.5	0	(1)					
6	4.5 (5)		(0.5)	+			0.5	+
7	1.5 (3)		(0.5)			(+)		
8	0.5 (1)		(0.5)	+		(0.5)		
9	0.5		(+)					
10	0 (1)		(0.5)	+	+			
11	0 (1.5)		(1)	+	+		(+)	

Table 5.9 Priory midden numbers of fish per species in sample. Original notes to table from Wilkinson's thesis: N total based on most abundant element overall (n) total based on most element in the sample + species present (Wilkinson, 1981, 208-211, Table 5)

Sample CNGII	Saithe 2mm	Saithe 1mm	Shanny	Wrasse	Eel	Shark or ray	Conger
A	5.5		(+)	-	-	-	-
B	12.5		(+)				
C	6						
D	4.5						
E	3	3.5	(+)				
F	12	1.5	(0.5)				
G	30.5 (36.5)	4					
H	33 (34.5)	8.5		(+)	+	+	
J	38 (41.5)	6		(0.5)	+	+	+
L	8						
M	15						
N	7.5						
Q	12.5	1					
R	21 (52.5)	5	(0.5)				

Table 5.10 CNGII numbers of fish per species in sample. Original notes to table from Wilkinson's thesis: N total based on most abundant element overall (n) total based on most element in the sample + species present (Wilkinson, 1981, 208-211, Table 5)

Sample Cnoc Coig	Saithe 2mm	Shanny	Eel	Sea scorpion	Eelpout	Shark or ray
1a	25	0.5 (1)	+			
1b	24.5	0.5	+			
1c	5					
1d	(3.5)					
1e	(0.5)	(+)				
2a	18.5	0.5				
2b	46	6.5	+			
2c	127.5 (141)	4 (4.5)				
2d	14.5 (15)	(+)				
2e	23	(+)	+			
2f	5 (7)		+			
2g	3 (4)					
3a	6	(+)				
3b	(0.5)					
4a	(0.5)					
4e	1					
4f	15.5	(0.5)		(+)		
5a	2	(+)				
5b	0.5					
6a	11.5	(+)	+			+
6b	41.5					
6c	90				+	
6d	18					
7a	17	(+)				
7b	5.5	(+)				
7c	7					
7d	13					
7e	0.5 (1.5)					
7f	7					
8a	11.5					
9a	4.5					
9b	7 (7.5)					
10a	20.5	(1)				
10b	7.5					
10c	4.5					
10d	7					
11a	5	(+)				
11b	26	(+)				
11c	8.5	1	+	(+)		+
11d	7	0.5 (1)	+			
11e	11.5	(+)				
11f	11.5	(1)	+			
11g	4.5				+	
11h	36.5	(0.5)				
13a	9					
14a	12.5	(+)		0.5		
14b	9				+	
14c	3 (4)					
14d	3.5					

Table 5.11 **Cnoc Coig numbers of fish per species in samples.** Original notes to table from Wilkinson's thesis: N total based on most abundant element overall (n) total based on most element in the sample + species present (Wilkinson, 1981, 208-211, Table 5)

Sample Cnoc Sligeach	Saithe 2mm	Saithe 1mm	Sea bream	Eel	Shark or ray	Eelpout	Monkfish	Wrasse	Shanny	Ray	Conger	Flatfish
B28	22.5 (47)	24	(+)	+	+	+	+	(0.5)			+	
B29	13.5	24.5	0.5 (1.5)	+	+	-	+	0.5		(+)		
B30	16.5	18.5	0.5	+	+	+	(+)	-	(+)			
B31	19	12	0.5	+	+	+	-	0.5	(0.5)	+	-	+
B32	7.5	8	(+)	+	+	+	+	-	-			

Table 5.12 Cnoc Sligeach numbers of fish per species in samples. Original notes to table from Wilkinson's thesis: N total based on most abundant element overall (n) total based on most element in the sample + species present (Wilkinson, 1981, 208-211, Table 5)

5.5 *Element representation*

Wilkinson's thesis gives the element representation for saithe, (Wilkinson, 1981, 213-218, Table 7) for other species only the most abundant element that he used to calculate his absolute abundances is given. In light of the apparently small contribution the other species made to the assemblages this decision is justifiable. Wilkinson recorded 39 element categories: otolith, premaxilla, maxilla, dentary, ventral pharyngeal plate, dorsal pharyngeal plates (1, 2 and 3), vomer, parasphenoid, articular, quadrate, sympletic, pterygoid, hyomandibular, pre-opercular, opercular, posttemporal, supracleithrum, cleithrum, epihyal, ceratohyal, hypohyal, urohyal, epibranchial (1, 2, 3, 4), hypobranchial (1, 2, 3), basiobranchial, opisthotic, exoccipital, basioccipital, thoracic vertebra, abdominal vertebra, caudal vertebra.

These element tables are in effect the only 'raw data' tables available. For the purpose of this thesis the data is presented here in a form that makes it more readily comparable to Sand and to the recent analysis of Cnoc Sligeach which followed the York system recording protocol (Harland *et al.*, 2003). Rather than the 39 element categories that Wilkinson uses the suite of 18 'QC1' diagnostic elements, vertebrae (QC2) and otolith (QC4) routinely recorded in the York system are shown. It must be noted, however, that Wilkinson did not record the scapula, an element which is included in the York system.

Generally Wilkinson focused on the 2mm fractions. The 1mm element representation was also given for Priory Midden sample 5, Caisteal nan Gillean I sample 4 and 5 and Cnoc Coig L2 and L6. For the series of fish bone concentrations from Cnoc Coig (samples 16-31) only the 1mm fraction is used. In some instances Wilkinson sorted otoliths from samples that he had not produced an element distribution for and in almost all cases included the 2mm and 1mm. These additional otoliths were extracted for the purposes of measuring for seasonality work. The element distribution from each site is discussed below. A problem that affects all the sites is that it is unclear where exactly in the section samples were taken from, if each sample is different contextually and, furthermore, if each sample equates to material from one specific place or if material was taken from several points in the same layer and combined to make one sample.

5.5.1 Priory midden

Column samples were taken from the north and east section faces of the control zone at the end of the excavation. Thirty-two layers were excavated at the site: results from 11 of these presented in Wilkinson's thesis. It is not explicitly stated but must be assumed that the remaining layers did not contain fish. It is very difficult to ascertain if the sample numbers Wilkinson uses really do correspond with the layers described in the site volume (Table 5.13).

Phase	Layer	Description
	1	Modern soil and turf
	2	Yellow-brown, heavily leached quartz sand
III	3	Thin horizon of dense shells, in dark brown sandy matrix
III	4	Buff-white calcareous sand, with very rare shells
III	5	Grey-brown sand, with more frequent, scattered shells
III	6	Buff-white, calcareous sand, containing occasional fish bones but very few shells
III	7	Grey-brown sand, containing moderate density of shells
III	8	Buff-white sand, with sporadic shells and fish bones
II	9 and 10	Dense shells in dark brown, compact, sandy matrix
II	11	Thin horizons of grey-brown wind-blown sand, apparently sterile

Table 5.13 Phasing for Layers 1-11 at Priory midden (Mellars, 1987a, 185-186), phase III is the most recent

From the 2mm fraction samples 5, 7, 8, 9, 10 and 11 all contained fewer than 30 identified specimens (QC1, 4 and 2 as defined in the York system). The element distributions for samples 1, 2, 3, 4, 6 and 7 are given in figures elephant (QC1, 2, 4) and elephant (QC1 only). Only a further 16 identified QC1, 2, or 4 bones were recovered from the >1mm fraction of sample 5 (Table 5.14).

With over 1000 identified specimens in each, samples 2 and 3 stand out as most fish rich. If the sample numbers do correspond with excavated layers, samples 3, 4, 6 and 7 all belong to phase III, the final period of site use. Layers 3, 5 and 7 are midden deposits within layers of wind- blown sand (layers 4 and 6). In addition to shells and burnt stones these layers are described in the site report as having concentrated patches of fish bones. Mellars states:
'These deposits quite clearly represent active periods of midden deposition on the site, but a precise interpretation of the levels in stratigraphic and depositional terms is difficult' (Mellars, 1987a, 190).
The depth of the wind- blown sand deposits vary: layer 6 from the section drawing in Chapter 2 (Mellars, 1987b, 188 Figure 12.5) is at its widest 20cm deep, whilst layer 4, a much thinner layer, appears to be less than 10cm.

	1	2	3	4	5	6	7	8	9	10	11	Total	>1mm 5
otolith	24	93	81	6	1	9	3	1	1			219	
basioccipital	9	25	27	1		3	2			1	1	69	
parasphenoid	3	10	14	2								29	
posttemporal	13	4	3			5						25	3
vomer	4	1		1		2	1					9	
premaxilla	13	2		2		3					1	21	
maxilla	6	3				4	1					14	
dentary	3	1				3	1					8	2
articular	12	8	2	2	1	2	1					28	
quadrate	10			3		1					2	16	
palatine	5					2					1	8	
ceratohyal	7	1				1						9	
preopercular	11	2		2		1					1	17	
opercular	4	1		1		2						8	
hyomandibular	14	6	1		1	3					2	27	
cleithrum	4	4				2						10	
supracleithrum	6					1						7	
infraphryngeal	15	11	1	1	1		2						1
total QC1and4	163	172	129	21	4	44	11	1	1	1	8	524	6
thoracic vert	42	118	110	6	1	7	7		1			292	
abdominal vert	92	460	360	46	12	22	34		1	1		1028	1
caudal vert	140	436	417	49	9	44	60	2	4		3	1164	10
total QC2	274	1014	887	101	22	73	101	2	6	1	3	2484	11
Total	437	1186	1016	122	26	117	112	3	7	2	11	3008	17

Table 5.14 Priory midden element distribution

The element distribution from samples 2 and 3 is interesting as it is mostly comprised of vertebrae, otoliths and some basioccipitals and parasphenoid (Figure 5.1, Figure 5.2, Figure 5.3). If the pattern is genuine and not simply a product of sampling bias this could reflect some sort of processing resulting in the discard of heads and vertebral column in the midden. Sample 1 on the other hand has more QC1 elements in proportion to vertebrae and a larger range of elements more indicative of a whole carcass.

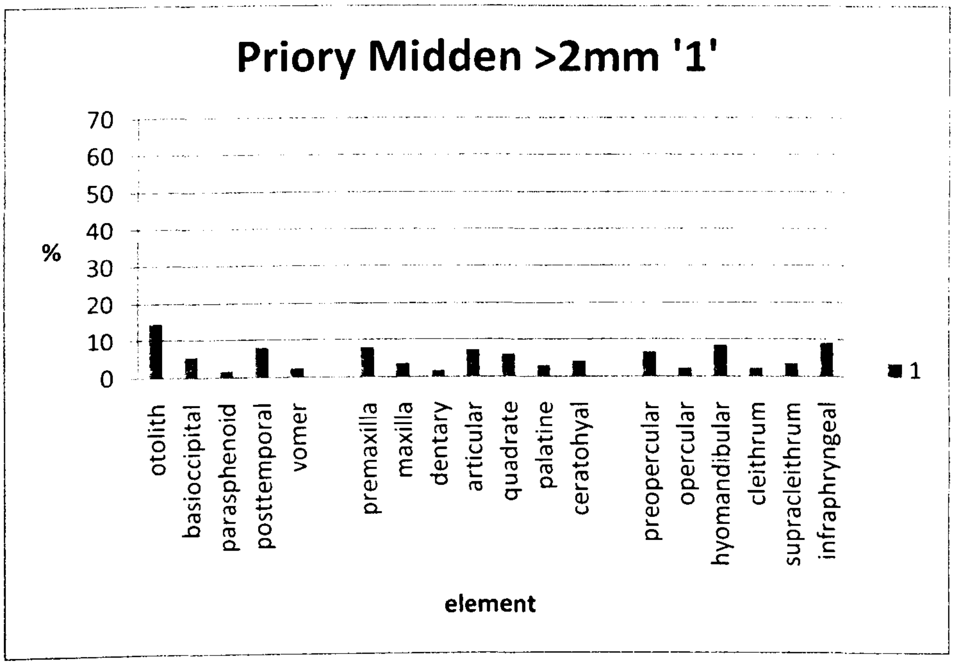


Figure 5.1 **Priory Midden sample 1 >2mm QC1 and 4 element distribution**

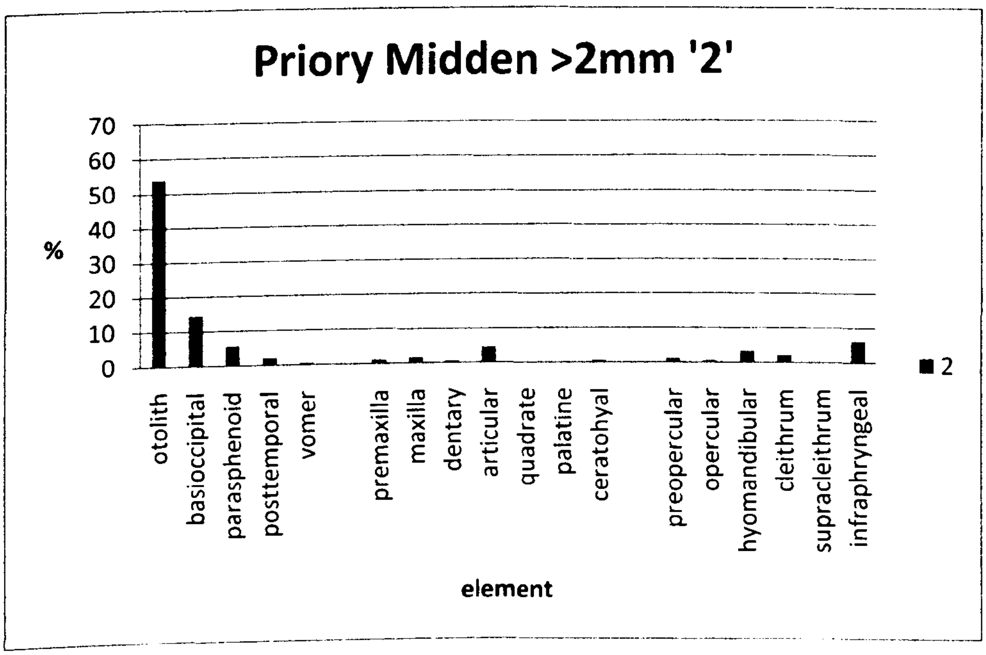


Figure 5.2 **Priory Midden sample 2 >2mm QC1 and 4 element distribution**

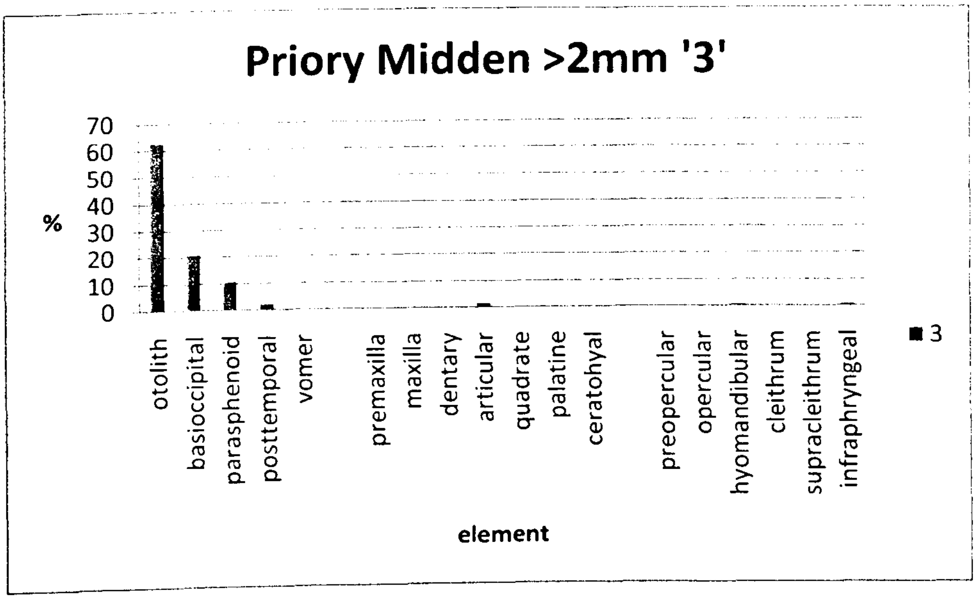


Figure 5.3 **Priory Midden sample 3 >2mm QC1 and 4 element distribution**

5.5.2 Caisteal nan Gillean I

According to Mellars samples were taken from trench B, one of three trenches excavated at the site (Mellars, 1987a, 174) (Table 5.15). Wilkinson, however, states that samples were taken from two tests pits and does not say how many samples taken from each, just that 5 samples were taken in total. Fish bone was recovered from 2 of these samples and the 1-2mm and >2mm fraction recorded by Wilkinson (Table 5.16). If these samples (4 and 5) did come from trench B they could potentially correspond with layers 4 and 5. As with the Priory Midden it is impossible to know if this is the case.

Layer	Description
4	dense shells in looser, paler, sandy matrix. Possible traces of a small pit or post hole can be seen at the base of the layer.
5	sequence of buff white, calcareous blown sand deposits, containing series of intercalculated palaeosols horizons

Table 5.15 **Description of layers containing fish bone, Trench B, Caisteal nan Gillean I (Mellars, 1987a, 174)**

A total of 514 identified fish bones (QC1, 2 and 4) were recorded from the >2mm fraction. From sample 4, 289 identified bones and sample 5, 225 bones. From the same samples a further 480 bones were identified from the 1-2mm fraction. For both samples the proportion of QC1 to QC 2 (vertebrae) is roughly as it would occur in a complete skeleton. In both samples the otolith is the most common element aside from vertebrae, in sample 5 it appears significantly over-represented (Figure 5.4, Figure 5.5).

CNGI	4			5		
	1-2mm	>2mm		1-2mm	>2mm	Site total
otolith	16	20	otolith	18	15	69
basioccipital	5	5	basioccipital	4	1	15
parasphenoid	1	6	parasphenoid		2	9
posttemporal	1	3	posttemporal	2	9	15
vomer		1	vomer		1	2
						0
premaxilla	14	13	premaxilla	4	6	37
maxilla	3	9	maxilla	2	2	16
dentary	6	12	dentary	3	4	25
articular	2	10	articular	2	4	18
quadrate	5	5	quadrate	1	2	13
palatine	1	3	palatine		1	5
ceratohyal	4	6	ceratohyal		3	13
preopercular		6	preopercular	1	1	8
opercular	1		opercular			1
hyomandibular	1	5	hyomandibular		2	8
cleithrum		2	cleithrum		3	5
supracleithrum	2	5	supracleithrum		3	10
infraphryngeal	4	11	infraphryngeal	1	2	18
thoracic vert	16	18	thoracic vert	12	20	66
abdominal vert	62	83	abdominal vert	49	56	250
caudal vert	94	77	caudal vert	148	90	409
total QC1 & 4	66	122		38	61	287
total	238	300		247	227	1012

Table 5.16 Caisteal nan Gillean I element distribution (1-2mm and >2mm fractions)

From the > 2mm fraction the overall pattern of QC1 and 4 elements for both samples is similar. The 1-2mm fraction does not vastly change the elements present, the only new element to be added is a single opercular in sample 4. Without detailed information on the identified elements it is impossible to know whether the elements are part or complete.

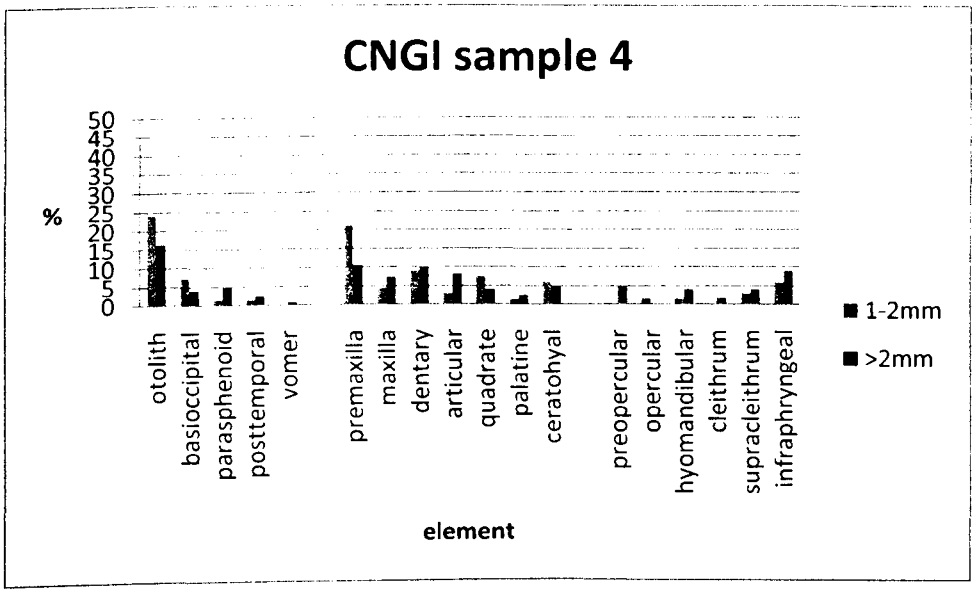


Figure 5.4 Caisteal nan Gillean I sample 4 QC1 and 4 element representation

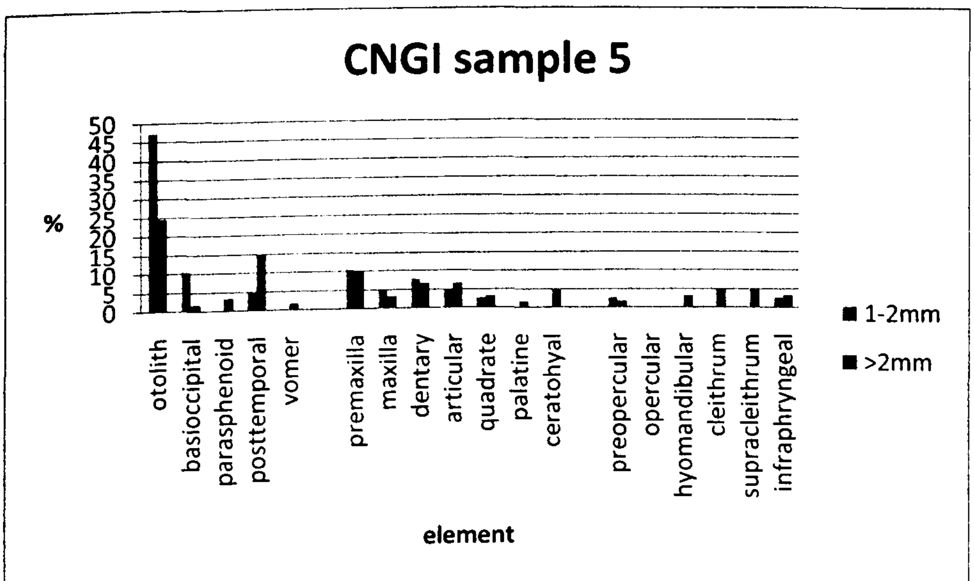


Figure 5.5 Caisteal nan Gillean I sample 5 QC1 and 4 element representation

5.5.3 Caisteal nan Gillean II

Four main trenches were excavated at the site, P, Q, R and U. Trench P was close to the centre of the site, the other three at the edges of the midden. Trench Q to the north, trench U to the west and trench R to the east of the central zone of the midden. The column from each trench had between 2-5 samples; the >2mm fraction was completely sorted and the otoliths from samples EFGHJ, QR sorted. However, it is impossible to match the fish bone samples with the excavated trenches. A total of 7048 identified fish bones (diagnostic fish bones as defined in the York system) recovered from the >2mm fraction from 14 samples (A, B, C, D, E, F, G, H, J, L, M, N, Q, R). Of these samples G, H and J each contain over 1500 identified specimens (Table 5.17). In addition, otoliths were recorded from the 1-2mm fraction.

	A	B	C	D	E	F	G	H	J	L	M	N	Q	R	total
otolith	11	25	12	9	6	24	61	66	76	16	30	15	25	42	418
basioccipital				1		8	34	24	16	2	1	1	4	13	104
parasphenoid		2				1	23	26	28				3	7	90
posttemporal					1	6	10	9	12				8	8	54
vomer						3		7	13					4	27
premaxilla		2		1		6	10	25	48	1		1	6	4	104
maxilla					1	5	7	29	29				2	9	82
dentary						7	7	12	35				4	3	68
articular						6	10	27	17				2	13	75
quadrate						7	4	20	28				2	10	71
palatine						2	1	11	6					2	22
ceratohyal						2	5	14	5				3	5	34
preopercular						1	5	8	7				2	2	25
opercular						1	1	4	2						8
hyomandibular						1	6	10	3				2	4	26
cleithrum							1	5							6
supracleithrum						2	6	6	13				4	5	36
infraphryngeal		1					1		3				2	105	
thoracic vert	2	8		5	8	34	145	138	167	5	10	4	27	80	633
abdominal vert	1	8	4	10	8	172	584	663	667	8	6	4	109	269	2513
caudal vert		7		9	8	191	620	703	752	3	3		114	242	2652
total QC1 & 4	11	30	12	11	8	82	192	303	341	19	31	17	69	165	1250
total	25	83	28	46	40	561	1733	2110	2268	54	81	42	388	1063	8298

Table 5.17 Caisteal nan Gillean II element distribution (>2mm fraction)

It is clear that there is a very different pattern between samples A, B, C, D, E, F, L, M, N, and samples F, G, H, J, Q, R. In the first group the total number of elements per samples is fewer than 50 and the majority of the elements are otoliths and vertebrae. The QC1 and QC4 element distribution typical of these samples is illustrated by sample B in Figure 5.6. In the second group there is a wider range of elements present and in larger quantities. Samples F, G, H, J and Q show a very similar QC1 and 4 distribution; sample F is shown in Figure 5.7. There is an underrepresentation of elements such as the infraphyrngeal and cleithrum, the otolith, other neurocranium elements and elements from the jaws are present. Sample R has a very different element distribution, rather than otolith the most abundant element the infraphryngeal is the most abundant. This is an incredibly strange pattern.

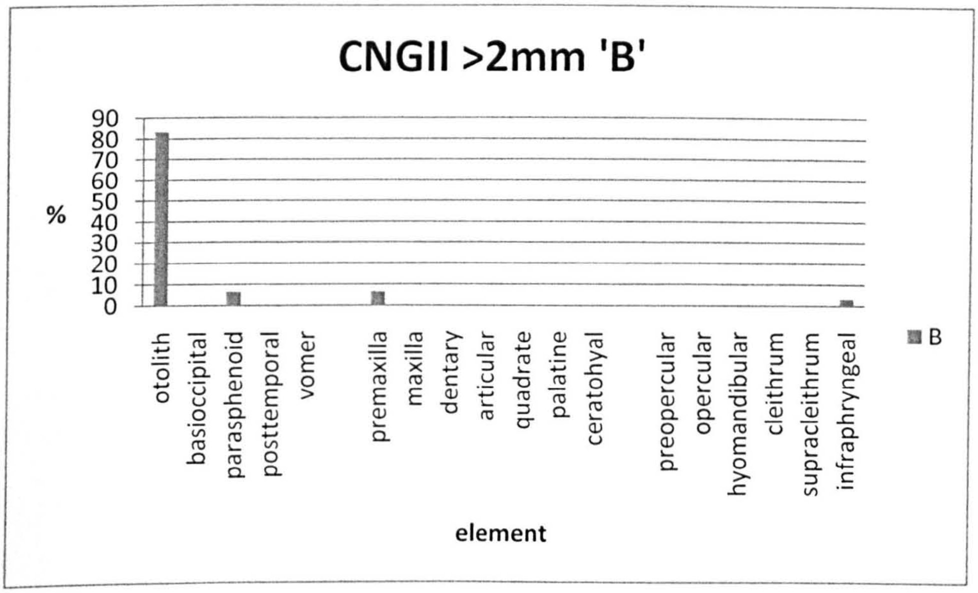


Figure 5.6 **Caisteal nan Gillean II sample B QC1 and 4 element representation**

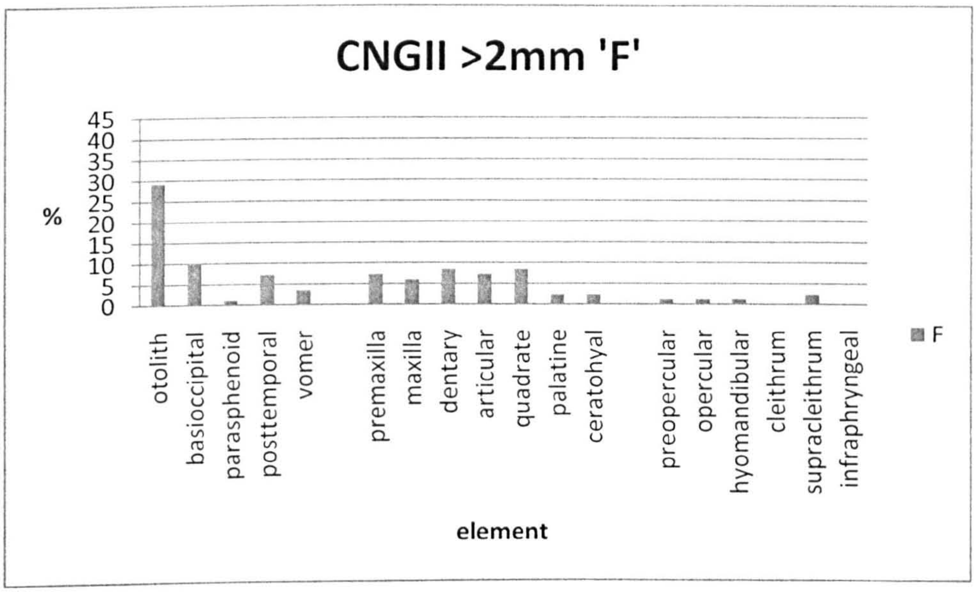


Figure 5.7 Caisteal nan Gillean II sample F QC1 and 4 element representation

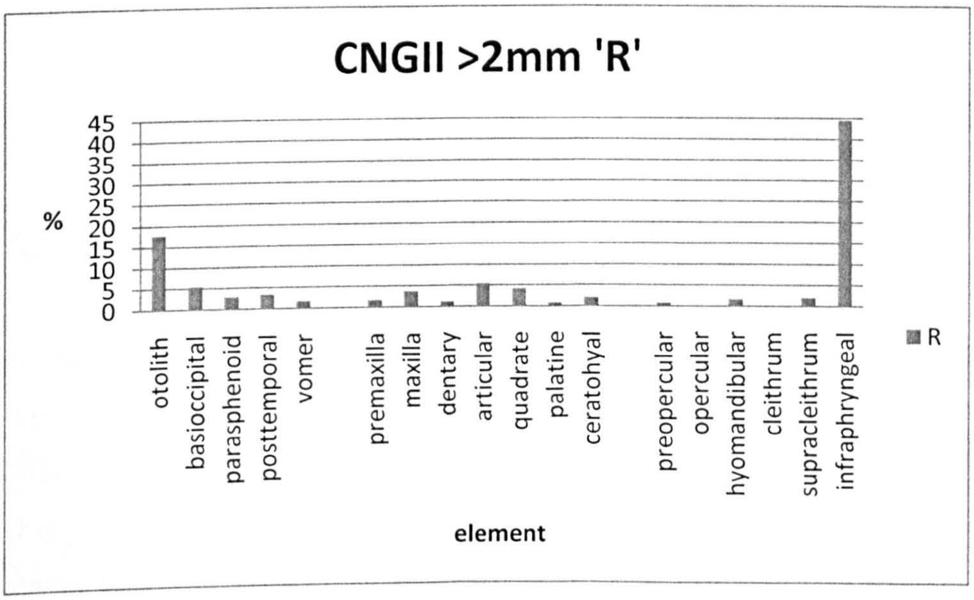


Figure 5.8 Caisteal nan Gillean II sample R QC1 and 4 element representation

5.5.4 Cnoc Coig

Cnoc Coig produced the largest number of samples, these were from columns taken from test pits and fish bone concentrations. No samples from trench excavation that did not contain concentrations of fish bones were included. From the 13 test pits across site the >2mm fraction of samples were analysed from pits 1-11. Wilkinson states that he recorded the greater than 2mm and greater than 1mm fractions from 10 of the 38 samples taken from small fish bone concentrations across the site (16, 18, 20, 21, 22, 23, 24, 29, 30, 31), only the results from the 1mm fraction are given in his thesis. Finally, Wilkinson analysed samples from two large adjacent concentrations or layers 250x250mm adjacent squares from the south-east quadrant of site where the deepest midden deposits were located (Wilkinson, 1981, 151). Unfortunately, it is impossible to locate their exact position as no grid square is given. From this last group the majority of the 30 samples taken were only sorted for otoliths. The other elements are given for both the 1-2mm and >2mm fractions for sample L2 and L6, both of which are from the lower level of the fish bone concentration.

5.5.5 Cnoc Coig test pits

A total of 41 samples from 11 test pits contained fish bone, many of these samples contain few diagnostic elements (Table 5.18, Table 5.19). Those pits with samples with ≥100 QC1 and QC4 elements are discussed in detail. Beginning with Pit 1, sample A (Figure 5.9) the otolith is the most abundant element. The cleithrum is absent but the supracleithrum (which articulates with the cleithrum) is present in small numbers. Similarly, the palatine is absent but other elements in the same region are present.

	Pit 1					Pit 2							Pit 3		Pit 4			Pit 5		Pit 6				
	a	b	c	d	e	a	b	c	d	e	f	g	a	b	a	e	f	a	b	a	b	C	d	e
otolith	50	49	10			37	92	255	29	46	10	6	12			2	31	4	1	23	83	180	36	16
basioccipital	6	8				2	38	141	15	17	17	1	5							4	3	33	7	3
parasphenoid	6	2				2	15	89	10	12	3	2					3			1	7	40	13	
posttemporal	4			1		9	43	128	4	8	9	2						1			6	5	7	1
vomer	3	2				2	32	59	2	6							2			2	4	10	5	3
premaxilla	10	5		1		5	82	207	3	13	9		3			2	1	1		4	14	9	25	2
maxilla	6	6		1	1	5	71	146	1	9	6		2	1			2	2		6	9	8	13	5
dentary	4	1	1	1		4	46	50	4	13	2	1	2				2			1	25	5	11	6
articular	10	4	1	1	1	11	70	275	4	27	4	5	4				2			9	6	14	9	4
quadrate	6	2		2		3	51	135	2	10	4	2	2		1		2			7	6	5	6	1
palatine						1	10	19	1	3												1	2	
ceratohyal	3			1			49	220	3	12	5	3									6	6	2	
preopercular	3	1				3	33	139		12	2	1								2	3	3	2	
opercular	2	1		1		1	15	32	1	4	2	3										1	2	
hyomandibular	3		1	2		5	56	241	3	17	4	8	1								3	5	9	2
cleithrum				3		5	6	50		12	1		1											1
supracleithrum	3					2	18	25	2	2	4		1								1	2	1	
infraphryngeal				7		6	5	18		1	5									2	9	85	2	
thoracic vert	43	26	3	2		14	118	307	51	91	26	4	18	1	2		19		1	36	76	238	34	7
abdominal vert	147	59	5	16	3	73	608	457	241	466	114	12	70	3		8	42		3	91	354	762	154	33
caudal vert	136	100	13	17	2	72	544	1604	266	363	88	17	65	7		5	100	7		91	229	1116	177	79
total QC1 and 4	119	81	13	21	2	103	732	2229	84	224	87	34	33	1	1	4	45	8	1	61	185	412	152	44
total fish	445	266	34	56	7	262	2002	4597	642	1144	315	67	186	12	3	17	206	15	5	279	844	2528	517	163

Table 5.18 Cnoc Coig test pit element distribution (>2mm fraction), pits 1-6

	Pit 7						Pit 8	Pit 9		Pit 10				Pit 11				Total test pits
	a	b	c	d	e	f	a	a	b	a	b	c	d	a	b	c	d	
otolith	34	11	14	26	1	14	23	9	14	41	14	9	14	10	52	17	14	1289
basioccipital	4	3		4	1	3		1		2	5		6	2	7	6	3	347
parasphenoid		3		4		2			1	6	4	1	3			2	2	233
posttemporal		3	1	2	3	4		1			3		1	3	3	4	1	257
vomer			2	1		1			1		1		2		3	1		144
premaxilla	4	5	2	5	1	1	3	1	2	11	14	4	5	2	11	15		482
maxilla	8	8		2		1	1			5	8	3	4	2	8	7	1	358
dentary	2	2	1	1		6			1	14	9	2	4		3	7		231
articular	4	4	5	5	2	2			1	2	2	5	6	2	7	9	4	521
quadrate	4	2		2	1	4		1	1	3	4	1	2	1	2	2	2	279
palatine	1			1		1					1							41
ceratohyal				1	1	2								1	4	1	1	321
preopercular		3	1	2		1				1	1	1	1	1	3	1		220
opercular						1				1					1	3		71
hyomandibular		1		7	3	1					6		2		1	4	1	386
cleithrum	1		1	1	1	1							1					85
supracleithrum		2		1	2	3				1	2				1	1		74
infraphryngeal	1	1		1		1		1							2	1		148
thoracic vert	48	14	13	26	4	4	8	6	1	26	19	11	15	15	75	26	*	1428
abdominal vert	92	38	26	107	19	40	9	21	6	59	94	26	48	37	235	71	300	4949
caudal vert	77	68	39	134	28	67	3	21	25	96	98	55	54	41	233	95	*	6232
total QC1 and 4	63	48	27	66	16	49	27	14	21	87	74	26	51	24	108	81	29	5487
total fish	280	168	105	333	67	160	47	62	53	268	285	118	168	117	651	273	329	18096

Table 5.19 Cnoc Coig test pit element distribution (>2mm fraction) continued, pits 7-11

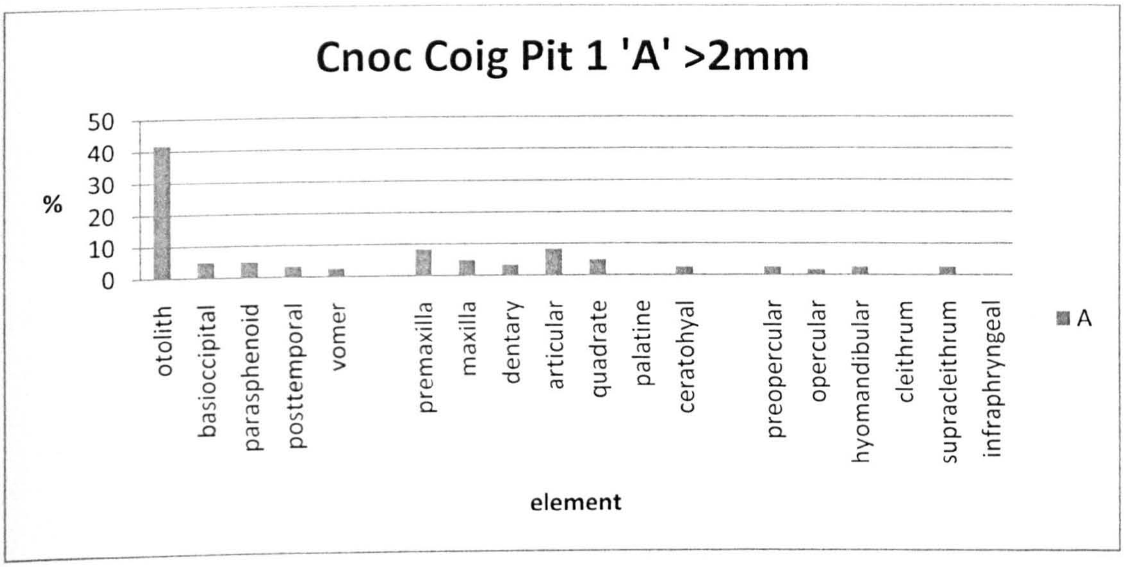


Figure 5.9 Cnoc Coig pit 1, sample A QC1 and 4 element representation

Figure 5.10 shows samples B, C and E from Pit 2. Sample C is of interest due to its large size (over 2000 QC1 and 4 elements out of a total of 4579) and it is one of the few samples where the otolith is not the most numerically abundant QC1 or 4 element, instead it is the articular. When the split between abdominal (including thoracic) and caudal vertebrae is considered there appear to be almost twice as many caudal vertebrae as abdominal vertebrae (Table 5.18). But, the distribution of other elements would seem to suggest that fish carcasses were being disposed of largely whole; elements from the head and appendicular region are well represented. In pit 6 heads and vertebrae are present but fewer elements from the opercular series and cleitherum and associated elements are present. In sample C the infraphryngeal is over represented, a similar pattern to sample R from Caisteal nan Gillean.

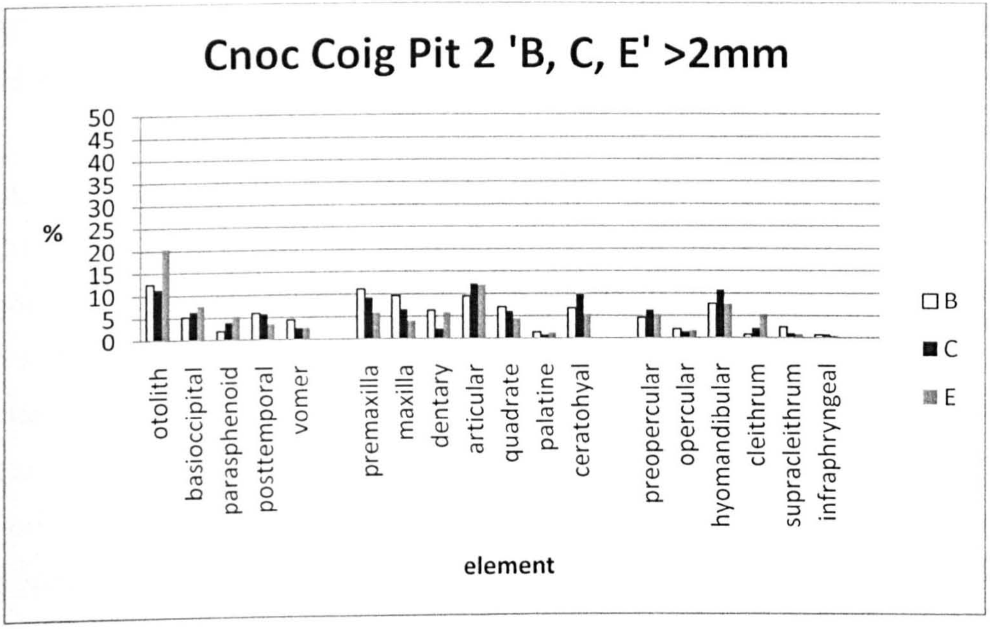


Figure 5.10 **Cnoc Coig pit 2, samples B,C,E QC1 and 4mm element representation**

5.5.6 Cnoc Coig fish bone concentrations

In the 1mm and 2mm fraction element distributions for the large fish bone concentrations (L2 and L6) it appears that vertebrae were not recorded according to their place along the vertebral column. This is not explicitly stated but the original table in Wilkinson's thesis does not show a blank for thoracic or cadaul vertebrae just a line that seems to indicate the total for abdominal vertebrae is the total for all vertebrae Table 5.20.

Despite both being from large concentrations of fish bones there are immediately noticeable differences in the element distribution patterns of L2 and L6. In sample L2 the otolith is by far the most abundant QC1 and QC4 element whereas in sample L6 this is not the case. Figure 5.11and Figure 5.12shows each element plotted as a % of the total number of QC1 and QC4 elements. In sample L2 otoliths account for half of the total number of QC1 and QC4 elements. The parasphenoid and basioccipital also show a peak from that sample when compared to the rest of the elements. This is slightly unusual as both these elements are midline elements (one in the body) yet they are more abundant than paired elements. From sample L6 the differences in element distribution are less pronounced and most parts of the fish are present. Otoliths only account for just under 9% of the total number of QC1 and QC4 elements. The ceratohyal is only present in the 1mm fraction and the hyomandibular only present in the 2mm fraction.

A chi-square test in the statistic package Minitab for the combined 1mm and 2mm fractions for L2 and L6 confirms that there is a statistical difference between the two samples. A statistically significant result is given if the P value is 0.05 or less and the P value for this comparison is 0.00. In other words, it is possible to say with a high degree of certainty that the element distributions from the two samples are different. (chi-square = 55.124 DF= 16 P value= 0.00). As can be seen from Table 5.20 there are lots of otoliths from sample L2 and it is possible that this may skew the comparison. However, when the chi-square test is run again, comparing L2 and L6 but without the otoliths there is still a significant difference (chi-square 163.268 DF = 14 P-value = 0.00).

	SE quadrant 2mm		1-2mm			small fish bone concentrations 1-2mm										
	L2	L6	L2	L6	**total**	16	18	20	21	22	23	24	29	30	31	**total**
otolith	142	55		13	**210**	2	58	70	1	64	60	5	31	19	22	**390**
basioccipital	39	16		4	**59**		5	15	1	10	13	4	4	10	5	**72**
parasphenoid	40	15		9	**64**		5	13		6	16	3	7	7	2	**64**
posttemporal	8	29	1	40	**78**		19	13	2	1	68	20	9	14	13	**178**
vomer	3	19	1	16	**39**		6	12	1	1	28	9	6	4	6	**79**
					0											
premaxilla	3	19	1	31	**54**		13	26	2	2	42	10	17	13	14	**152**
maxilla	5	27	1	19	**52**		6	41		2	54	11	17	18	10	**165**
dentary	4	18		35	**57**		13	21	2		54	11	17	5	16	**152**
articular	6	49	1	12	**68**	1	15	24	1		54	7	11	8	9	**145**
quadrate	5	37		12	**54**	1	14	35			59	8	11	12	13	**167**
palatine	2	15	3	32	**52**		6	20		1	28	9	8	6	5	**89**
ceratohyal	5			8	**13**		3	25			36	10	5		7	**89**
					0											
preopercular	4	56		3	**63**		8	21			26	9	1		4	**77**
opercular	3	28		4	**35**		9	6			29	8	2	2	6	**71**
hyomandibular	2	57			**59**		15	15			40	19	2	5	2	**113**
cleithrum		43			**43**		4	4		1	1		1	2		**17**
supracleithrum	2	8	3	33	**46**		22	7	1	1	46	8	4	4	10	**125**
infraphryngeal	2	26	1	36	**65**	92	32	10	1	75	29	4	4	6	5	**290**
					0											
thoracic vert			*	*	**0**		9	60	7	80	37	5	58	26	10	**292**
abdominal vert	2502	596	87	390	**3575**	3	32	101	49	205	100	6	255	26	39	**816**
caudal vert			*	*	**0**	1	151	250	107	344	617	123	409	101	124	**2227**
					0											
total QC1 and 4	275	517	99	697	**1588**	100	445	789	175	793	1437	289	879	288	322	**5517**
total fish	2777	1113	12	307	**4209**	96	253	378	12	164	683	155	157	135	149	**2182**

Table 5.20 **Cnoc Coig element distribution (2mm and 1-2mm fractions) for large fish bone concentrations and small concentrations from across the site**

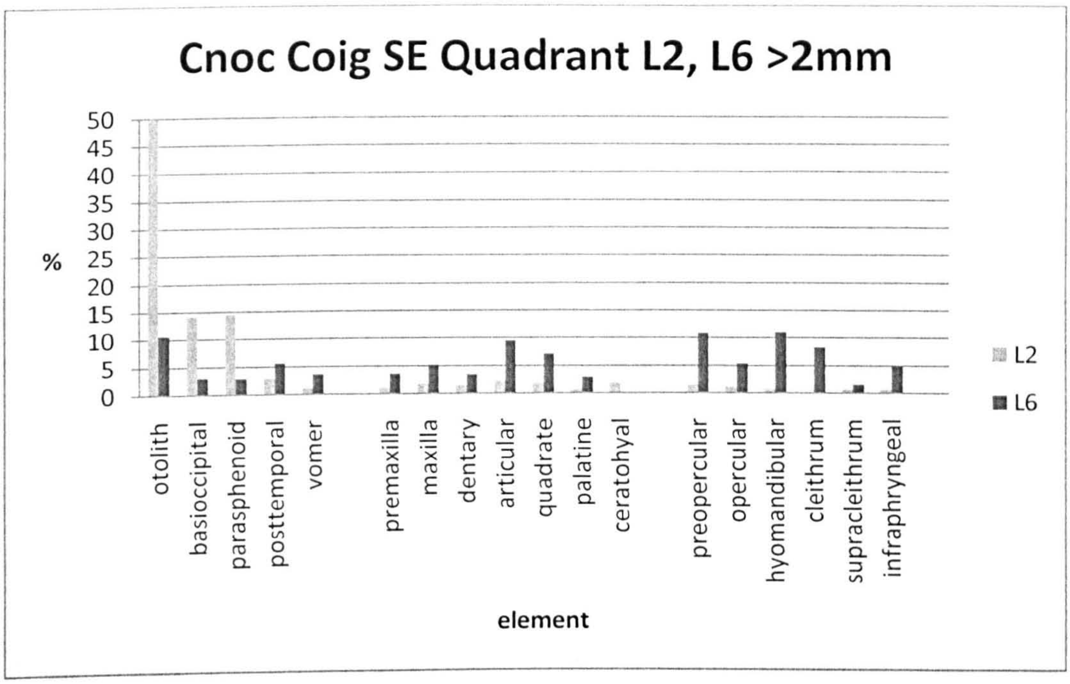


Figure 5.11 Cnoc Coig south-east quadrant L2 and L6 >2mm QC1 and 4 element representation

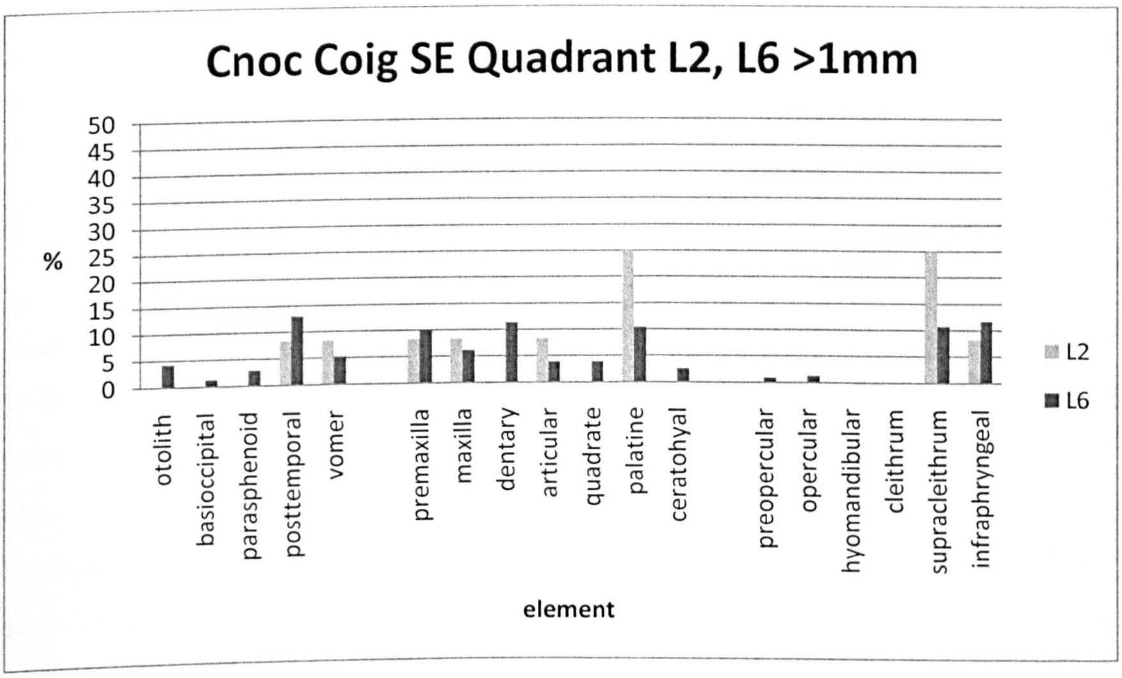
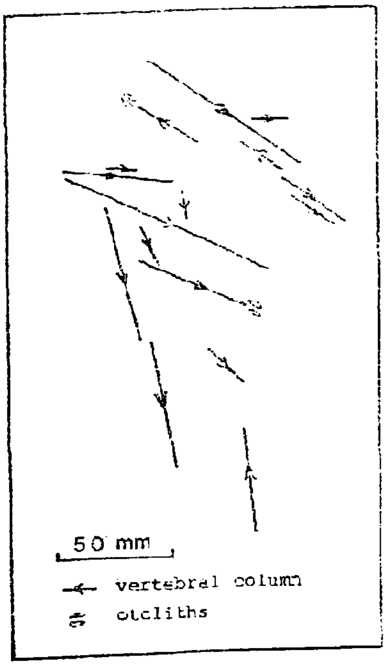


Figure 5.12 Cnoc Coig south-east quadrant L2 and L6 >2mm QC1 and 4 element representation

5.5.7 Cnoc Coig fish bone concentrations

Sixteen articulated skeletons were found from Cnoc Coig (schematically illustrated in Figure 5.13), the exact elements represented are difficult to ascertain but the vertebral column is present and in two cases both otoliths. This means certainly in some cases fish were dumped after processing with heads intact (Wilkinson, 1981, 77).



This certainly fits with the element skeletal patterning seen in L6 and in some of the samples from other sites and is consistent with many of the small fish bone concentration samples (for example 18, 20, 23 and 29). However, not all of the element representations from the concentrations show a wide range of elements.

Figure 5.13 Articulated fish from Cnoc Coig (Wilkinson, 1981, Figure 13)

Concentrations 18, 20, 23, 24, 30, 31 and 29 all show a fairly even spread of elements, with the otolith most often the most abundant element and vertebrae and most of the other parts of the fish well represented. Sample 16 and 22 are very different. Concentration 16 has very few vertebrae and few QC1 elements other than infraphryngeals. Concentration 22 also has a high proportion of infraphyrngeals but also has otoliths and vertebrae in abundance.

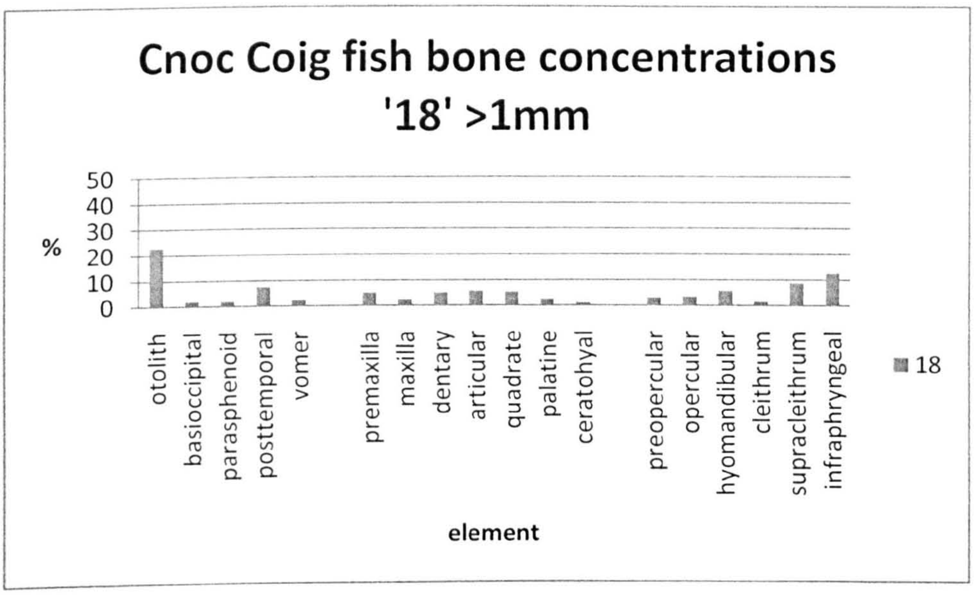


Figure 5.14 Cnoc Coig fish bone conentrations, sample 18 QC1 and 4 element representation

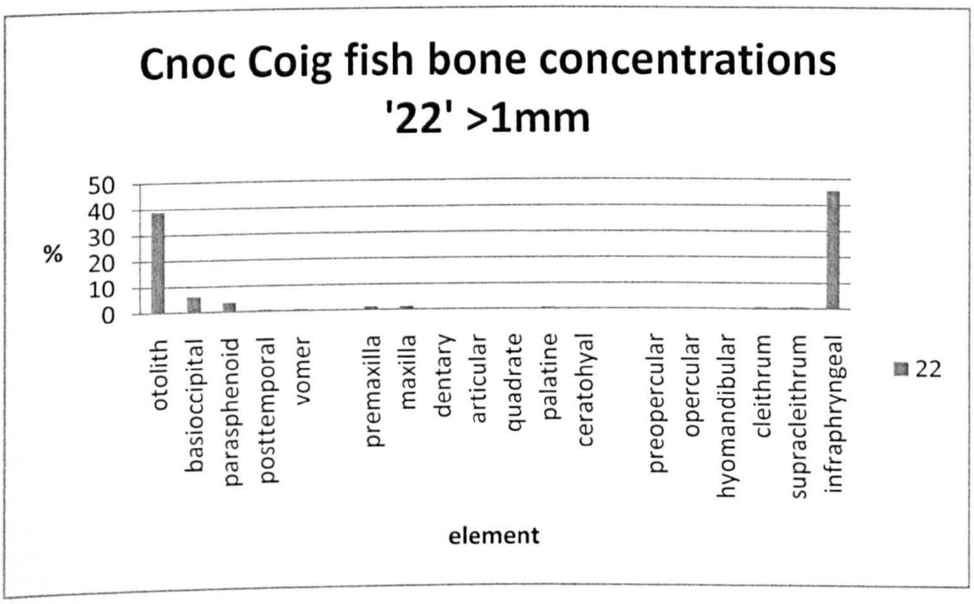


Figure 5.15 Cnoc Coig fish bone concentrations sample 22 QC1 and 4 element representation

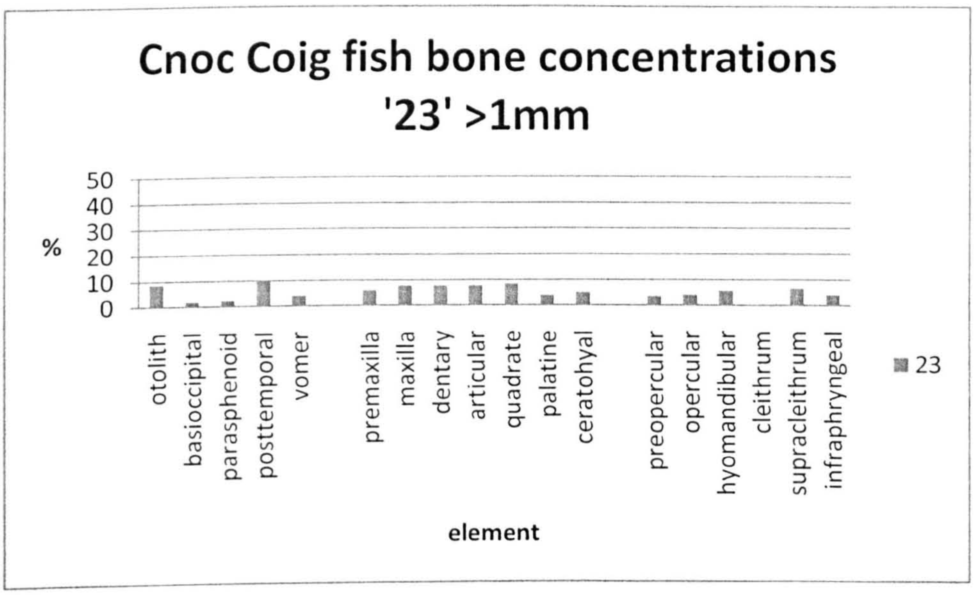


Figure 5.16 Cnoc Coig fish bone concentrations sample 23 QC1 and 4 element representation

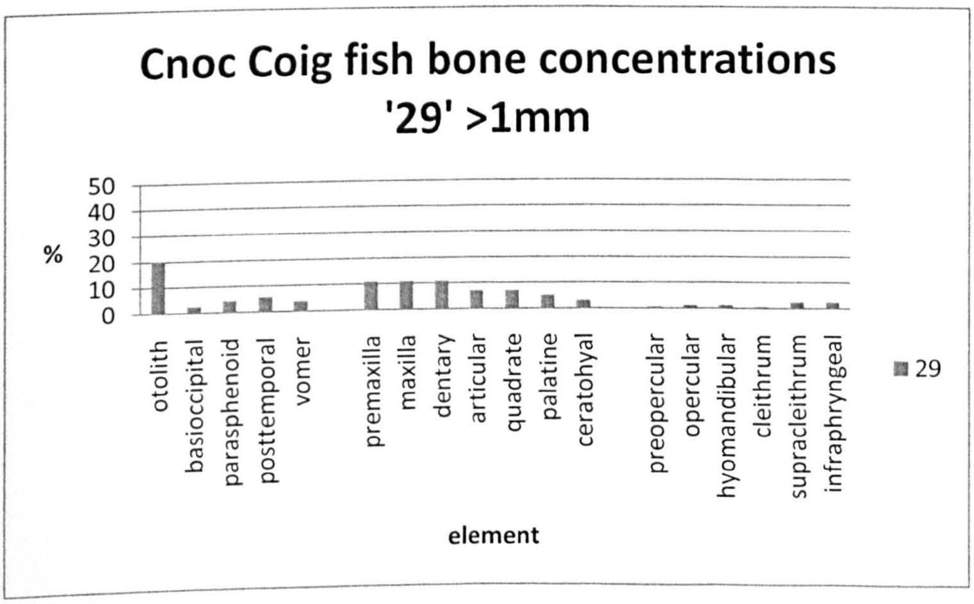


Figure 5.17 Cnoc Coig fish bone concentrations sample 29 QC1 and 4 element representation

5.6 *Cnoc Sligeach*

Two trenches were excavated at the site and according to Mellars a series of well-stratified samples were taken from trench B. Wilkinson analysed 5 of these samples, 28-32. The >2mm fraction was recorded for all elements; only otoliths from the 1-2mm fraction were recorded. The otolith is the most common element other than vertebrae in all samples. The QC1 and QC4 element distribution is given for each sample (Table 5.21). In most samples elements from the head and jaw area are consistently relatively well represented, such as the premaxilla, articular and basioccipital (for example sample 29, Figure 5.18). In sample 30 the cleithrum, supracleithrum and infraphryngeal are absent but are only present in small numbers in the other samples. It appears that complete or near complete skeletons were discarded.

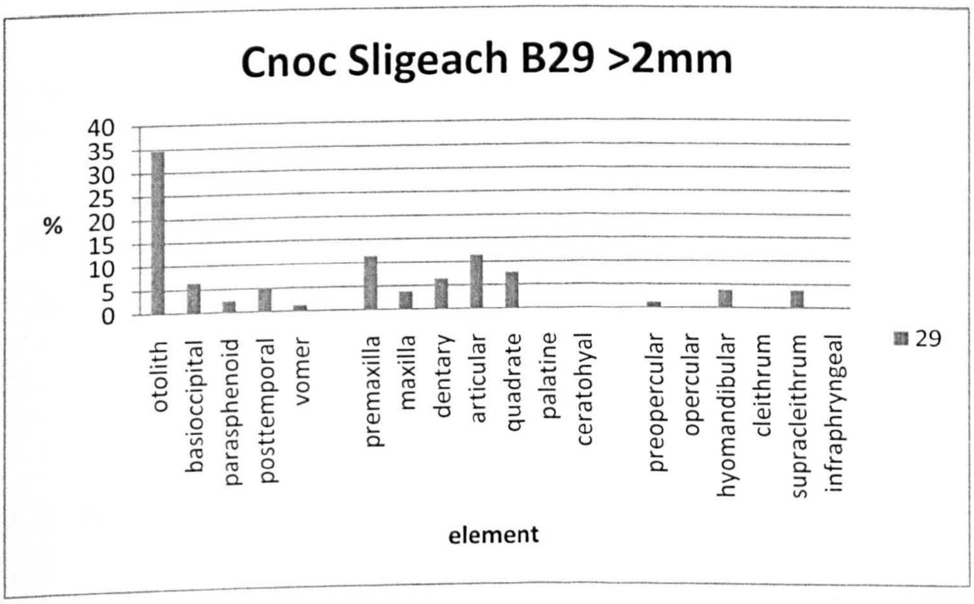


Figure 5.18 Cnoc Sligeach B29 QC1 and 4 element representation

	28	29	30	31	32	Total
Otolith	45	27	33	38	15	158
basioccipital	10	5	10	16	8	49
parasphenoid	12	2	9	4	5	32
posttemporal	22	4	5	6	2	39
Vomer	5	1	6	6	1	19
Premaxilla	20	9	9	6		44
Maxilla	12	3	10	10	3	38
Dentary	4	5	4	8	5	26
Articular	23	9	14	19	7	72
Quadrate	7	6	6	2		21
Palatine	3		2	4		9
Ceratohyal	12		3	4	5	24
preopercular	8	1	6	8	2	25
Opercular			1	2		3
hyomandibular	16	3	1	5	7	32
Cleithrum	3			4	2	9
supracleithrum	11	3		5	2	21
infraphryngeal	6			3		9
thoracic vert	77	46	49	53	32	257
abdominal vert	250	101	241	270	131	993
caudal vert	322	138	239	357	137	1193
total QC1 and 4	219	78	119	150	64	630
total fish	868	363	648	830	364	3073

Table 5.21 **Cnoc Sligeach element distribution**

5.7 *Reanalysis of Cnoc Sligeach*

In order to better assess if re-analysis of all the Oronsay material be worthwhile one site was re-recorded for this thesis. Cnoc Sligeach was chosen as the otolith histograms from the site show a bimodal distribution as for Sand, but based solely on Wilkinson's data the two cannot be directly compared. The >1mm and 2-4mm fraction were analysed for all 5 samples (B28, B29, B30, B31, B32) and from the 1/8" fraction available for samples B29, B30, B31. The aim of this was to provide quantifiable data on preservation factors such as fragmentation and burning and to be able to further assess the element distribution pattern by using a quantification method that allows MNE to be calculated.

The five samples from Cnoc Sligeach are from the same column sample from trench B which was near the summit of the site. One can assume that the sample number refers to stratigraphic (vertical) sequence but it is not entirely clear the relationship of the samples to each other. Two layers were recorded on site and Mellars suggested that rather than being *in situ* material had been deposited from elsewhere on the site, perhaps including clearing out of a hearth. The samples are described as well stratified but it is impossible to match up which sample is from which layer. Thus, the raw data is presented here sample by sample for archive purposes but the element representation and otolith lengths discussed on a site basis.

5.7.1 Preservation and modification

Based on QC1 (cranial and appendicular bones) and QC4 (otoliths) elements the assemblage from Cnoc Sligeach was generally well preserved (Table 5.22, Table 5.23). On the majority of specimens the bone surface texture was generally excellent, good or fair (as defined in Table 5.22). There is no obvious difference in preservation according to fraction size. Equally there is no discernable difference between sample number. For the same specimens few were less than 20% complete. Specimens were fragmented but not to the degree to prevent identification. Most of the otoliths (QC4) were in the category 41% and above complete, in practice meaning that generally at least half of each otolith was present.

From all specimens, both identified and unidentified, 362 specimens were recorded as charred or calcined (Table 5.24). Heeding the comment on fragmentation above it needs to be remembered that this is specimens not whole elements. The number of whole elements (and in turn fish) this actually relates to could be much fewer. From sample B28 7% of specimens were burnt, from B29 around 5%, from B30 around 7%, from B31 3% and 5% from B32. The presence of burnt material, albeit in small quantities, is consistent with Mellars' understanding that trench B had re-deposited material including hearth clear out.

column	recovery	QC	excellent	good	fair	poor	total
CSLIG-B28	>1	4	12	15	11	17	55
	2-4	1	8	37	34	9	88
		4	4	14	11	18	47
CSLIG-B28 subtotal			24	66	56	44	190
CSLIG-B29	>1	1	7	7	3		17
		4	26	16	7	13	62
	2-4	1	8	16	12	1	37
		4	13	6	5	3	27
	1/8	1	1	7	10		18
		4		5	2	1	8
CSLIG-B29 subtotal			55	57	39	18	169
CSLIG-B30	>1	1	14	15	3		32
		4	43	15	9	12	79
	2-4	1	6	31	13	6	56
		4	12	14	2	3	31
	1/8	1	2	29	33	5	69
		4	5	16	1	1	23
CSLIG-B30 subtotal			82	120	61	27	290
CSLIG-B31	>1	4	12	8	2	4	26
	2-4	1	36	48	19	5	108
		4	13	7	10	9	39
	1/8	1	3	15	16		34
		4	1	8	2	3	14
CSLIG-B31 subtotal			65	86	49	21	221
CSLIG-B32	>1	4	8	4	3	1	16
	2-4	1	17	12	3	1	33
		4	6	4	3	2	15
CSLIG-B32 subtotal			31	20	9	4	64
Total			257	349	214	114	934

Table 5.22 Cnoc Sligeach reanalysis surface texture of QC1 elements Assessment of surface texture based on the following criteria (Harland *et al.*, 2003): Excellent – majority of surface fresh or even slightly glossy; very localized flaky or powdery patches, Good – lacks fresh appearance but solid; very localized flaky or powdery patches, Fair – surface solid in places, but flaky or powdery on up to 49% of specimen, Poor – surface flaky or powdery over >50% of specimen

column	recovery	QC	0-20%	21-40%	41-60%	61-80%	81-100%	total
CSLIG-B28	>1	4		3	11	8	32	54
	2-4	1	4	37	20	23	4	88
		4			7	6	34	47
CSLIG-B28 subtotal			4	40	38	37	70	189
CSLIG-B29	>1	1	1	3	4	5	4	17
		4			18	11	33	62
	2-4	1	1	18	8	6	4	37
		4			2	4	21	27
	1/8	1	1	10	2	4	1	18
		4					8	8
CSLIG-B29 subtotal			3	31	34	30	71	169
CSLIG-B30	>1	1	2	15	5	8	2	32
		4			12	10	57	79
	2-4	1	5	24	15	9	3	56
		4			1	2	28	31
	1/8	1	8	32	17	11	1	69
		4			1	5	17	23
CSLIG-B30 subtotal			15	71	51	45	108	290
CSLIG-B31	>1	4			4	1	21	26
	2-4	1	6	34	23	32	13	108
		4		1	3	2	33	39
	1/8	1	2	9	9	9	5	34
		4				2	12	14
CSLIG-B31 subtotal			8	44	39	46	84	221
CSLIG-B32	>1	4			1	3	12	16
	2-4	1		6	14	10	3	33
		4		1		3	11	15
CSLIG-B32 subtotal				7	15	16	26	64
Grand Total			30	193	177	174	359	933

Table 5.23 Cnoc Sligeach reanalysis QC1 and 4 percentage element completeness

Beyond burning, few specimens showed signs of other modification (Table 5.25). Three had a surface texture consistent with partial digestion (Jones, 1986, Wheeler and Jones, 1989). A further 6 specimens had been crushed whilst the bone was fresh. Probable causes are mastication or trampling. No cut marks were present.

Column	recovery	QC	calcined	charred	total
CSLIG-B28	>1	4	2		2
	2-4	0	19	33	52
		1	7	1	8
		2	3	11	14
CSLIG-B28 subtotal			31	45	76
CSLIG-B29	>1	0		1	1
		1		1	1
	2-4	0	19	13	32
		1	1	7	8
		2	4	3	7
	1/8	0	1		1
		2		2	2
CSLIG-B29 subtotal			25	27	52
CSLIG-B30	>1	0		4	4
		1	1		1
	2-4	0	27	71	98
		1	1	4	5
		2	4	6	10
	1/8	0	3	20	23
		1		1	1
		2	5	1	6
CSLIG-B30 subtotal			41	107	148
CSLIG-B31	>1	4		1	1
	2-4	0	16	13	29
		1		2	2
		2	4	9	13
		4	3	2	5
	1/8	0	2	5	7
		2	3	2	5
CSLIG-B31 subtotal			28	34	62
CSLIG-B32	>1	0		2	2
	2-4	0	11	5	16
		2	2	4	6
CSLIG-B32 subtotal			13	11	24
Total			138	224	362

Table 5.24 Cnoc Sligeach reanalysis burning, all elements

column	Recovery	QC	acid etched	crushed	total
CSLIG-B28	>1	4	2		2
	2-4	2		5	5
CSLIG-B29	>1	4	1		1
CSLIG-B32	2-4	2		1	1
Total			**3**	**6**	**9**

Table 5.25 Cnoc Sligeach reanalysis bone modification QC1, 2 and 4

5.7.2 Taxonomic abundance

In total 6662 specimens were recorded from Cnoc Sligeach, 4125 of which were identifiable to species or family level. However, the taxa list in Table 5.26 is deceptive. Although 15 species are listed the majority of these are represented by only 1 or 2 specimens. The most commonly recorded species was saithe (3079) followed by pollack (120). 789 specimens were identified as either saithe or pollack, and a further 95 as cod, saithe or pollack. As discussed in Chapter 4 saithe and pollack are closely related and osteologically can be very similar, it is therefore standard practice to record at genus level (*Pollachius*) when unsure which species an element is. Of the QC1 elements it was found that the hyomandibular, posttemporal and maxilla in the assemblage were often too poorly or partially preserved to identify beyond genus (*Pollachius*).

This species list in Table 5.26 increases the known taxa recovered from the site, although in most cases this is only by one specimen. Taxa identified in this doctoral work not previously included by Wilkinson are sand eel family, cuckoo wrasse, butterfish, halibut family, corkwing, gurnard family and Norway pout. Conversely there are several species, such as monkfish and thornback ray, which Wilkinson lists as present at the site which were not identified by the author. Saithe remains the most abundant species. Rather than Wilkinson's work focusing on saithe at the expense of other taxa it is clear now that the other taxa are present only in small quantities

Taxa	Common name	CSLIG-B28	CSLIG-B29	CSLIG-B30	CSLIG-B31	CSLIG-B32	Total
Ammodytidae	Sand Eel Family				1		1
Anguilla Anguilla	Eel		2				2
Belonidae	Garfish Family			1	1		2
Conger conger	Conger Eel	1					1
Gadidae	Cod Family	26	10	17	28	14	95
Gadus morhua	Cod		1				1
Gadus/Pollachius	Cod or Saithe or Pollack	1		12	3	5	21
Labrus bergylta	Ballan Wrasse			1	1		2
Labrus bimaculatus	Cuckoo Wrasse			1			1
Pagellus bogaraveo	Red Sea Bream			1			1
Perciformes	Perciformes order			1			1
Pholis gunnellus	Butterfish			1			1
Pleuronectidae	Halibut Family				1		1
Pollachius	Saithe or Pollack	209	125	230	155	70	789
Pollachius pollachius	Pollack	10	33	39	35	3	120
Pollachius pollachius?	Pollack?			1			1
Pollachius virens	Saithe	349	523	992	1025	190	3079
Scorpaenidae	Scorpion-fish Family			2			2
Sparidae	Sea Bream Family				1		1
Symphodus (Crenilabrus) melops	Corkwing					1	1
Triglidae	Gurnard Family			1			1
Trisopterus esmarki	Norway Pout	1					1
Unidentifed Fish	Unidentified Fish	483	372	939	568	175	2537
Total		**1080**	**1066**	**2239**	**1819**	**458**	**6662**

Table 5.26 Cnoc Sligeach reanalysis numbers of identified specimens (NISP) by sample. Unidentified fish includes specimens (QC0) not typically identified in the York system and truly unidentifiable specimens.

5.7.3 Element representation

A detailed breakdown of element distribution is given for all *Pollachius* (this includes specimens identified as saithe, pollack and the *Pollachius* genus level) QC1, 2 and 4 elements (Table 5.27). In terms of recovery the greater than 1mm but less than 2mm fraction contained the least number of specimens. In all samples vertebrae are the most common elements, there are typically around 50 vertebrae in a saithe's body, therefore, if whole or near complete carcasses were discarded a high proportion of vertebrae would be expected. All samples showed a very similar QC1 and 4 element distribution, but as the samples may not be archaeologically distinct from each other this is hardly surprising. The element distribution graph for sample B28 is shown in Figure 5.19 (combined recovery), each element is shown as a percentage of total QC1 and QC4 elements from the sample. Otoliths are the most abundant element in all samples, the distribution of other elements is more variable but QC1 elements are certainly underrepresented. Vertebrae are well represented and the lack of QC1 elements in any great proportion may be down to preservation bias towards the otolith. The element distribution pattern remains the same when minimum number of elements (based on the number of zones present in an element) is calculated (Figure 5.20).

		B28		B28 Total	B29			B29 Total	B30			B30 Total	B31			B31 Total	B32		B32 Total	Grand Total
QC	ELEMENT	>1	2-4		>1	1/8	2-4		>1	1/8	2-4		>1	1/8	2-4		>1	2-4		
1																				
	articular		14	14	1		8	9	3	5	4	12		8	16	24		3	3	62
	basioccipital		1	1		5	2	7		11	2	13		7	11	18		4	4	43
	ceratohyal		5	5						1		1			3	3		4	4	13
	cleithrum								1	1		2			2	2		1	1	5
	dentary		2	2			4	4	3		2	5		1	8	9		1	1	21
	hyomandibular		9	9	1		4	5	1	4	4	9		1	4	5		7	7	35
	infraphryngeal		2	2					1	1		2			4	4				8
	maxilla		4	4	3	3		6	6	9	5	20			10	10		3	3	43
	opercular										1	1			4	4				5
	palatine									1	2	3		1	4	5				8
	parasphenoid		5	5	1	5	1	7	4	18	6	28		2	5	7		4	4	51
	preopercular		2	2	2			2	2		2	4			6	6		2	2	16
	posttemporal		12	12	1	2	5	8		4	4	8		1	4	5		1	1	34
	premaxilla		9	9	2		6	8	4		6	10		2	4	6				33
	quadrate		5	5	2		3	5	1	5	4	10		2	2	4				24
	supracleithrum		4	4		2	2	4		1	2	3		2	5	7		1	1	19
	scapula		5	5														1	1	6
	vomer		2	2	1	1		2	2	1	4	7		2	6	8				19
1 Total			81	81	14	18	35	67	28	62	48	138		29	98	127		32	32	445
2	abdominal vertebra														2	2		13	13	15
	abdominal vertebra 1		58	58		42	28	70		86	41	127		60	41	101		20	20	376
	abdominal vertebra 2		43	43		37	21	58		78	39	117		53	36	89		12	12	319
	abdominal vertebra 3		100	100		70	70	140		203	90	293		164	167	331		51	51	915
	caudal vertebra		27	27		4	4	8		10	1	11		25	13	38		4	4	88
	caudal vertebra 1		83	83		76	80	156		214	94	308		126	134	260		63	63	870
	caudal vertebra 2		62	62		43	29	72		72	47	119		45	108	153		30	30	436

		B28		B28 Total	B29			B29 Total	B30			B30 Total	B31			B31 Total	B32		B32 Total	Grand Total
QC	ELEMENT	>1	2-4		>1	1/8	2-4		>1	1/8	2-4		>1	1/8	2-4		>1	2-4		
	first vertebra		13	13		7	8	15		17	4	21		18	13	31		7	7	87
	vertebra													3	4	7				7
2 Total			386	386		279	240	519		680	316	996		494	518	1012		200	200	3113
4	otolith	54	47	101	60	8	27	95	75	22	31	128	26	14	36	76	16	15	31	431
Grand Total		54	514	568	74	305	302	681	103	764	395	1262	26	537	652	1215	16	247	263	3989

Table 5.27 Cnoc Sligeach QC1, 2 and 4 element *Pollachius* representation by recovery and sample

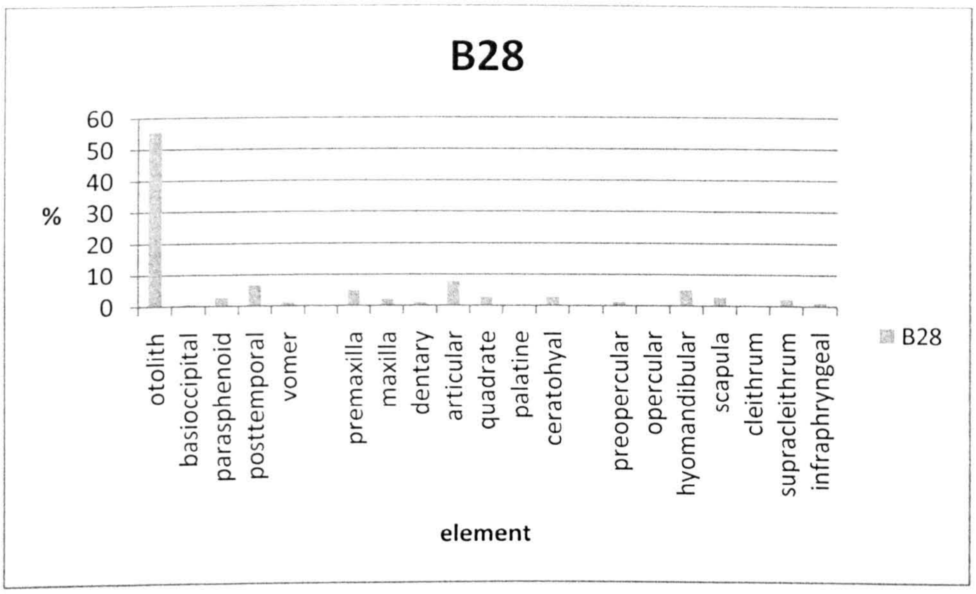


Figure 5.19 **Cnoc Sligeach reanalysis *Pollachius* B28 element representation**

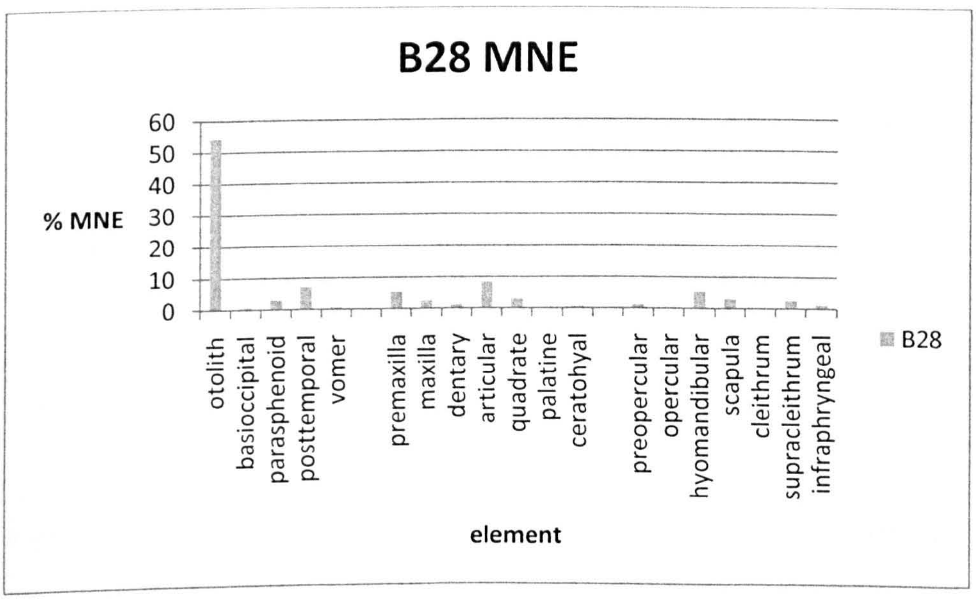


Figure 5.20 **B28 *Pollachius* MNE Cnoc Sligeach reanalysis**

5.7.4 Fish size

The reanalysis of Cnoc Sligeach estimated fish size in two ways; by comparison of QC1 elements with modern reference specimens of known size and calculation of estimated total lengths from *Pollachius* otolith measurements. From the minor species estimation of fish size was only possible on one QC1 specimen from Cnoc Sligeach, a medium (around 301-500mm estimated total length) ballan wrasse from B30. A conger eel vertebrae was noted to have been from a large (estimated total length of around 501-800mm) conger eel. Based on QC1 elements from the 2-4mm fraction mainly small (approximately 150-300mm total length) *Pollachius* specimens were present in all samples. From the same samples and fraction a higher proportion of otoliths with tiny (approximately less than 150mm) *Pollachius* specimens were recorded.

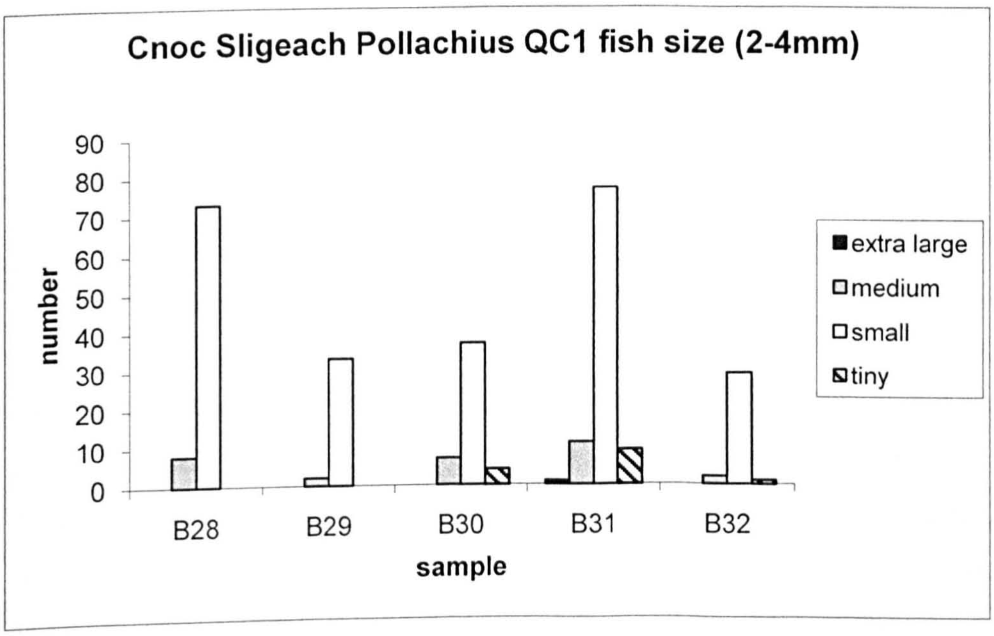


Figure 5.21 Cnoc Sligeach Pollachius (pp, pv, p) QC1 elements fish size

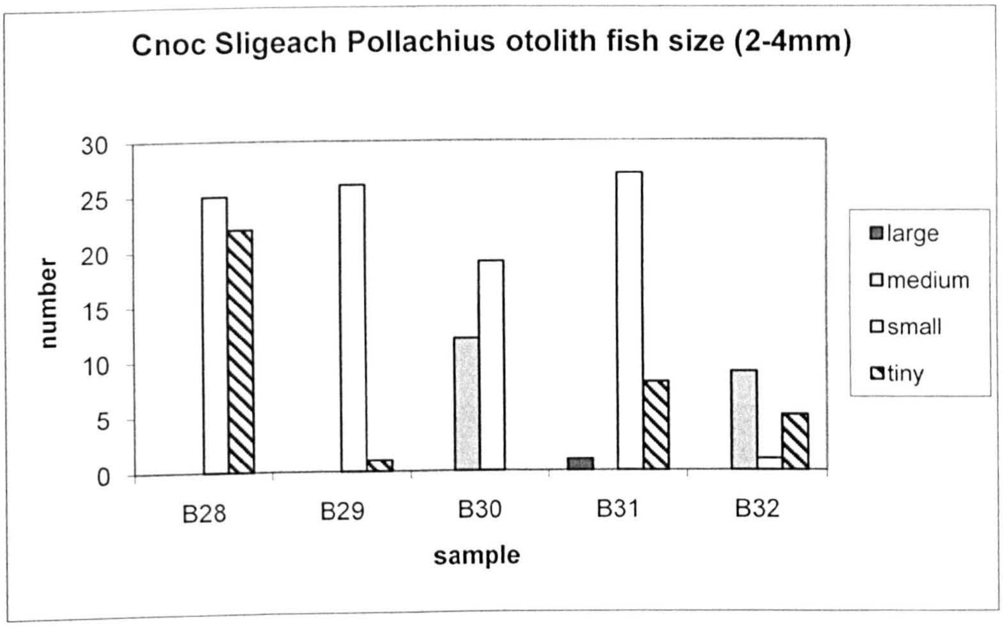


Figure 5.22 **Cnoc Sligeach Pollachius (pp, pv, p) QC4 elements fish size**

A less qualitative estimate of size can be calculated from the measurements taken on elements, in this case the otolith. Otolith width was found to be most appropriate as often the tip of the otolith had broken off preventing the complete otolith length from being measured; this is at odds with Wilkinson choosing otolith length during his analysis. Rather than calculating fish total length from element measurements Wilkinson used the raw otolith length measurements in his histograms. As the raw data was not available in a usable form this made the data only directly comparable with other otolith length measurements. My re-recording of the otoliths is important as it provides a dataset that is readily comparable and allows estimation of fish total length. Jones' (1991) regression equation was applied, to the otolith width measurements, as given in Chapter 3, and the estimated total lengths plotted (measurements are in Appendix 6). The estimated total length of *Pollachius* specimens for all samples and recovery method (>1mm, 2-4mm and 1/8) was between 60 and 600 mm but there are two modes, one around 80-160mm and one around 250-300mm (Figure 5.23).

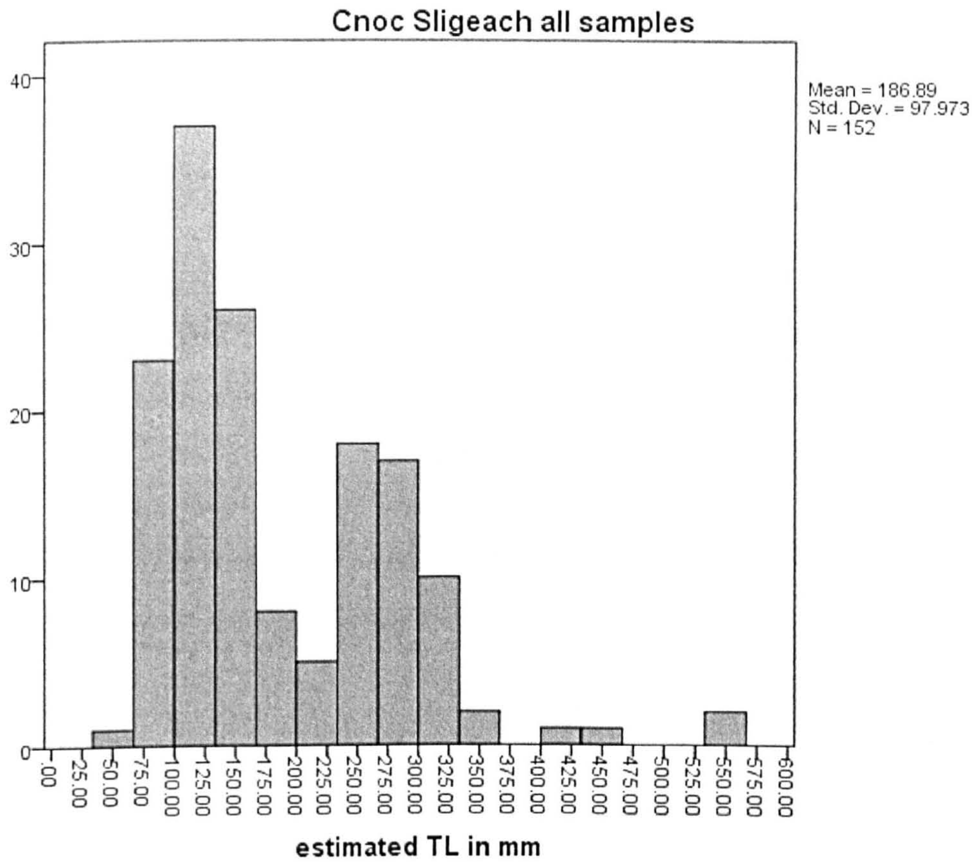


Figure 5.23 **Cnoc Sligeach *Pollachius* otolith estimated total lengths, combined samples (18 intervals along the x-axis)**

There are smaller and, therefore, younger fish than at Sand but this may simply be a reflection of methodology. This is important. The greater than 1mm, less than 2mm fraction from Sand was not analysed, my reanalysis of Cnoc Sligeach *did* include the >1mm fraction. By following theYork system standard practice for fish of not recording the greater than 1mm fraction smaller otoliths may have been missed and this could affect the total fish length distribution pattern. But, when the two distributions are compared they are very similar and the peaks from both sites accord well with first and second year fish.

5.7.5 Season of capture of fish at Oronsay

Wilkinson's original modern otolith length distribution histograms, on which the separate seasonal use of the Oronsay sites is based are given in Figure 5.24. This shows (for second year fish) that although there is an overlap in otolith lengths at each catch the *range* of otolith lengths are different. These otolith lengths are combined; they may represent different catches on different days, no more than 5 days apart, and from different locations round the island. Only catches with greater than 40 otoliths were included (Mellars and Wilkinson 1980, 28). The only period of time when Wilkinson was unable to catch saithe was late winter and spring, this is consistent with fisheries information that at this time the 2nd-3rd year fish migrate into deeper water.

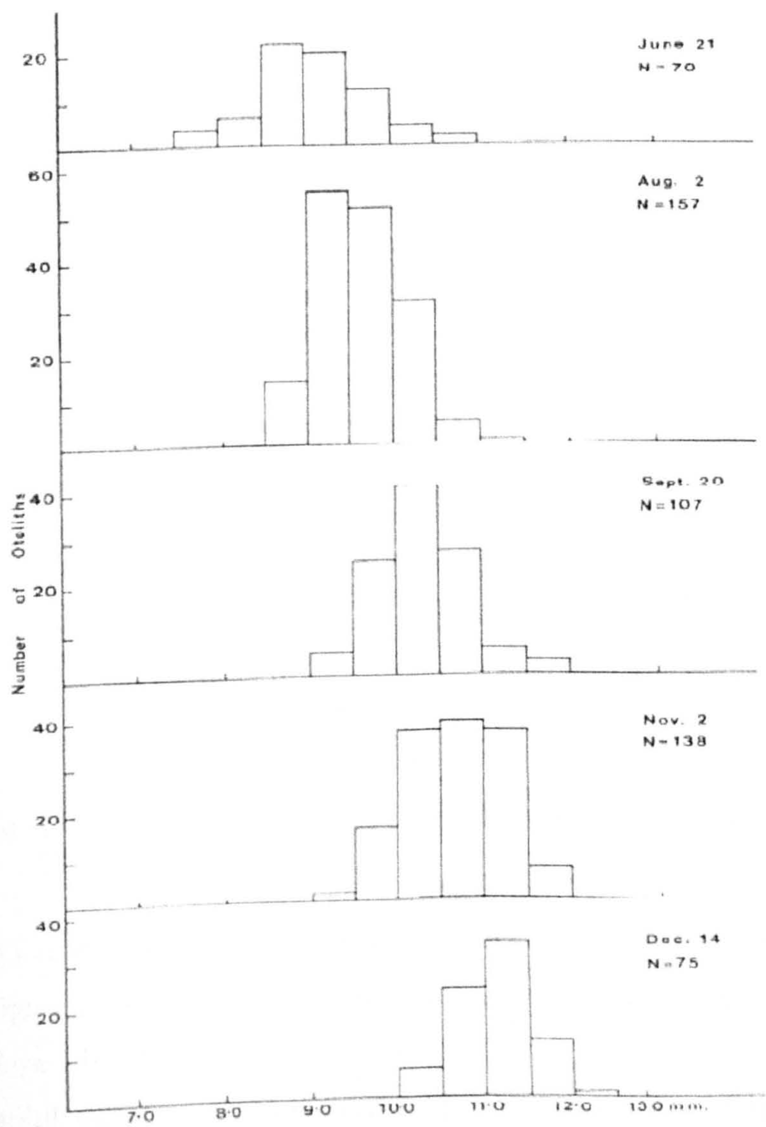


Figure 5.24 Modern Otolith length distributions by Wilkinson (1981, Figure 21)

In Figure 5.25 the otolith lengths from catches over a period of several days in July and November show that two age cohorts were caught. Wilkinson matches these measurements to first and second year fish, presumably on the basis of the length of fish the otoliths were extracted from. These two occasions were the only time that he caught first year fish. Interestingly, the two distributions are very similar, when the gap in season of capture is considered. This demonstrates that based on otolith measurements, a good size sample is required to examine the range in sizes; season of capture cannot be calculated on a single specimen or small sample It is also important as it demonstrates that two size cohorts (and therefore ages) of fish can be caught at more than one point in the year.

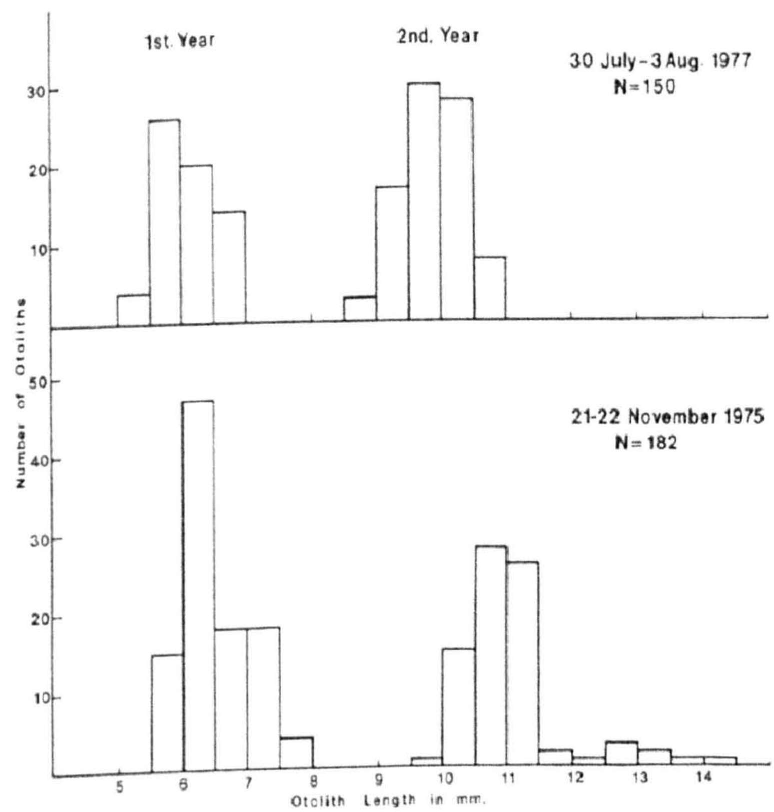


Figure 5.25 Modern otolith lengths from July and November (Mellars and Wilkinson 1980, 28, Figure 8)

Wilkinson then compared the archaeological otolith lengths to these distributions. Figure 5.26 shows the distributions of the otolith lengths from the separate sites; these show a bimodal distribution for all but Priory Midden. The bimodal distribution of otolith total length estimates from the reanalysis of Cnoc Sligeach confirms the bimodal distribution of Wilkinson's otolith length histogram.

By comparing these distributions with the modern fish data Wilkinson has proposed the following seasons of fishing: Priory Midden, winter (some point from December to March), Cnoc Sligeach, mid-summer (July or August), Cnoc Coig, autumn (September or November) and early summer (June or July) at Caisteal nan Gillean II.

Of most interest is the otolith data from Cnoc Coig. Here, although the combined otolith length distribution from Cnoc Coig is bimodal and consistent with both first and second year fish (Figure 5.24). The samples from the individual fishbone concentrations, Wilkinson states, do not all reflect this pattern (1981, 77-78, 220, Table 9). Many of the samples from fishbone concentrations have only one peak. This would suggest that at the site two sizes of fish were caught but not necessarily at the same time. Wilkinson concludes that fish remains were dumped in single size groups. This may in turn indicate that these single size groups represent single catches. The archaeological evidence appears to confirm this. Unlike at Sand, discrete deposits of fish bone were recorded during the excavation at Cnoc Coig, it is likely the otoliths *do* represent individual catches. Thin section analysis of these otoliths, then is recommended with the aim of more closely identifying the season of capture, to see if there is a great intra-site variation.

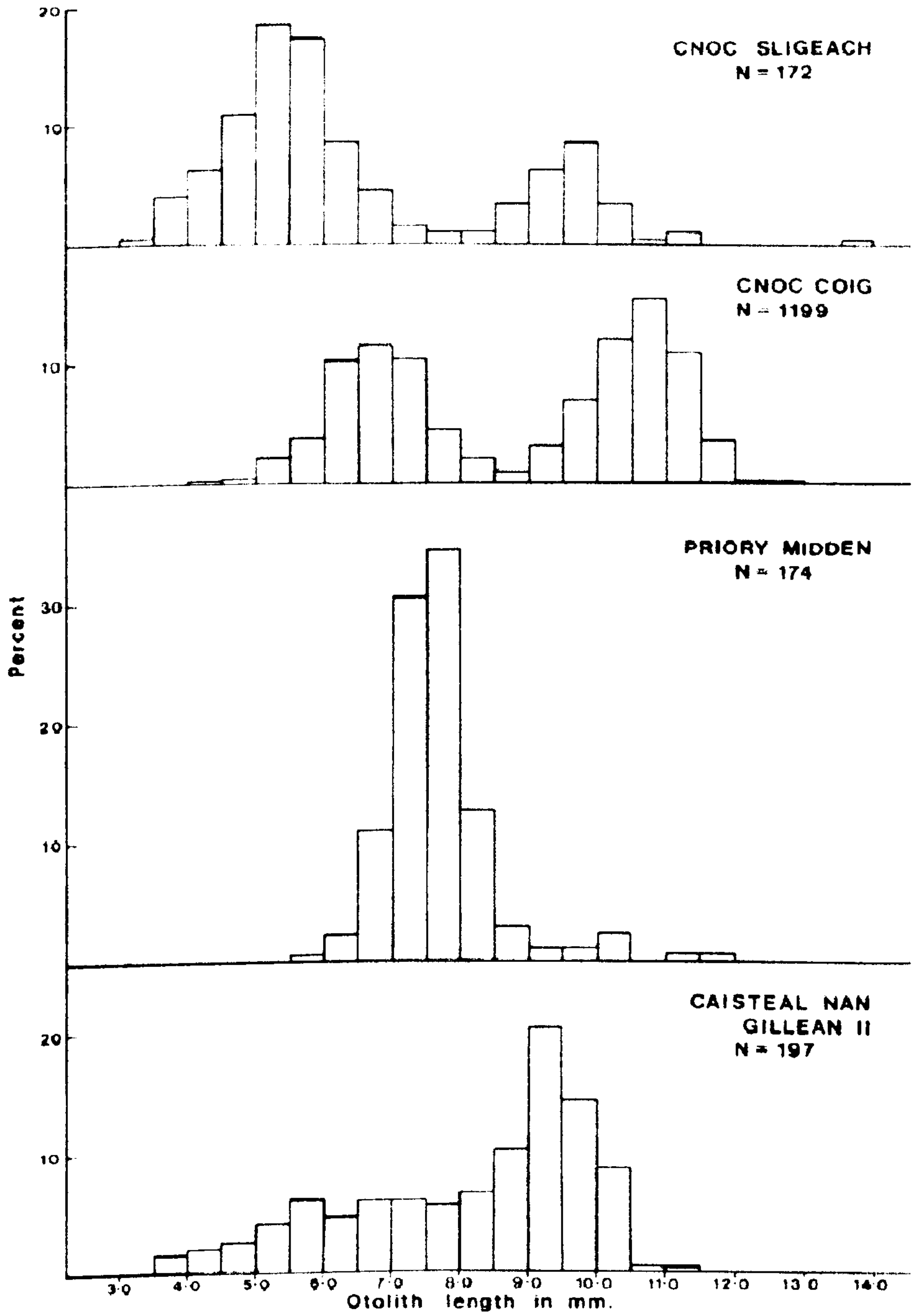


Figure 5.26 Otolith length distributions from Oronsay (Mellars and Wilkinson 1980, 6, Figure 6)

I do not feel that at present, even with Wilkinson's modern samples that there is adequate information on saithe growth and periods of capture to fully assess season of capture based on otolith (and subsequently total length) measurements. Without a link between the modern otolith and the modern fish total length it is impossible to begin to discuss the size of fish caught, other than smaller or larger than other otolith lengths.

The lack of first year fish is also a problem, the differing seasons proposed for the sites are largely based on the second year fish modern samples.

In addition to fish season of capture evidence the cluster of middens in the late Mesolithic is key to the argument for semi-permanence and intensive marine exploitation at Oronsay. However, the dating of sites is problematic, especially with those taken earlier in the programme of work, this is especially an issue for Cnoc Sligeach and Caisteal nan Gillean II (Table 2.2). The sites largely fall in the later half of the 5th millennium cal BC, the earliest dates are from Casiteal nan Gillean II and put use here perhaps into the very late 6th millennium. From Cnoc Sligeach for example, the only date that is not from a mixed source is from charcoal and is dated to 4700-3900 cal BC, this is a large error range. From Cnoc Coig dates are on charcoal from below the shell midden and within it with associated aretfacets. These point to a date in the later part of the 5th millennium, however, human remains from the site have a younger date, going into the early 4th millennium. There is a potential combined span of 800 years. Mellars acknowledges the inadequacy of the dates (Mellars 2004, 181), and clearly if arguments of semi-permanence are to be properly assessed more and reliable dates are need. This is a problem that does not just affect Oronsay, across many of the sites, at Sand there are too few dates and from a limited material.

5.8 *Summary*

Quantified Mesolithic assemblages in Scotland are scarce, and previously, only limited quantified data from Oronsay has only been available. The picture is still by no means complete but mammal, bird and fish bone from Cnoc Coig can now be considered together. At Cnoc Coig, grey seal were most numerically abundant, with a minimum of at least 9 individuals represented. Grigson and Mellars suggest that these animals were hunted relatively close to the site and complete carcasses processed on site for meat, skins, and also for blubber which could be used as a fuel in lamps (Grigson and Mellars, 1987, 284). In contrast, the authors argue that selective parts of red deer and wild boar were brought to the site primarily for tool manufacture (Grigson and Mellars, 1987, 254).

Nolan concludes that *'the exploitation of birds was neither intensive nor large scale, as would be the case if large breeding colonies of sea birds were being exploited.'* (Nolan, 1986, 298). He suggests that birds may only have been actively hunted during the autumn. At other times birds which had died from natural causes were collected (Nolan, 1986, 298). Regarding the contribution the birds would have made as a food resource Nolan concludes that they would have been a significant but not major component of the overall diet.

A specialised fishery, perhaps by nets or rod and line, is evident at all sites and saithe is overwhelmingly the predominant species (Wilkinson, 1981). This abundance was confirmed for Cnoc Sligeach in my reanalysis, quantifiable information on recovery, preservation, burning and fish estimated total length was provided by the reanalysis. The element distributions from the sites are not easy to interpret. Otoliths and vertebrae are present in all samples and other head and jaw bones less well represented. It is unclear to what extent this is a taphonomic pattern or evidence of fish processing.

Chapter 6 Discussion

6.1 Introduction

In this chapter the comparative data, primarily drawing on the sites with quanitifable data (Sand, An Corran, Morton and the suite of Oronsay sites) is discussed in the context of zooarchaeological zooarchaeological variation, and marine resource intensification.

6.2 Zooarchaeological variation:mammals

The assemblage from Sand is amongst the earliest from Mesolithic Scotland and makes an important contribution to our understanding of animal exploitation in the Mesolithic. Sand fits in with the general pattern that red deer is present on all sites thus known regardless of excavation or sampling strategy. At most of these sites tools manufactured from red deer are also present. Wild boar (or *Sus* sp.) is present at all but Priory Midden and Caisteal nan Gillean II but as yet no tools have been identified to wild boar. Unlike red deer, roe deer is not found on every site, it occurs at Sand, Morton, An Corran but is largely absent from the Oronsay sites. Aurochs is not as common across the sites as wild boar or red deer; it was positively identified from An Corran (where tools made from Aurochs were identified) and Morton, but is absent from the Oronsay sites and Druimvargie. *Bos* sp. was identified at Sand and MacArthur's cave. Based on a qualitative assessment the specimens from Sand may be domestic and certainly the specimen with metal cut mark would indicate a date later than the Mesolithic. This and the sheep specimens (which based on preservation were intrusive) show that over the life of the midden later material has become incorporated. One of the most striking features of the An Corran assemblage is the presence of brown bear, an animal absent from all other sites. Despite the location of these coastal sites the mammals used are very much land animals, only on Oronsay are seals present (at Sand the only seal specimen was from the undated topsoil layer).

A greater variety is seen in the smaller-sized mammals from the sites. Otter is present at all the west coast sites but not from Morton. It may be that this reflects the local ecology of the site. At Sand and An Corran otter is only represented by a single specimen whilst at Cnoc Coig otters were the second most numerically abundant taxa after red deer. Otters may been caught for their meat and, or fur. Badger was recorded at MacArthur's cave, for which there is no quantification data, and a single maxillary premolar was recorded from Sand. Several taxa are only found at single sites, hedgehog at Morton, hare at An Corran and pine marten at Caisteal nan Gillean I. Canid remains were present at Sand and An Corran but the fox from Sand is the first identification from a Mesolithic site. Wild cat was noted at MacArthur's cave and Bartosiewicz also recorded wild cat at An Corran (although he states that his taxa may not be related to human activity at the site).

Although red deer is present at every site it is not necessarily the most abundant species. Figures 6.1-6.6 show the relative numerical abundance of taxa at those sites with NISP data expressed as a % of total NISP: Morton (12), An Corran (383), Cnoc Coig (612), Caisteal nan Gillean II (64), Priory Midden (15) and Sand (87). At Sand small mammal and sheep or goat specimens are excluded, at An Corran small mammal and wild cat specimens are excluded. Species that are less than 1% are combined under 'other'. At Sand, An Corran and Caisteal nan Gillean II red deer is numerically most abundant but at Cnoic Coig and Priory Midden seal is most abundant. The sizes of the assemblages vary from a few identified specimens to several hundreds. The number of specimens identified to species at Morton is only 12, several species are only represented by single specimens and the importance of aurochs is inflated by the small sample size. Only at the Oronsay sites is otter relatively well represented compared to the other taxa at the sites.

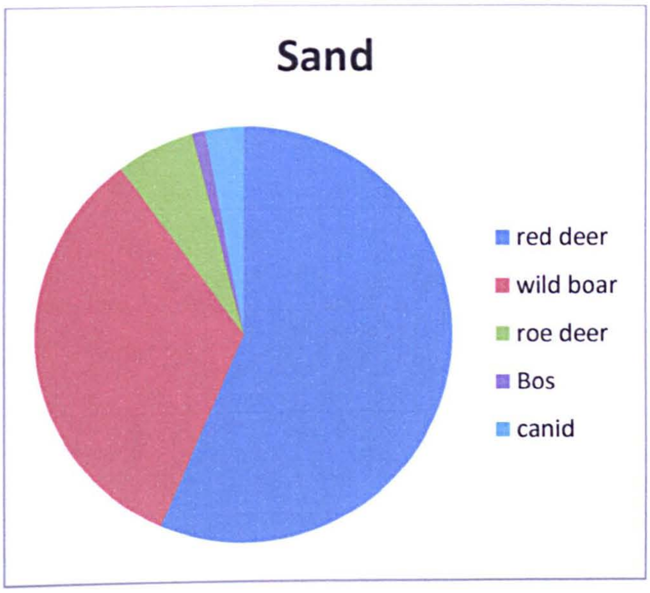


Figure 6.1 **Mammal relative abundance at Sand** (main shell midden)

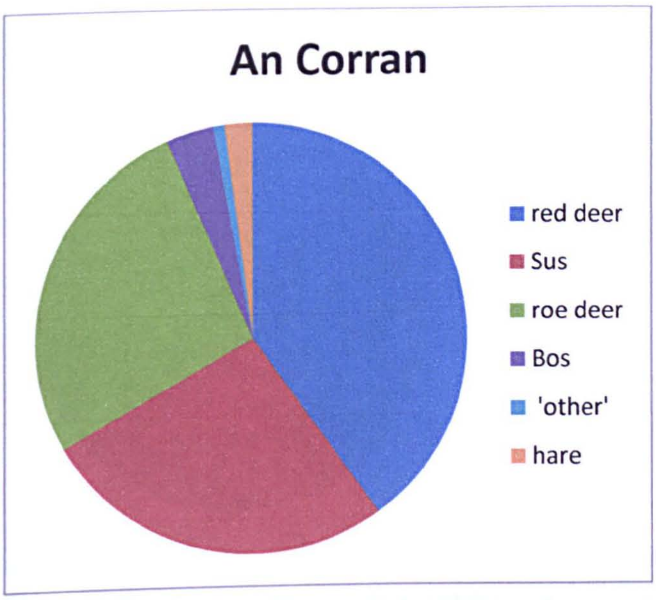


Figure 6.2 **Mammal relative abundance at An Corran**

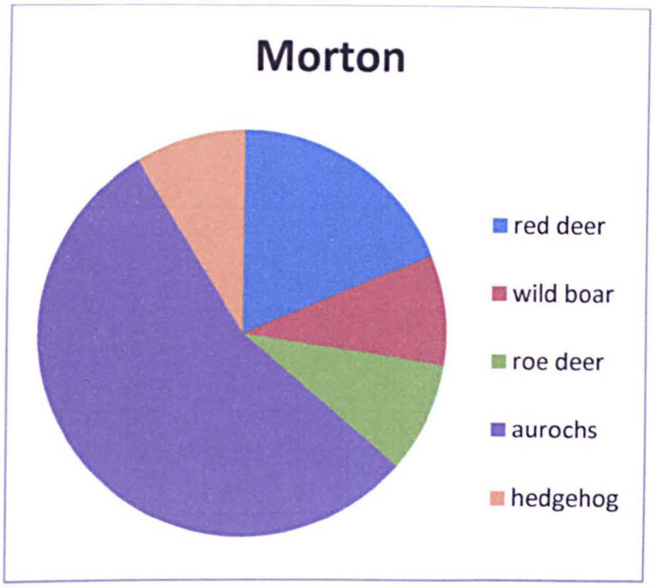


Figure 6.3 Mammal relative abundance at Morton

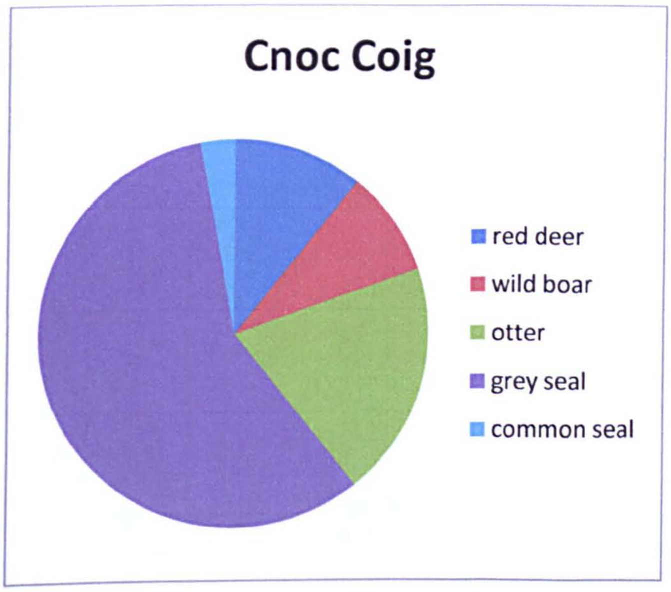


Figure 6.4 Mammal relative abundance at Cnoc Coig

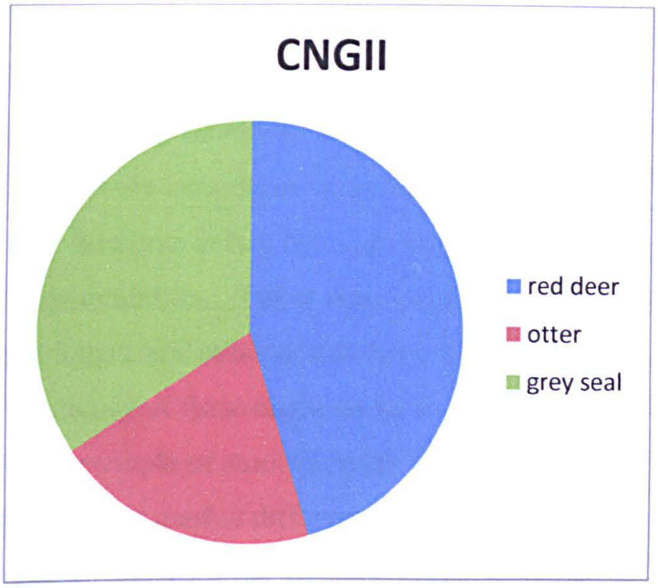


Figure 6.5 Mammal relative abundance at Caisteal nan Gillean II

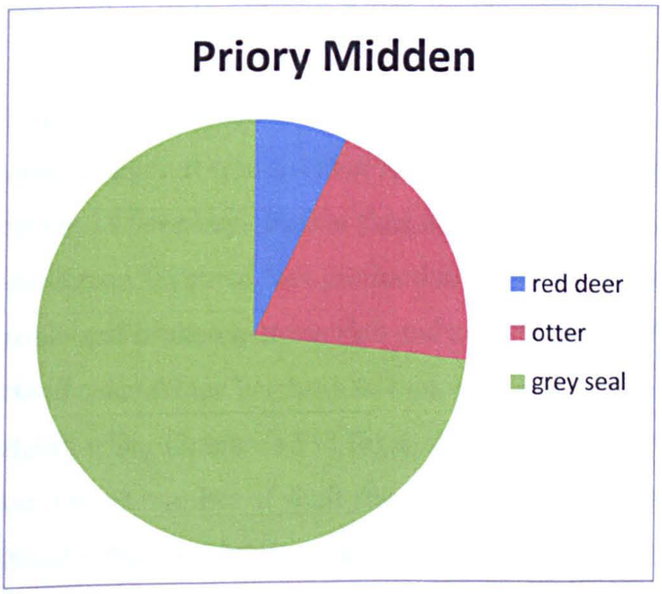


Figure 6.6 Mammal relative abundance at Priory Midden

Turning to the sites with element representation information at Sand although red deer is numerically the most abundant species from the shell midden contexts perhaps only 2 animals may be represented (based on the MNE of phalanges). This is an estimate and without the confidence in the context divisions from within the shell midden this figure may be skewed, but, it at least shows that the red deer at the site is by no means there in large quantities. Rather than a clear butchery pattern at Sand the greater numbers of phalanges and metapodials compared to other elements seems to instead reflect the frequency of these elements in the body. It is likely that red deer, probably no more than a couple of animals, were brought to the site whole but the high fragmentation of bones may mask a different pattern. Wild boar is the next most numerically abundant species and a similar element pattern was noted. One caveat with the York system recording protocol is that vertebrae and ribs are not routinely recorded, this makes it difficult to fully assess if whole animals were present.

High fragmentation of mammal bone is not only a feature of the Sand mammal assemblage. It was noted at An Corran, Morton and at MacArthur's Cave by Anderson in the 19th century. Rather than marrow extraction as a cause for fragmentation Anderson favoured tool production for hide working, based on the presence of bone tools and broken marrow rich and non-marrow rich bones. A major contribution of the Sand assemblage has been to look at fragment patterns of the main shell midden in detail using Outram's FFI for the first time (Outram 2001). The methodology is reliant on a large number of shaft fragments over 30mm long. The extent of fragmentation at Sand is further highlighted by the small number present in the sample analysed but this also hindered the application of the method. Some helical fractures were recorded, and from the range of scores it can be surmised that bone was broken in both a fresh and dry state. Fragmentation for tool manufacture fits in with the worked bone analysis by Hardy. From the wear patterns and retouch Hardy found that many of the tools from Sand seemed to have been used to exhaustion and hence have been discarded. Thirty percent of mammal specimens (identified and unidentified combined) were burnt. It is conceivable that tool manufacture and marrow extraction both occurred.

At Cnoc Coig the degree of fragmentation of specimens is not explicitly discussed but few complete bones were recorded for red deer and wild boar. Grigson and Mellars suggest that for red deer and wild boar (which are present in similar proportions) based on the elements present certain parts of the body were brought to the site for use as a raw material rather than food; hide working may be represented. Antler appears to have been used on a greater scale than at Sand; the worked bone is not dicussed in detail. In contrast to Sand, seal (grey and common) are the most abundant taxa at Cnoc Coig. Whole carcasses were believed to have been brought to the site and complete bones were present unlike for red deer and wild boar. Despite a greater numerical abundance Nolan's spatial analysis concluded that neither regular, annual exploitation nor a short period of intensive exploitation of seal took place. Next in numerically abundance at Cnoc Coig is otter. As for seal the otter remains are not thought to represent regular exploitation of otters. Grigson and Mellars noted that much of the otter bone was burnt and Nolan's work found that most groupings of bones were found close to hearths.

An Corran and Sand are on the coast of the same body of water, the Inner Sound and apart from the suite of Oronsay middens are the two sites located nearest to each other. Despite this there are differences in taxa present. Red deer and wild boar (or *Sus* sp.) are the most numerically abundant at both sites but at An Corran roe deer has a greater relative abundance compared to Sand. Differences in minor species are also apparent, hare and brown bear are present at An Corran, fox at Sand.

Figure 6.7 compares the element distribution of a range of elements (NISP) from Sand, Cnoc Coig and An Coran. As discussed in the methodology chapter minimum number of elements (MNE) provides a good estimate of the actual number of elements present, MNE estimates are not available for Cnoc Coig and An Corran. A problem is also posed by the Sand data. In the York recording system mammal vertebrae and ribs are not routinely recorded but vertebrae and ribs were recorded at Cnoc Coig and An Corran. This means that Figure 6.7 is based on a limited set of elements.

At An Corran the large numbers of red deer metapodials compared to other elements is striking and it is a pattern that is seen in the roe deer to a lesser extent. Bartosiewizc notes that fragmentation of these elements has inflated their apparent abundance. It is difficult to assess, just from the NISP data if whole animals were present at the site. Teeth, ribs, vertebrae and for red deer antler were also present so it seems that some whole animals were present at An Corran. At Cnoc Coig the lack of meat bearing bones, presence of terminal elements and lack of vertebrae and ribs led to Grigson and Mellar's conclusion that parts of the deer and wild boar body were brought to the site. At Sand, based on Figure 6.7 a similar interpretation might be suitable but when MNE is taken into consideration the number of terminal appendicular elements appears to reflect the frequency with which they occur in the body.

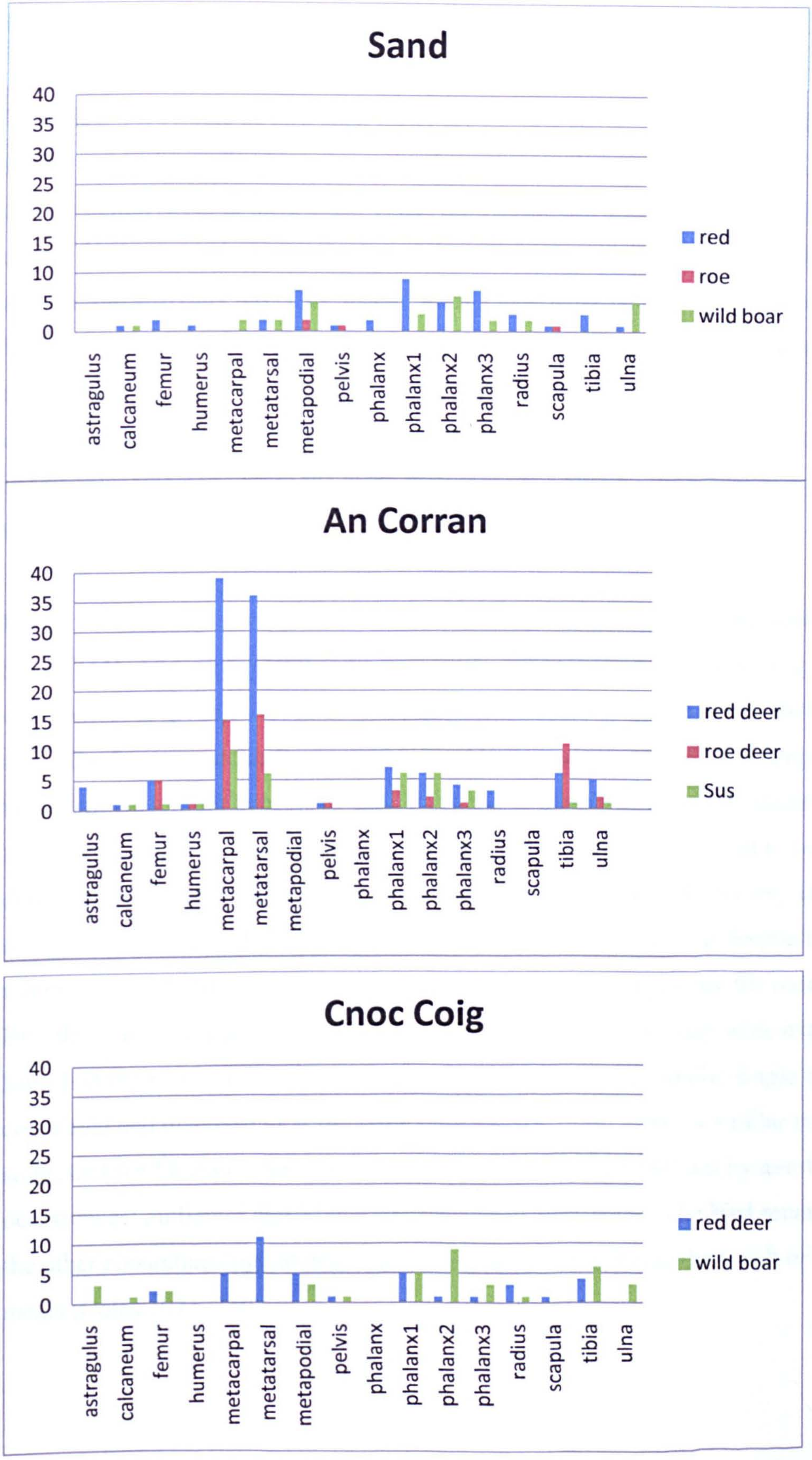


Figure 6.7 **Element distribution from Sand, An Corran and Cnoc Coig**

6.3 Zooarchaeological variation: birds

There is a huge range of bird taxa; many are sea and shore birds though some inland, freshwater and woodland species were also present. Auks, such as great auk, razorbill and guillemot occur at most sites. Shag, cormorant and gulls are also found at several sites. The bird remains from Druimvargie rockshelter are conspicuous by their absence and the site also only has 'fish' listed. Rather than there being a complete absence of bird and identifiable fish it seems more likely to be a factor of Antiquarian excavation technique. The taxa range from Sand is quite narrow and as at many of the sites shag, cormorant and great auk features, but, it does seem that razorbills and guillemots were specifically targeted. From the main shell midden contexts 719 razorbill or guillemot QC1 bones were identified.

Figure 6.8 to 6.10 show the relative abundance of bird taxa for the sites with NISP data: Sand (734), An Corran (107) and Cnoic Coig (305) (at Morton only the number of occurrences is given). At An Corran puffin is the most abundant taxa followed by great auk. The focus on alcids is apparent but not to the extent at Sand. The large number of taxa from Cnoc Coig appears to buck this general pattern of abundant alcids in the Mesolithic. Nolan's spatial analysis slightly reduces the taxa believed to have been deposited by humans rather than natural deaths but this is still 39 species. However, many of these species have fewer than 10 identified specimens and despite the great range in taxa at Cnoc Coig great auk and razorbill and guillemot are the most abundant. But, there does not appear to be evidence for any intensive or large scale exploitation. Based on their spatial distribution Nolan suggests that on the whole, single birds were consumed and disposed of at the same time (Nolan 1986, 299). A similar scenario was suggested for Morton. The bird bone is not quantified by NISP but by number of occurrences: guillemot and gannet occurred most frequently. The bird remains (as for the other zooarchaeological material) were interpreted as being the result of individual meals (Coles 1971, 350).

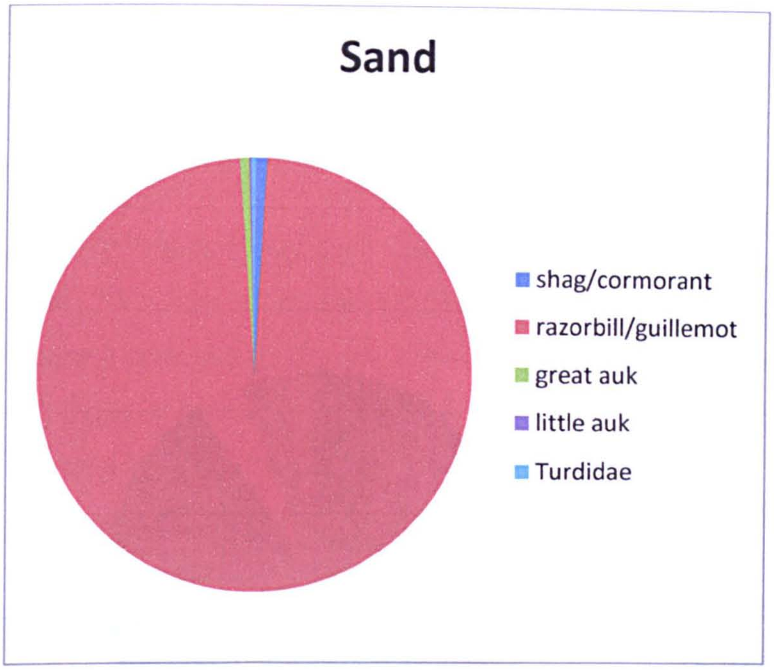


Figure 6.8 Sand bird taxonomic abundance

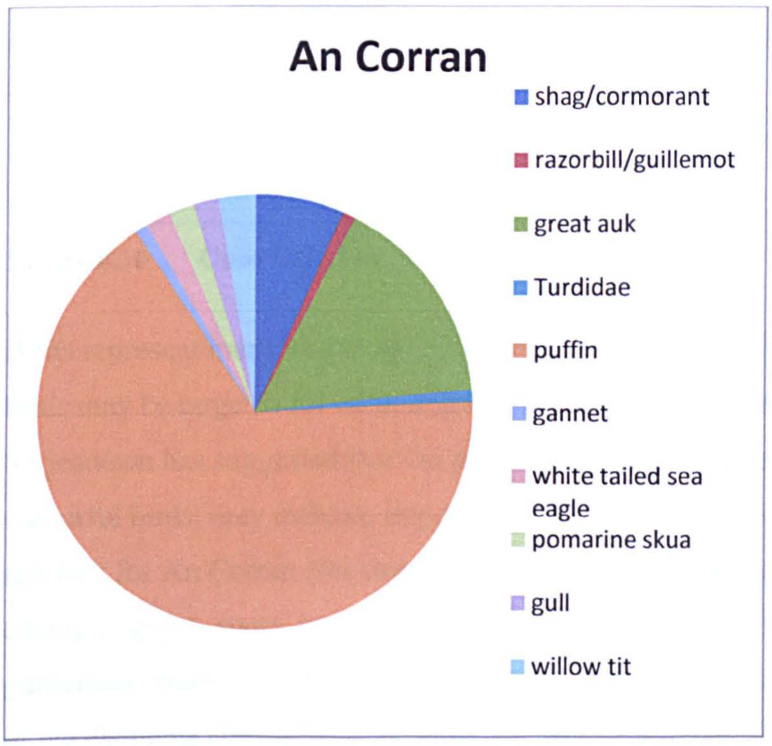


Figure 6.9 An Corran bird taxonomic abundance

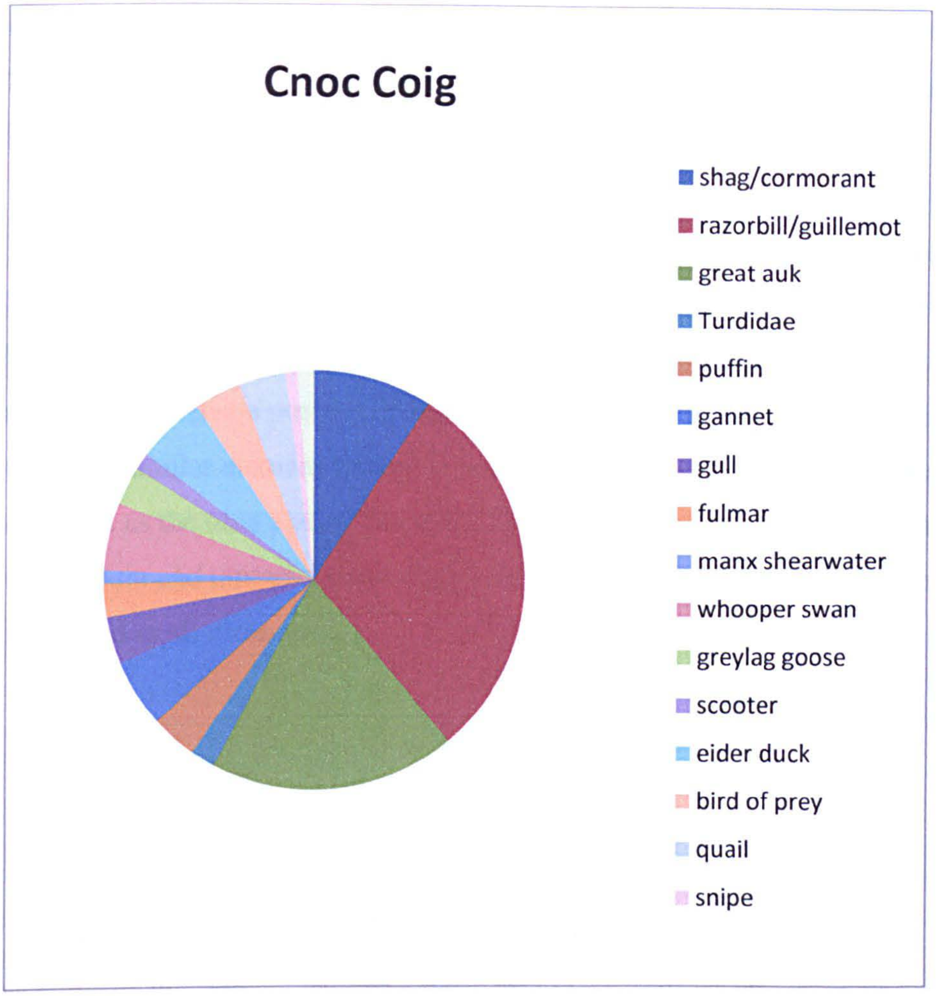


Figure 6.10 Cnoc Coig bird taxonomic abundance

Birds represent many potential resources; food, fat, oil, skin, feathers and bone and birds may be targeted for all or a few of these resources (Serjeantson 2009). Serjeantson has suggested that the presence of minor species at a site, even raptors or colourful birds, may indicate targeting for the use of feathers (2009, 207). This may be relevant for An Corran (for example the white tailed sea eagle) and Oronsay (for example, geese, swan, buzzard). At Sand, the element distribution of razorbills and guillemots, based on MNE from the main shell midden, showed an underrepresentation of leg elements compared to pectoral and wing elements. From the suite of elements recorded in the York system it is difficult to assess if whole birds were brought to the site as no elements from the skull and vertebral column are included in the diagnostic elements routinely recorded. A few cut marks, consistent with wing removal were recorded. If wings had been removed and taken away from the site then an underrepresentation of wing elements would be expected. If wings had been removed elsewhere and then processed at the site only wing elements would be expected. At Sand it is possible to say that although legs and wings were discarded more wings made it into the midden than legs.

The NISP element representation for alcids (razorbill, guillemot, great auk or puffin) for Sand (796), An Corran (68) and Cnoc Coig (43 *in situ*) is compared in Figure 6.11. The humerus is the most abundant element at all sites, it is a robust and distinctive element and this may have a positive bias but the femur in alcids is also distinctive. At An Corran a similar element pattern is seen to Sand. At Cnoc Coig the patterning is slightly different as the ulna and coracoid are less well represented than An Corran and Sand but the scapula and tarsometatarsus more so. Whole birds seem to have been processed and discarded at all three sites.

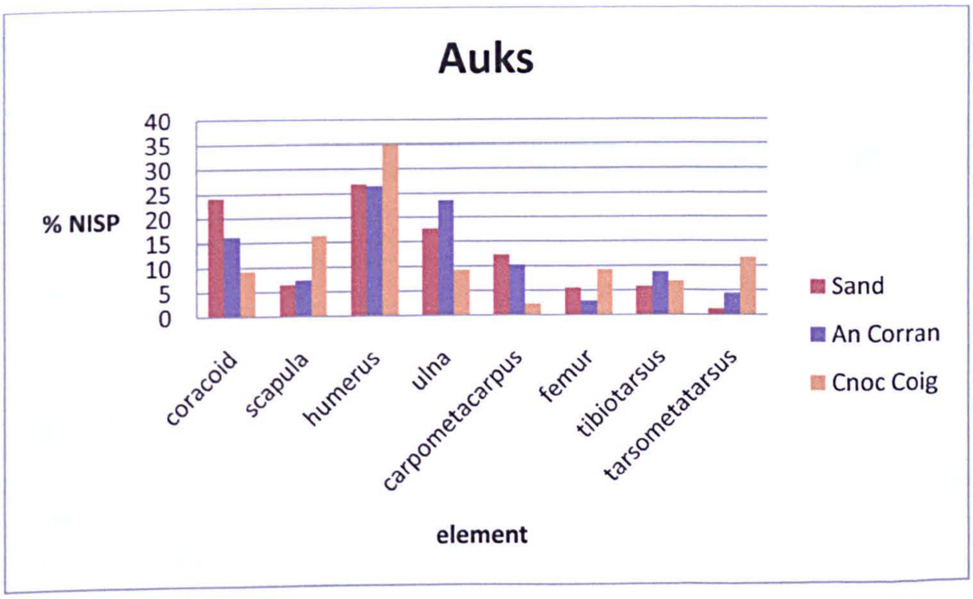


Figure 6.11 Sand, An Corran and Cnoc Coig bird element distributions

6.4 Zooarchaeological variation: fish

A broad range of fish was already known from Mesolithic Scotland and the analysis of Sand has further contributed to this list: herring, gurnard (from topsoil layer), horse mackerel, mackerel, corkwing wrasse, goldsinny, butterfish and sandeel family. In addition, reanalysis of the Cnoc Sligeach fish has added, albeit in very small numbers, sandeel family, cuckoo wrasse, butterfish, halibut family, corkwing wrasse, gurnard family and Norway pout to the known species at the site. A pattern of inshore fishing emerges with taxa such as saithe, eel and wrasse (either ballan or cuckoo) present at the Oronsay sites, An Corran and Sand. At Morton, on the east coast, however, these species are not present. Only 5 fish species were recorded at Morton; sturgeon, salmon or trout, cod, haddock and turbot. This stark difference in taxa may reflect the location of the site, habitat exploited (deep water versus shallow), fishing method, and perhaps a combination of all three.

Taxon	Sand	An Corran	Cnoc Sligeach
dogfish families	x		
salmon or trout		x	
Herring	x		
Eel	x	x	
saithe	x	x	x
pollack	x		
saithe or pollack	x		
cod	x	x	
cod, saithe or pollack	x		
Atlantic horse mackerel	x		
corkwing wrasse	x		
ballan wrasse	x		
cuckoo wrasse	x	x	
butterfish	x		
Atlantic mackerel	x		
plaice		x	
cottid		x	

Table 6.1 Taxa with greater than 10 NISP from Sand, An Corran and Cnoc Sligeach reanalysis

At An Corran and Sand there is a greater variety in the minor species, at the Oronsay sites the fish is almost exclusively saithe. Table 6.1 shows the taxa recorded in greater numbers than 10 (NISP) from Sand, An Corran and the Cnoc Sligeach reanalysis. At Sand saithe, and to a lesser extent pollack, and wrasse are the most abundant but herring (NISP 87), mackerel (NISP 159), cod (NISP 99) also feature.

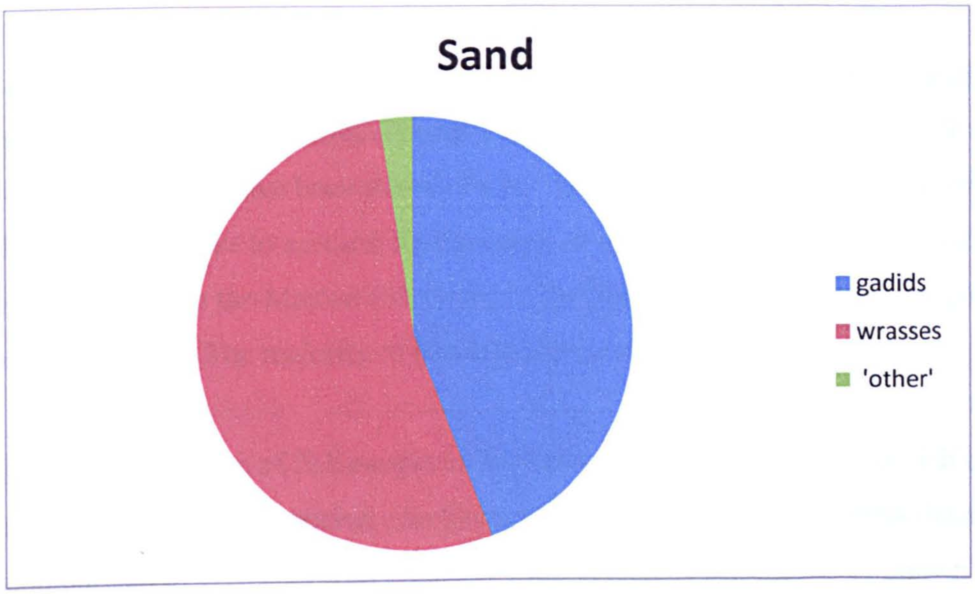


Figure 6.12 Relative abundance of fish at Sand (main shell midden contexts).

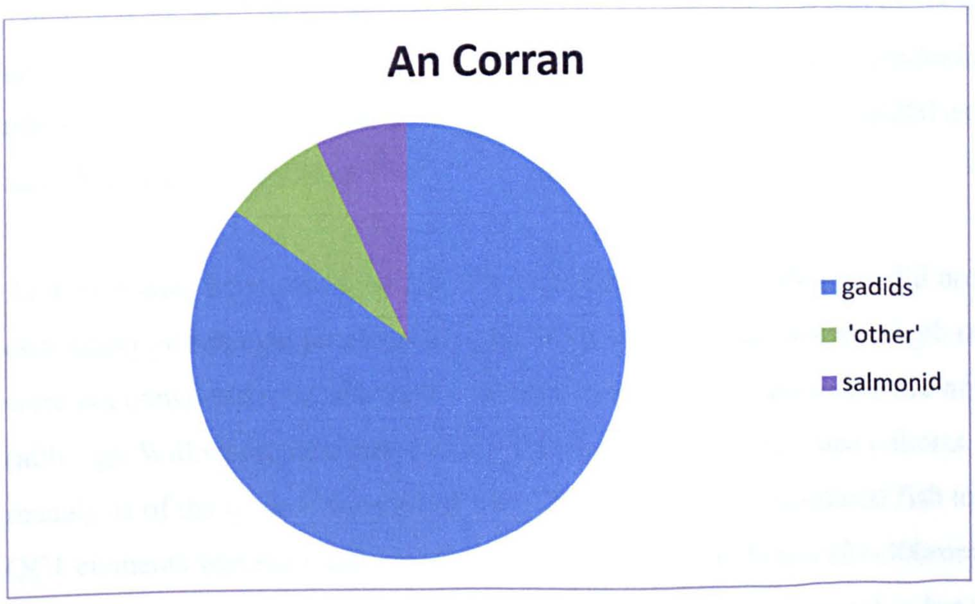


Figure 6.13 Relative abundance of fish at An Corran.

The relatively minor importance of these species is highlighted, however, when the % relative abundance is taken into consideration (Figure 6.12) taxa that are not gadids or labrids make up only around 2% of total NISP. At An Corran gadids are most abundant, second in numerical abundance are salmonids, and 'other' taxa make up a larger proportion of total NISP.

At the Oronsay sites the range of taxa is even narrower than that from Sand. The method of fishing method used must have been highly selective to exclude by-catch taxa or they may have been thrown back. At Sand the method of fishing must have been less selective to account for the range of species. The total number of identified specimens from the Morton fish bone assemblage is given but no further quantifiable data provided. The majority of identified specimens are cod.

In terms of the size of fish caught at An Corran and Sand the range of fish caught was narrow regardless of species. An Corran fish of estimated total length (based on comparison of elements with elements from reference specimens of known total length) was between 150-300mm. At Sand from the main shell midden although 65% of specimens were from the same size bracket smaller and larger specimens were present. Three percent were large (501-800mm TL), 25% from medium fish (301-500mm TL) and 6% from tiny fish of a total length less than 150mm. Based on *Pollachius* otolith measurements two modes of estimated total length were around 130-200 estimated TL and another at 280-350 mm TL.

At the Oronsay sites assessing fish size is more difficult. Wilkinson did not record an estimation of fish total length in his general recording. The otolith length measurements were not converted to total length estimates. The raw measurements are not provided (although Wilkinson measured to 0.05mm) but given in .5mm size cohorts. During reanalysis of the Cnoc Sligeach fish bone for this thesis an estimated fish total length for QC1 elements was recorded for all QC1 elements. A medium (301-500mm TL) ballan wrasse specimen was recorded and a conger eel vertebrae was noted to have been from a large fish (501-800mm TL). The *Pollachius* specimens (predominantly saithe) size ranges vary with sample. The majority are from small (151-300mm TL) sized fish but samples B30 and B31 also have specimens from fish less than 150mm TL. When fish estimated total length is calculated from otolith measurements two modes of fish size are apparent, one around 80-160 mm total length and one around 250-300 mm total length.

At Morton the majority of the cod specimens were from fish of an estimated total length of over 500mm and some over 1m. The turbot was over 750mm and the sturgeon around 3m estimated total length. These taxa perhaps reflect the different coastal setting to the west coast; a quicker drop off into deeper water from the shoreline and less rocky coastline.

The elements present provide a guide to any processing (and therefore removal of some elements) that may have taken place. My reanalysis of Cnoc Sligeach largely confirmed the element distribution pattern from Wilkinson's thesis. Re-recording of the material *did* provide data on fish size and modification such as burning and has allowed the otolith data from the site to be compared with Sand.

At Sand and An Corran the material is from combined contexts and certainly from Sand the deposits are from material that appears to have little stratification. It is likely that a composite picture of fishing is represented. The numbers of specimens from Sand may be from one very large catch or from several catches. If the latter is the case any differences in fish processing will be masked. The MNE element distribution for gadids and labrids showed a very different pattern between the two taxonomic groups. For the wrasses (primarily ballan wrasse) the infraphryngeal is the most common element and the robust and distinct nature of the infraphryngeal is likely to have positively skewed its abundance. Albeit in smaller numbers all other parts of the fish are present. The pattern for gadids (primarily saithe) shows the jaw area as most abundant. The bones around the gill area are underrepresented. Elements such as the opercular and scapula are, however less robust than jaw elements such as the premaxilla and this may have influenced the element distribution. If the element pattern is real and not a result of preservation it is possible that if fish were filleted the method involved the removal of the gill and appendicular area and discard at the midden of the vertebral column and head. Similar processing may have occurred at An Corran.

Figure 6.14 compares the % NISP element distribution for An Corran and Sand gadids. Immediately apparent is the abundance of otoliths for Sand (the otolith was omitted from the MNE distribution in chapter 4) but not at An Corran. Aside from the abundance of otoliths at Sand the pattern of the other elements is similar and abdominal and caudal vertebrae are well represented from both sites.

As for the wrasse infraphryngeal it is difficult to tell if the abundance of otoliths at Sand is a factor of preservation and ease of recognition and identification. The otolith in gadids is a very robust and distinctive, even a small fragment would be identifiable to sample sorters and by analyst at least to the family level. An overabundance of otoliths is a clear pattern from the Oronsay sites. It is clear from the few articulated specimens from the Cnoc Coig fishbone concentrations that some fish at Oronsay were processed in such a way to leave the heads and vertebrae intact. At Priory midden, samples 2 and 3 the otolith is main element and there is an absence of jaw and appendicular elements. At Caisteal nan Gillean I, although the otolith is present in sample 5 a wide range of elements are also present whilst in sample 4 otoliths are not as abundant. At Caisteal nan Gillean II matching the samples with the trench is impossible from the information thus available but there are clear patterns between samples: some are almost exclusively otoliths, others have otoliths but other elements are well presented. Sample R has an odd pattern with the infraphryngeal abundant.

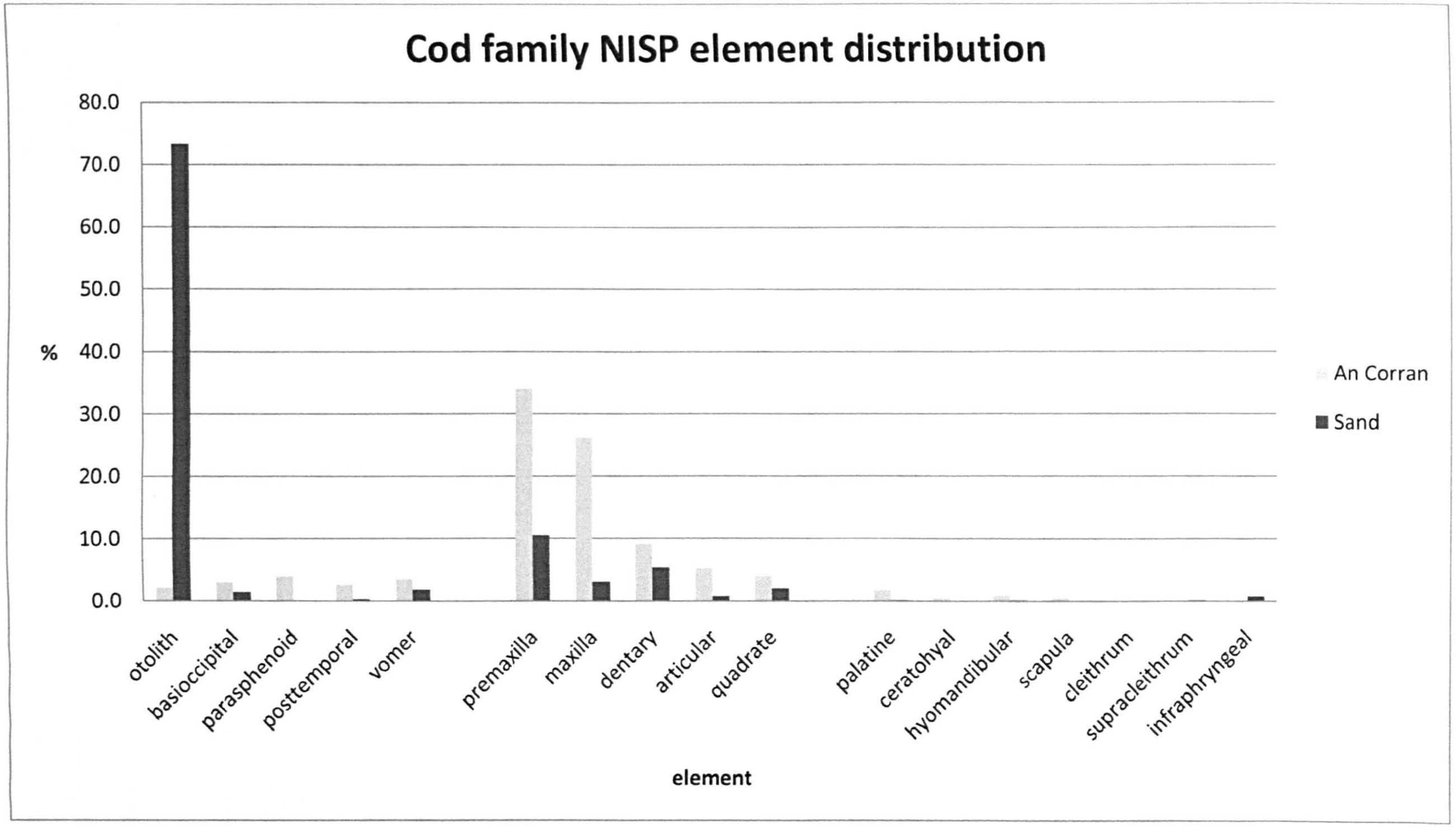


Figure 6.14 Gadid % NISP element distribution for An Corran and Sand

Unlike Sand and An Corran, at the Oronsay sites, especially Cnoc Coig, discrete deposits of fish bones and large fish bone concentrations were noted during excavation. It is very difficult to match the sample information given in Wilkinson's thesis with the site context information. It is unclear for the sites with column samples just what the individual samples represent, this is frustrating as for many of the samples there does seem to be, based on the skeletal element pattern, evidence of fish processing. Samples within a column sample often vary, could this reflect processing of different catches? Can each sample within a column really be treated as an archaeological unit? Matching these samples with the site context record is paramount to understanding fish processing at the site and warrants revisiting. Certainly from Cnoc Coig discrete, archaeological different deposits of fish bone were recorded and this site presents most potential for further work.

At Morton the element distribution data is descriptive; for cod, the predominant species 'numerous head bones' along with abdominal and caudal vertebrae were present. For head bones and vertebrae to be discarded filleting, with minimal removal of bones, seems a likely processing method.

6.5 Marine resource use; intensive or not?

The datasets are limited but extensive marine resource use in the Mesolithic of Scotland is no longer restricted to the very late Mesolithic, or just to Oronsay. Turning first to Oronsay, Grigson and Mellars and Nolan concluded that at Cnoc Coig the exploitation of seal and seabirds was not on a large scale or repeated over a long period of time. It is primarily the fish bone evidence that (along with human isotope evidence) has led to the Mellars' marine intensification hypothesis. Whilst the evidence for fishing and seabird fowling is limited at An Corran and Morton it was highly targeted at Sand.

With highly targeted fishing *and* fowling at Sand it could be argued that marine resource exploitation at the site was more intensive than at the Oronsay middens, there is not a evidence of increasing intensification through the Late Mesolithic of Scotland. However, this resource exploitation could have been intensive in its own right, be it on a large-scale for a short period of time or on a much smaller scale but over a longer period of time. The period of accumulation at Sand is an issue in terms of interpreting how intensive fishing and fowling may have been. Hardy and Wickham-Jones suggest that the midden accumulated quickly. If this accumulation was within one year then fishing and fowling at the site could be considered intensive. However, if the midden was used over several years small scale fishing and fowling seems more likely. The shell middens at Oronsay are larger than Sand but the period of accumulation is again open to interpretation. Mellars suggests that within the potential span of 800 years at the sites occupation may have been punctuated, if this is the case; fishing could have occurred at a small scale over many years.

Chapter 7 Conclusion

7.1 *Introduction*

The intitial aim of this thesis was to assess if there was an intensification of marine resources in Mesolithic Scotland based on the zooarchaeological evidence. How then, has this thesis contributed to our understanding of this issue? This chapter summarises the key conclusions of the thesis and evaluates the extent to which the three objectives as outlined in the introduction have been met:

1. To explore the variation within the zooarchaeological record
2. To assess the use of marine resources and seasonal resource scheduling
3. To examine the implications of the above in relation to the intensification or not or marine resources in the Mesolithic

7.2 *Variation within the zooarchaeological record*

Despite a general pattern of a focus on several key species in Mesolithic Scotland this thesis has found considerable variation within the zooarchaeological record in terms of taxa present, relative abundance of taxa and skeletal element patterning. A small number of sites with quantifiable data remains a problem for mammal, bird and fish remains and hampers detailed inter-site comparison for many of the assemblages. The situation, has, however vastly improved from when McCormick and Buckland's review of assemblages was conducted (McCormick and Buckland, 1997).

The variation in local site ecology may be a contributing factor to wider variation in the smaller mammals, for example, the presence of badger at MacArthur's cave and Sand attests to a locally wooded environment. Many sites are limited to presence or absence data but Sand, An Corran, Cnoc Coig and Morton have quantified data for comparison. This reveals differences in species relative abundance and processing. At Sand and An Corran red and roe deer account for most of the mammalian taxa, whilst at the Oronsay sites seal is the predominant mammal. The seal remains at the Oronsay sites are so far an anomaly when compared to the general pattern of the exploitation of terrestrial mammals but exploitation was not large scale (Nolan, 1986, Grigson and Mellars, 1987).

Even though only based a small number of sites, processing of animals as assessed by skeletal element patterning does seem to vary; at Sand whole red deer appear to have been brought to site, at An Corran although other elements are present metapodials seem to have been selected for use. At Cnoc Coig a lack of vertebrae and ribs and abundance of terminal elements also suggests that whilst some whole animals may be present specific bones were selected to be brought to the site (Grigson and Mellars, 1987). Several methodological issues were raised; the impact of fragmentation on element abundance and recording methodology used. When NISP data is used a high degree of bone fragmentation may skew element distribution patterns by overinflating the abundance of certain elements, however, as raw data NISP is available for site comparison. The recording methodology used can also have an impact on the element skeletal pattern. In the York recording system protocol a suite of diagnostic elements are fully recorded, but this does not included any ribs or vertebrae. This makes it difficult to fully assess processing patterns. Prior to the Sand assemblage the York system had primarily been used for Viking age and later assemblages and a direct application to a highly fragmented Mesolithic assemblage with a relatively low proportion of QC1 elements was, with hindsight, not the best recording methodology to have used. The mammal elements recorded should be extended and ribs and vertebrae recorded as QC2 elements as for fish. Fish vertebrae are not fully recorded but taxon and the place along the vertebral column is and recording this for mammal vertebrae as well would be a relatively quick addition to recording. Similarly, a quick recording of ribs would not greatly increase recording time but would aid interpretation considerably.

The issue of a small corpus of sites with quantifiable data is also an issue for the bird remains. Again only Sand, An Corran and Cnoc Coig have detailed assemblages. There are stark differences in the taxa present and this is likely to reflect three factors: local ecology, availability of birds and season of birding. At Sand, auks, especially razorbills and guillemots were almost exclusively targeted. At An Corran, puffin (another member of the auk family) was the most abundance species but more taxa were present in smaller numbers (Bartosiewicz, forthcoming). A very wide range of taxa were present at Cnoc Coig and there is little evidence of a focused birding strategy (Nolan, 1986). However, auks are still the most abundance taxa present. The importance of auks such as razorbill and guillemot in the Mesolithic is highlighted when the sites without quantifiable data are also considered, they are consistently present.

The fish bone from Sand has added to the already wide range of species at Mesolithic sites in Scotland, including herring, horse mackerel and Atlantic mackerel. Variations were found in taxa present, relative abundance, size of fish present and skeletal patterning. Based on taxa presence or absences data a pattern of inshore fishing (although not necessarily shore-based) is seen for the west coast sites, fishing at Morton may have been in deeper water. This wide range of species *present* on a site does, however belie the closely targeted fishing strategies evident at Sand (for wrasses and gadids) and at the Oronsay sites (for saithe). At Sand a wider range of minor species were present but not in large numbers. Wrasses were also present in numbers at An Corran. The wrasses at An Corran and Sand, are likely to be a result of the rocky shorelines around the Inner Sound.

The reanalysis of Cnoc Sligeach has provided important quantifiable data on fish size, that was lacking from Wilkinson's analysis and thus allows a more details comparison with An Corran and Sand. At the three sites most fish were typically under 500mm with the size range at An Corran most narrow. At most of the sites the skeletal element pattern, where most parts of the body are present is consistent with filleting of fish. Many of the identifiable elements would be left in the discarded carcass. Preservation biases against certain elements, however, remains an issue in fully assessing this. The most detailed fish bone assemblage in terms of context control and the remains of individual catches of fish is Cnoc Coig and this site holds the most potential for further detailed reanalysis.

7.3 *Seasonal resource scheduling of marine resources in Mesolithic Scotland*

There is strong evidence for the use of marine resources throughout the Late Mesolithic of coastal western Scotland, based on the small corpus of sites available. All sites do, however also target terrestrial mammals, although their remains seem mostly connected to tool manufacture. Although seal is largely restricted to the Oronsay sites here exploitation here does not seem to have been on a large scale; one season of seal capture is evident but *not* repeated annual capture

Sea bird hunting is a feature of sites throughout the Mesolithic. At Sand and An Corran it is highly targeted and at Sand seasonally restrictive to most likely the late summer and autumn months during the post-breeding moult. However, exploitation may have been intensive (many birds caught in one period) or consistent over time (birds repeatedly processed at a site over time). At Cnoc Coig and Morton birding is not highly targeted or large scale.

Highly targeted fishing for wrasses and gadids, primarily saithe, took place at Sand in the 7th millennium. The extent to which this was the result of many fish caught in a short time period) or fish repeatedly caught over several years is difficult to assess due to the small number of dates and lack of stratigraphy in the midden. I favour a season of capture of late summer and autumn; this is primarily based on when saithe are known to be super abundant in the area. The issue of growth rates and otolith size is one that requires further work and is discussed below. Fish remains at An Corran and Morton were less abundant; the fishery does not appear highly targeted. Highly targeted fishing also took place at the Oronsay sites in the later part of the 5th and early 4th millennium. Here Wilkinson has proposed a much tighter seasonal framework for fish capture than at Sand. This appears to suggest specific seasons of fishing at the different sites but as fish total lengths are not provided the data is hard to compare. I do not believe there is yet enough data on the growth of young saithe or the means to relate this to the otolith measurements. Fishing for saithe on Oronsay may have occurred at different times of the year at different sites but this may not have formed an annual seasonal round around the island during the same year.

7.4 *Marine intensification in Mesolithic Scotland; final conclusions*

This thesis does **not** support the hypothesis for an intensification of marine resource use in Mesolithic Scotland. The comparative body of data available is small, and my analysis of Sand, therefore, plays a crucial role in furthering our understanding of subsistence practices in the period. With the addition of Sand and Bartosiewicz's (forthcoming) work at An Corran the Oronsay sites, with a strong marine focus are no longer an anomaly. The discovery, analysis and publication of new sites may change interpretations, but, when the currently available mammal, bird and fish bone evidence is considered there is not zooarchaeological evidence for an intensification of marine resources through the Mesolithic.

There **is** evidence for strong marine resource use but this is more sensibly interpreted (as it has been in Scandinavia) as a local reaction to, and exploitation of, available resources rather than part of a long-term trajectory of an ever increasing marine diet which ends ultimately in the switch to agriculture (Rowley-Conwy 2004 and *contra* Mellars 20004, Richards *et al.*, 2005).

7.5 *Suggestions for further work*

The corpus of sites with faunal remains available is small and, a plea for more sites and more dates is an obvious one. Aside from this, this section makes recommendations for future work on the existing fish bone assemblages. The reanalysis of the Cnoc Sligeach largely confirmed Wilkinson's results, but did provide valuable data on fish size. Full reanalysis of all the Oronsay sites is not recommended but the reanalysis of the otoliths from all the sites is. This would allow a fully comparable dataset. A necessary partner to this is more information on young saithe growth patterns and their seasonal availability. This should also include an investigation of fishing methods for saithe, for example, are different fishing methods really size selective.

Cnoc Coig is the only site which has evidence for deposits of single dumps of fish bone, presumably processing waste from a single catch. Wilkinson's otolith analysis hinted at a difference in fish size between these deposits. In addition to the re-recording of the otoliths a more detailed contextual and stratigraphic reassessment of the Cnoic Coig fish bone concentrations would allow a more detailed insight into fish processing patterns. These distinct deposits of fish bone also makes the otoliths from Cnoc Coig a contender for thin section analysis to more closely assess season of capture as they appear the only deposits from any site to thus far meet the criteria of Van Neer *et al.*(2004).

The Cnoc Coig material would also be suitable for a further thin section methodology that has yet to be applied to British material but has been successfully used (albeit on a very small sample) on Norwegian and Danish material; the use of $\delta^{18}O$ values. The ratio of values is used as a means to estimate sea water temperature and to, by extension, indicate season of capture (Hufthammer, 2010, Ritchie et al., 2013).

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Appendix 1. **Sand mammal QC1 element measurements**

Element	Taxon	Context	Bone id	Measurements			
Astragulus				**Bd**	**Dl**	**GLl**	**GLm**
	red deer	topsoil	SFS4-2000	35.44	25.91	54.05	50.65
Calcaneum				**C+D**	**GL**		
	red deer	topsoil	SFS4-3120	37.82	109.9		
Humerus				**BT**			
	red deer	organic rich	SFS4-1800	48.3			
Metapodials				**Bd**			
	red deer						
		main shell midden	SFS4-12	36.39			
		main shell midden	SFS4-1928	45.85			
		main shell midden	SFS4-1965	46.88			
		organic rich	SFS4-329	40.84			
		organic rich	SFS4-5967	39.85			
Mandibular molar1				**LM**	**BM**		
	Bos sp.	organic rich	SFS4-2251	28.78	11.94		
Mandibular molar3*				**P6**	**P7**		

Element	Taxon	Context	Bone id	Measurements			
	wild boar	main shell midden	SFS4-2521	16.5	16.26		
Phalanx 1				**GL**	**Ll**		
	red deer						
		main shell midden	SFS4-1820	24	25.23		
		main shell midden	SFS4-5854	26.9			
		main shell midden	SFS4-5855	27.2			
Radius				**Bp**	**Bd**		
	red deer						
		topsoil	SFS4-1998		53.92		
		main shell midden	SFS4-7	55.76			
	wild boar						
		main shell midden	SFS4-1835		39.42		
Scapula				**GLP**			
	large mammal						
		main shell midden	SFS4-5852	63.12			
Tibia				**Bd**			
	red deer	main shell midden	SFS4-1917	36.32			

Element	Taxon	Context	Bone id	Measurements			
				GB			
Navicular- cuboid	*Bos* sp.	sandy soil	SFS4-2537	49.35			

* measurements P6 and P7 taken on the wild boar mandibular molar3 follow Dobney *et al* 1999

Appendix 2. **Sand bird QC1 element measurements**

Element	Taxon	Context	Bone id	Measurements			
Carpometacarpus				**GL**	**Bp**	**Did**	**L**
	guillemot	main shell midden	SFS4-3911			6.75	
	guillemot	main shell midden	SFS4-3912			6.97	
	guillemot	main shell midden	SFS4-4174			6.46	
	guillemot	topsoil	SFS4-4638		10.35		
	guillemot	main shell midden	SFS4-4988	40.56	10.68		
	guillemot	main shell midden	SFS4-3909		9.95	6.32	
	guillemot	main shell midden	SFS4-3910		11.85		
	guillemot	main shell midden	SFS4-3935		10.23		
	guillemot	main shell midden	SFS4-4175		9.39		
	razorbill or guillemot	topsoil	SFS4-3959		9.31		
	razorbill or guillemot	main shell midden	SFS4-4002			5.65	
	razorbill or guillemot	main shell midden	SFS4-4068		8.79		
	razorbill or guillemot	main shell midden	SFS4-4069			6.53	
	razorbill or guillemot	main shell midden	SFS4-4070			6.08	
	razorbill or guillemot	main shell midden	SFS4-4098		9.75		
	razorbill or guillemot	main shell midden	SFS4-4141		9.32		
	razorbill or guillemot	main shell midden	SFS4-4204	40.52	10.64	6.2	40.06
	razorbill or guillemot	main shell midden	SFS4-4205		9.51		
	razorbill or guillemot	main shell midden	SFS4-4206			6.6	
	razorbill or guillemot	main shell midden	SFS4-4207		10.15		
	razorbill or guillemot	main shell midden	SFS4-4209			6.72	
	razorbill or guillemot	main shell midden	SFS4-4416			6.23	
	razorbill or guillemot	organic rich	SFS4-4521		10.82		

Element	Taxon	Context	Bone id	Measurements			
	razorbill or guillemot	organic rich	SFS4-4522			6.8	
	razorbill or guillemot	main shell midden	SFS4-4543		9.7		
	razorbill or guillemot	main shell midden	SFS4-4545			6.1	
	razorbill or guillemot	main shell midden	SFS4-4556		9.61		
	razorbill or guillemot	main shell midden	SFS4-4629			6.47	
	razorbill or guillemot	topsoil	SFS4-4640			7.13	
	razorbill or guillemot	topsoil	SFS4-4642			6.52	
	razorbill or guillemot	topsoil	SFS4-4675		9.94		
	razorbill or guillemot	topsoil	SFS4-4698			7.25	
	razorbill or guillemot	main shell midden	SFS4-4742		9.99	6.49	
	razorbill or guillemot	main shell midden	SFS4-4761			6.91	
	razorbill or guillemot	main shell midden	SFS4-4788		10.97		
	razorbill or guillemot	main shell midden	SFS4-4811			7.04	
	razorbill or guillemot	main shell midden	SFS4-4880		10.91		
	razorbill or guillemot	topsoil	SFS4-4897			6.69	
	razorbill or guillemot	topsoil	SFS4-4899			7.16	
	razorbill or guillemot	topsoil	SFS4-4900		10.69		
	razorbill or guillemot	topsoil	SFS4-4901			6.74	
	razorbill or guillemot	main shell midden	SFS4-4915			6.23	
	razorbill or guillemot	main shell midden	SFS4-4918			7.07	
	razorbill or guillemot	main shell midden	SFS4-5068		10.73		
	razorbill or guillemot	main shell midden	SFS4-5069		9.46		
	razorbill or guillemot	main shell midden	SFS4-5071		10.2		
	razorbill or guillemot	main shell midden	SFS4-5132			6.68	
	razorbill or guillemot	organic rich	SFS4-5141			6.66	
	razorbill or guillemot	topsoil	SFS4-5238		10.31		
	razorbill or guillemot	topsoil	SFS4-5249			6.25	

Element	Taxon	Context	Bone id	Measurements			
	razorbill or guillemot	shell midden	SFS4-5310		10.29		
	razorbill or guillemot	sandy soil	SFS4-5547		10.29		
	razorbill or guillemot	main shell midden	SFS4-5744		9.41		
	razorbill or guillemot	main shell midden	SFS4-5747		10.09		
	great auk	topsoil	SFS4-5291		13.66		
	auk family	topsoil	SFS4-3955		8.56		
		main shell midden	SFS4-4603			7.39	
		main shell midden	SFS4-5101			7.27	
Coracoid				**GL**	**BF**	**Bb**	**Lm**
	razorbill	main shell midden	SFS4-3853	36.69	12.8		35.95
	razorbill or guillemot	main shell midden	SFS4-4003	38.26			
		main shell midden	SFS4-4823	35.56			35.29
Humerus				**GL**	**SC**	**Bp**	**Bd**
	guillemot	topsoil	SFS4-3951	11.75			
	guillemot	topsoil	SFS4-3952	11.41			
	guillemot	topsoil	SFS4-3969	11.38			
	guillemot	main shell midden	SFS4-4085	10.43			
	guillemot	main shell midden	SFS4-4190	83.19	7.25	18.26	
	guillemot	main shell midden	SFS4-4193	11.24			
	guillemot	main shell midden	SFS4-4408	11.14			
	guillemot	main shell midden	SFS4-4409	9.78			
	guillemot	main shell midden	SFS4-4483	11.49			
	guillemot	main shell midden	SFS4-4554	81.66	6.91	16.85	8.17
	guillemot	main shell midden	SFS4-4612	8.88			
	guillemot	main shell midden	SFS4-4614	9.26			

Element	Taxon	Context	Bone id	Measurements			
	guillemot	topsoil	SFS4-4634	11.4			
	guillemot	topsoil	SFS4-4635	11.36			
	guillemot	main shell midden	SFS4-4658	11.25			
	guillemot	main shell midden	SFS4-4752	10.04			
	guillemot	main shell midden	SFS4-4753	10.27			
	guillemot	main shell midden	SFS4-4786	9.02			
	guillemot	main shell midden	SFS4-4821	10.2			
	guillemot	main shell midden	SFS4-4835	9.21			
	guillemot	main shell midden	SFS4-4906	10.38			
	guillemot	main shell midden	SFS4-5054	77.54	7	16.99	10.76
	guillemot	main shell midden	SFS4-5157	82.12	16.87	8.7	
	guillemot	topsoil	SFS4-5185	10.21			
	guillemot	topsoil	SFS4-5186	10.09			
	guillemot	main shell midden	SFS4-5214	9.25			
	guillemot	main shell midden	SFS4-5223	81.63	17.68	9.13	
	guillemot	topsoil	SFS4-5231	9.76			
	guillemot	organic rich	SFS4-5276	9.77			
	guillemot	main shell midden	SFS4-5305	17.5	10.14		
	guillemot	main shell midden	SFS4-5754	10.52			
	guillemot	topsoil	SFS4-5760	10.08			
	guillemot	main shell midden	SFS4-5763	10.4			
	guillemot	main shell midden	SFS4-3981	16.61			
	guillemot	main shell midden	SFS4-3985	11.47			
	guillemot	main shell midden	SFS4-3985	11.48			
	guillemot	main shell midden	SFS4-4192	17.8			
	razorbill	main shell midden	SFS4-4042	67.85	6.44	16.34	
	razorbill	main shell midden	SFS4-4609	8.21			

Element	Taxon	Context	Bone id	Measurements			
	razorbill	main shell midden	SFS4-4657	9.63			
	razorbill	topsoil	SFS4-4699	70.28	6.65	16.7	9.04
	razorbill	main shell midden	SFS4-4751	9.51			
	razorbill	main shell midden	SFS4-4907	9.07			
	razorbill	main shell midden	SFS4-5061	9.56			
	razorbill	main shell midden	SFS4-5062	9.16			
	razorbill	main shell midden	SFS4-5755	8.78			
	razorbill or guillemot	topsoil	SFS4-3882	15.63			
	razorbill or guillemot	main shell midden	SFS4-3888	17.01			
	razorbill or guillemot	main shell midden	SFS4-3889	16.38			
	razorbill or guillemot	main shell midden	SFS4-3891	10.26			
	razorbill or guillemot	main shell midden	SFS4-3980	17.87			
	razorbill or guillemot	main shell midden	SFS4-3982	11.22			
	razorbill or guillemot	main shell midden	SFS4-4140	17.22			
	razorbill or guillemot	main shell midden	SFS4-4191	16.99			
	razorbill or guillemot	topsoil	SFS4-4257	16.57			
	razorbill or guillemot	topsoil	SFS4-4261	11.37			
	razorbill or guillemot	organic rich	SFS4-4377	9.66			
	razorbill or guillemot	main shell midden	SFS4-4555	17.34			
	razorbill or guillemot	main shell midden	SFS4-4608	17.99			
	razorbill or guillemot	main shell midden	SFS4-4613	15.19			
	razorbill or guillemot	topsoil	SFS4-4633	17.05			
	razorbill or guillemot	main shell midden	SFS4-4656	17.65			
	razorbill or guillemot	main shell midden	SFS4-4719	17.16			
	razorbill or guillemot	main shell midden	SFS4-4721	17.44			
	razorbill or guillemot	main shell midden	SFS4-4724	7.93			
	razorbill or guillemot	main shell midden	SFS4-4837	16.39			

Element	Taxon	Context	Bone id	Measurements			
	razorbill or guillemot	main shell midden	SFS4-4881	8.75			
	razorbill or guillemot	main shell midden	SFS4-4941	17.85			
	razorbill or guillemot	main shell midden	SFS4-4942	8.45			
	razorbill or guillemot	topsoil	SFS4-4984	10.48			
	razorbill or guillemot	main shell midden	SFS4-4987	17.68			
	razorbill or guillemot	main shell midden	SFS4-4996	9.41			
	razorbill or guillemot	main shell midden	SFS4-5053	10.04			
	razorbill or guillemot	main shell midden	SFS4-5055	16.83			
	razorbill or guillemot	main shell midden	SFS4-5056	16.81			
	razorbill or guillemot	main shell midden	SFS4-5057	16.67			
	razorbill or guillemot	main shell midden	SFS4-5110	18.57			
	razorbill or guillemot	main shell midden	SFS4-5195	58.57	8.13		
	razorbill or guillemot	main shell midden	SFS4-5212	15			
	razorbill or guillemot	main shell midden	SFS4-5601	9.89			
	razorbill or guillemot	organic rich	SFS4-5615	16.73			
	great auk	main shell midden	SFS4-4138	9.21			
	great auk	main shell midden	SFS4-4620	11.49			
	great auk	main shell midden	SFS4-5334	11.96			
	auk family	main shell midden	SFS4-3983	12.15			
	auk family	main shell midden	SFS4-4043	6.53			
	auk family	organic rich	SFS4-4510	8.17			
	auk family	topsoil	SFS4-4637	10.48			
	thrush and chat family	main shell midden	SFS4-5655	6.86			
Scapula				**GLP**	**SLC**	**Dic**	**GL**
	guillemot	main shell midden	SFS4-3997		11.52		
	razorbill or guillemot	main shell midden	SFS4-3860		11.04		

Element	Taxon	Context	Bone id	Measurements			
	razorbill or guillemot	main shell midden	SFS4-3860				
	razorbill or guillemot	main shell midden	SFS4-3914		10.42		
	razorbill or guillemot	main shell midden	SFS4-3915		10.62		
	razorbill or guillemot	main shell midden	SFS4-3998		10.7		
	razorbill or guillemot	main shell midden	SFS4-3999		9.84		
	razorbill or guillemot	main shell midden	SFS4-4060		10.53		
	razorbill or guillemot	main shell midden	SFS4-4061		11.22		
	razorbill or guillemot	main shell midden	SFS4-4061		11.19		
	razorbill or guillemot	main shell midden	SFS4-4143		11.12		
	razorbill or guillemot	main shell midden	SFS4-4185		11.12		
	razorbill or guillemot	main shell midden	SFS4-4211		11.29		
	razorbill or guillemot	topsoil	SFS4-4236		9.92		
	razorbill or guillemot	topsoil	SFS4-4237		10.91		
	razorbill or guillemot	topsoil	SFS4-4262		10.94		
	razorbill or guillemot	organic rich	SFS4-4381		10.75		
	razorbill or guillemot	organic rich	SFS4-4382		9.76		
	razorbill or guillemot	organic rich	SFS4-4401		9.93		
	razorbill or guillemot	organic rich	SFS4-4523		11.34		
	razorbill or guillemot	main shell midden	SFS4-4606		9.62		
	razorbill or guillemot	main shell midden	SFS4-4627		10.61		
	razorbill or guillemot	main shell midden	SFS4-4663		11.23		
	razorbill or guillemot	main shell midden	SFS4-4664		11.26		
	razorbill or guillemot	main shell midden	SFS4-4665		11.24		
	razorbill or guillemot	main shell midden	SFS4-4666		11.09		
	razorbill or guillemot	organic rich	SFS4-4706		10.6		
	razorbill or guillemot	main shell midden	SFS4-4738		10.86		
	razorbill or guillemot	main shell midden	SFS4-4759		11.76		

Element	Taxon	Context	Bone id	Measurements			
	razorbill or guillemot	main shell midden	SFS4-4798		10.73		
	razorbill or guillemot	organic rich	SFS4-4874		10.82		
	razorbill or guillemot	main shell midden	SFS4-4910		8.9		
	razorbill or guillemot	main shell midden	SFS4-4911		10.35		
	razorbill or guillemot	main shell midden	SFS4-4952		10.78		
	razorbill or guillemot	topsoil	SFS4-4991		11.46		
	razorbill or guillemot	main shell midden	SFS4-5017		10.18		
	razorbill or guillemot	main shell midden	SFS4-5046		10.82		
	razorbill or guillemot	main shell midden	SFS4-5064		10.33		
	razorbill or guillemot	main shell midden	SFS4-5065		10.93		
	razorbill or guillemot	main shell midden	SFS4-5087		10.84		
	razorbill or guillemot	topsoil	SFS4-5118		9.55		
	razorbill or guillemot	topsoil	SFS4-5119		10.02		
	razorbill or guillemot	topsoil	SFS4-5120		9.26		
	razorbill or guillemot	organic rich	SFS4-5142		10.42		
	razorbill or guillemot	topsoil	SFS4-5209		9.5		
	razorbill or guillemot	topsoil	SFS4-5327		10.78		
	razorbill or guillemot	main shell midden	SFS4-5364		11.23		
	razorbill or guillemot	main shell midden	SFS4-5365		10.55		
	razorbill or guillemot	sandy soil	SFS4-5374		10.1		
	razorbill or guillemot	topsoil	SFS4-5391		11.25		
	razorbill or guillemot	topsoil	SFS4-5428		11.63		
	razorbill or guillemot	main shell midden	SFS4-5442		10.54		
	razorbill or guillemot	sandy soil	SFS4-5489		11.04		
	razorbill or guillemot	main shell midden	SFS4-5539		11.43		
	razorbill or guillemot	sandy soil	SFS4-5561		10.33		
	razorbill or guillemot	main shell midden	SFS4-5742		10.8		

Element	Taxon	Context	Bone id	Measurements			
	razorbill or guillemot	main shell midden	SFS4-5743		11.6		
	razorbill or guillemot	main shell midden	SFS4-5796		10.7		
	razorbill or guillemot	main shell midden	SFS4-5797		10.87		
	razorbill or guillemot	topsoil	SFS4-5808		10.71		
	great auk	main shell midden	SFS4-4667		16.73		
	auk family	topsoil	SFS4-5252		11.06		
	auk family	shell midden	SFS4-5542		10.17		
Tarsometatarsus				**GL**	**SC**	**Bp**	**Bd**
	guillemot	main shell midden	SFS4-4197	36.28	3.51	8	7.5
	razorbill or guillemot	main shell midden	SFS4-4345			8.11	
Tibiotarsus				**GL**	**Bd**	**Dip**	**Dd**
	razorbill or guillemot	topsoil	SFS4-3884				5.49
	razorbill or guillemot	main shell midden	SFS4-4024		6.93		
	razorbill or guillemot	main shell midden	SFS4-4101			7.06	
	razorbill or guillemot	main shell midden	SFS4-4202		7.17		
	razorbill or guillemot	main shell midden	SFS4-4203		7.25		
	razorbill or guillemot	topsoil	SFS4-4264		6.35		
	razorbill or guillemot	topsoil	SFS4-4287		6.08		
	razorbill or guillemot	main shell midden	SFS4-4347		7.25		
	razorbill or guillemot	main shell midden	SFS4-4430		7.44		
	razorbill or guillemot	main shell midden	SFS4-4432		7.07		
	razorbill or guillemot	main shell midden	SFS4-4449		7.71		
	razorbill or guillemot	main shell midden	SFS4-4494		6.71		6.84
	razorbill or guillemot	main shell midden	SFS4-4564				7.48

Element	Taxon	Context	Bone id	Measurements			
	razorbill or guillemot	main shell midden	SFS4-4736		7.4		
	razorbill or guillemot	main shell midden	SFS4-4807		6.82		
	razorbill or guillemot	topsoil	SFS4-4848		6.82		
	razorbill or guillemot	main shell midden	SFS4-4950		7.15		
	razorbill or guillemot	main shell midden	SFS4-4951		6.79		
	razorbill or guillemot	topsoil	SFS4-5027		6.88		
	razorbill or guillemot	topsoil	SFS4-5257		7.04		
	razorbill or guillemot	topsoil	SFS4-5362		7.22		
	razorbill or guillemot	sandy soil	SFS4-5375		6.96		
	razorbill or guillemot	main shell midden	SFS4-5437		6.94		
	razorbill or guillemot	shell midden	SFS4-5469		5.99		
	razorbill or guillemot	sandy soil	SFS4-5521		7.78		
	razorbill or guillemot	main shell midden	SFS4-5571		6.99		
	razorbill or guillemot	main shell midden	SFS4-5741				7.31
	razorbill or guillemot	topsoil	SFS4-5804				7.15
	razorbill or guillemot	main shell midden	SFS4-5818				7.56
	auk family	topsoil	SFS4-3956		6.75		
	auk family	shell midden	SFS4-5312		6.24		
	auk family	main shell midden	SFS4-5739				6.06

Appendix 3. **Fish QC1 and QC4 element measurements**

Element	Taxon	Context	Bone id	M1	M2	M3
articular	ballan wrasse	topsoil	SFS4-6800	3.16		
articular	ballan wrasse	main shell midden	SFS4-7100	2.41		
basioccipital	saithe	main shell midden	SFS4-1049	3.05	3.31	
basioccipital	saithe	main shell midden	SFS4-737	3.03	3.51	
basioccipital	saithe	main shell midden	SFS4-7313	2.82	3.46	
basioccipital	saithe	main shell midden	SFS4-791	2.57	4.01	
basioccipital	saithe	sandy soil	SFS4-7633	3.02	4.23	
basioccipital	saithe	topsoil	SFS4-6846	3.62	4.07	
basioccipital	saithe	topsoil	SFS4-7189	2.99	3.76	
basioccipital	saithe	topsoil	SFS4-7540	2.84	3.8	
basioccipital	pollack	main shell midden	SFS4-880	3.04	3.19	
basioccipital	pollack	main shell midden	SFS4-1781		6.32	
basioccipital	cod	main shell midden	SFS4-7113		10.63	
basioccipital	cod, saithe or pollack	main shell midden	SFS4-7127	11.75		
basioccipital	cod family	main shell midden	SFS4-1656	2.64	3.48	
basioccipital	cod family	main shell midden	SFS4-12371	2.79	3.28	
basioccipital	cod family	main shell midden	SFS4-6886	3.68	4.82	
basioccipital	cod family	sandy soil	SFS4-12014	1.55	2.01	
basioccipital	ballan wrasse	main shell midden	SFS4-7740	4.73	5.57	
basioccipital	wrasse family	main shell midden	SFS4-2669	3.09	3.78	
basioccipital	wrasse family	main shell midden	SFS4-2581	4.76	5.26	
basioccipital	wrasse family	main shell midden	SFS4-2822	5.04	5.21	
basioccipital	wrasse family	main shell midden	SFS4-1748	2.76	3.04	
basioccipital	wrasse family	main shell midden	SFS4-1719	3.08	3.14	
basioccipital	wrasse family	main shell midden	SFS4-2995	2.47	2.72	
basioccipital	wrasse family	main shell midden	SFS4-2568	3.18	3.21	
basioccipital	wrasse family	main shell midden	SFS4-6881	5.18	5.23	
basioccipital	wrasse family	main shell midden	SFS4-7125	4.92	5.37	
basioccipital	wrasse family	main shell midden	SFS4-7126	4.78	4.77	
basioccipital	wrasse family	sandy soil	SFS4-7634	3.68	3.83	
basioccipital	wrasse family	shell midden	SFS4-7673	3.84	3.88	
basioccipital	wrasse family	shell midden	SFS4-7609	3.82	4.49	
basioccipital	wrasse family	topsoil	SFS4-6745	3.15	3.8	
basioccipital	wrasse family	topsoil	SFS4-6746	3.57	3.77	
basioccipital	wrasse family	topsoil	SFS4-6824	3.24	3.04	
basioccipital	wrasse family	topsoil	SFS4-6685	3.03	3.44	
basioccipital	wrasse family	topsoil	SFS4-13106	2.96	3.45	
dentary	saithe	main shell midden	SFS4-1043	1.82	2.49	
dentary	saithe	main shell midden	SFS4-1044	1.64	2.32	

Element	Taxon	Context	Bone id	M1	M2	M3
dentary	saithe	main shell midden	SFS4-12176		2.55	
dentary	saithe	main shell midden	SFS4-7316	2.86	2.48	
dentary	saithe	main shell midden	SFS4-7418	2.88		
dentary	saithe	main shell midden	SFS4-7023	4.52	4.69	
dentary	saithe	main shell midden	SFS4-7112	4.09		
dentary	saithe	topsoil	SFS4-6157	3.61	3.48	
dentary	saithe	topsoil	SFS4-13012		2.46	
dentary	pollack	main shell midden	SFS4-6093	4.84	4.92	
dentary	pollack	main shell midden	SFS4-12253	5.46		
dentary	pollack	main shell midden	SFS4-2844	6.51		
dentary	pollack	main shell midden	SFS4-6179		5.84	
dentary	saithe or pollack	main shell midden	SFS4-1045		2.21	
dentary	saithe or pollack	main shell midden	SFS4-604	1.72	2.36	
dentary	saithe or pollack	main shell midden	SFS4-1597	2.35		
dentary	saithe or pollack	topsoil	SFS4-15707	5.83		
dentary	cod	main shell midden	SFS4-709		1.71	
dentary	cod	main shell midden	SFS4-819	1.49	2.03	
dentary	cod	main shell midden	SFS4-2915	1.86		
dentary	cod, saithe or pollack	main shell midden	SFS4-708	1.92	2.5	
dentary	cod, saithe or pollack	topsoil	SFS4-2792	3.98		
dentary	cod family	main shell midden	SFS4-2684		2.3	
dentary	cod family	main shell midden	SFS4-7024	2.6		
dentary	cod family	topsoil	SFS4-6848	2.86		
dentary	ballan wrasse	main shell midden	SFS4-1246	5.26		
dentary	wrasse family	main shell midden	SFS4-2888	6.88		
dentary	wrasse family	main shell midden	SFS4-1076	2.77	4.13	
dentary	wrasse family	topsoil	SFS4-2790	5.86		
dentary	wrasse family	topsoil	SFS4-2755	3.86		
otolith	saithe or pollack	main shell midden	SFS4-15377	5.84	2.29	
otolith	saithe or pollack	main shell midden	SFS4-15361		3.51	
otolith	saithe or pollack	main shell midden	SFS4-14128	10.71	3.91	
otolith	saithe or pollack	main shell midden	SFS4-14129	10.45	3.72	
otolith	saithe or pollack	main shell midden	SFS4-14130		3.45	
otolith	saithe or pollack	main shell midden	SFS4-14131	9.95	3.74	
otolith	saithe or pollack	main shell midden	SFS4-14133		3.27	
otolith	saithe or pollack	main shell midden	SFS4-14135		3.44	
otolith	saithe or pollack	main shell midden	SFS4-14143	9.34	3.51	
otolith	saithe or pollack	main shell midden	SFS4-14144		3.76	
otolith	saithe or pollack	main shell midden	SFS4-14146		3.34	
otolith	saithe or pollack	main shell midden	SFS4-14147		3.16	
otolith	saithe or pollack	main shell midden	SFS4-14153	6.12	2.37	
otolith	saithe or pollack	main shell midden	SFS4-15238		3.46	
otolith	saithe or pollack	main shell midden	SFS4-15239	8.8	3.41	
otolith	saithe or pollack	main shell midden	SFS4-15240		3.94	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	main shell midden	SFS4-15241		3.39	
otolith	saithe or pollack	main shell midden	SFS4-15243		2.56	
otolith	saithe or pollack	main shell midden	SFS4-15245		3.36	
otolith	saithe or pollack	main shell midden	SFS4-15248	6.47	2.56	
otolith	saithe or pollack	main shell midden	SFS4-15249	6.95	2.67	
otolith	saithe or pollack	main shell midden	SFS4-16193		2.9	
otolith	saithe or pollack	main shell midden	SFS4-16194		2.62	
otolith	saithe or pollack	main shell midden	SFS4-14709		3.12	
otolith	saithe or pollack	main shell midden	SFS4-14710	17.11	7.14	
otolith	saithe or pollack	main shell midden	SFS4-14711		6.54	
otolith	saithe or pollack	main shell midden	SFS4-14712		3.85	
otolith	saithe or pollack	main shell midden	SFS4-14717	12.05	4.32	
otolith	saithe or pollack	main shell midden	SFS4-14718	10.7	3.64	
otolith	saithe or pollack	main shell midden	SFS4-14721	9.46	3.35	
otolith	saithe or pollack	main shell midden	SFS4-14724		3.34	
otolith	saithe or pollack	main shell midden	SFS4-14725	5.81	2.32	
otolith	saithe or pollack	main shell midden	SFS4-14726		3.53	
otolith	saithe or pollack	main shell midden	SFS4-14732		4.37	
otolith	saithe or pollack	main shell midden	SFS4-14733		3.51	
otolith	saithe or pollack	main shell midden	SFS4-14734		4.09	
otolith	saithe or pollack	main shell midden	SFS4-14735	9.42	4.09	
otolith	saithe or pollack	main shell midden	SFS4-14736		4.11	
otolith	saithe or pollack	main shell midden	SFS4-14737	10.72	3.99	
otolith	saithe or pollack	main shell midden	SFS4-14738		3.88	
otolith	saithe or pollack	main shell midden	SFS4-14739	8.99	3.2	
otolith	saithe or pollack	main shell midden	SFS4-14740		2.55	
otolith	saithe or pollack	main shell midden	SFS4-14741		2.63	
otolith	saithe or pollack	main shell midden	SFS4-14742		3.92	
otolith	saithe or pollack	main shell midden	SFS4-14743		3.75	
otolith	saithe or pollack	main shell midden	SFS4-14744		3.25	
otolith	saithe or pollack	main shell midden	SFS4-14746		2.91	
otolith	saithe or pollack	main shell midden	SFS4-14747		3.23	
otolith	saithe or pollack	main shell midden	SFS4-14752		2.17	
otolith	saithe or pollack	main shell midden	SFS4-14753		3.81	
otolith	saithe or pollack	main shell midden	SFS4-14754		3.33	
otolith	saithe or pollack	main shell midden	SFS4-14755		2.62	
otolith	saithe or pollack	main shell midden	SFS4-14756		2.53	
otolith	saithe or pollack	main shell midden	SFS4-14757		2.37	
otolith	saithe or pollack	main shell midden	SFS4-14758		3.28	
otolith	saithe or pollack	main shell midden	SFS4-14761	7.97	2.87	
otolith	saithe or pollack	main shell midden	SFS4-14762	6.92	2.6	
otolith	saithe or pollack	main shell midden	SFS4-14765		2.66	
otolith	saithe or pollack	main shell midden	SFS4-14766		2.58	
otolith	saithe or pollack	main shell midden	SFS4-14767		2.27	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	main shell midden	SFS4-14769		3.82	
otolith	saithe or pollack	main shell midden	SFS4-14771	6.99	2.48	
otolith	saithe or pollack	main shell midden	SFS4-14773		2.65	
otolith	saithe or pollack	main shell midden	SFS4-14774		2.3	
otolith	saithe or pollack	main shell midden	SFS4-14783		2.82	
otolith	saithe or pollack	main shell midden	SFS4-14785		2.67	
otolith	saithe or pollack	main shell midden	SFS4-14786	6.41	2.48	
otolith	saithe or pollack	main shell midden	SFS4-14792		2.95	
otolith	saithe or pollack	main shell midden	SFS4-14794		2.97	
otolith	saithe or pollack	main shell midden	SFS4-14795		2.66	
otolith	saithe or pollack	main shell midden	SFS4-14799		3.34	
otolith	saithe or pollack	main shell midden	SFS4-14802		2.46	
otolith	saithe or pollack	main shell midden	SFS4-14804		2.41	
otolith	saithe or pollack	main shell midden	SFS4-13880		2.34	
otolith	saithe or pollack	main shell midden	SFS4-13881	5.81	2.35	
otolith	saithe or pollack	main shell midden	SFS4-13882	3.17		
otolith	saithe or pollack	main shell midden	SFS4-13885		3.16	
otolith	saithe or pollack	main shell midden	SFS4-13886		3.35	
otolith	saithe or pollack	main shell midden	SFS4-13887		2.53	
otolith	saithe or pollack	main shell midden	SFS4-13892		2.43	
otolith	saithe or pollack	main shell midden	SFS4-13897	2.49		
otolith	saithe or pollack	main shell midden	SFS4-13900		2.32	
otolith	saithe or pollack	main shell midden	SFS4-15269		2.49	
otolith	saithe or pollack	main shell midden	SFS4-15270	9.46	3.64	
otolith	saithe or pollack	main shell midden	SFS4-15271	9.29	3.33	
otolith	saithe or pollack	main shell midden	SFS4-15273		3.57	
otolith	saithe or pollack	main shell midden	SFS4-15274	6.14	2.55	
otolith	saithe or pollack	main shell midden	SFS4-15275		2.35	
otolith	saithe or pollack	main shell midden	SFS4-15215		2.44	
otolith	saithe or pollack	main shell midden	SFS4-15216		3.58	
otolith	saithe or pollack	main shell midden	SFS4-15218		3.62	
otolith	saithe or pollack	main shell midden	SFS4-15220		3.24	
otolith	saithe or pollack	main shell midden	SFS4-15221		3.39	
otolith	saithe or pollack	main shell midden	SFS4-15223	6.53	2.78	
otolith	saithe or pollack	main shell midden	SFS4-15227		3.31	
otolith	saithe or pollack	main shell midden	SFS4-15230		2.94	
otolith	saithe or pollack	main shell midden	SFS4-15231		2.28	
otolith	saithe or pollack	main shell midden	SFS4-15264		2.78	
otolith	saithe or pollack	main shell midden	SFS4-15265		3.56	
otolith	saithe or pollack	main shell midden	SFS4-15266		3.56	
otolith	saithe or pollack	main shell midden	SFS4-15276		3.91	
otolith	saithe or pollack	main shell midden	SFS4-15279	5.97	2.38	
otolith	saithe or pollack	main shell midden	SFS4-15280	5.55	2.28	
otolith	saithe or pollack	main shell midden	SFS4-15198		3.57	
otolith	saithe or pollack	main shell midden	SFS4-15206	10.19	3.74	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	main shell midden	SFS4-15207	6.3	2.45	
otolith	saithe or pollack	main shell midden	SFS4-15208		3.36	
otolith	saithe or pollack	main shell midden	SFS4-15209		3.68	
otolith	saithe or pollack	main shell midden	SFS4-15200		5.7	
otolith	saithe or pollack	main shell midden	SFS4-11585	13.63	5.2	
otolith	saithe or pollack	main shell midden	SFS4-11586		6.31	
otolith	saithe or pollack	main shell midden	SFS4-11587	10.21	3.77	
otolith	saithe or pollack	main shell midden	SFS4-11588		3.58	
otolith	saithe or pollack	main shell midden	SFS4-11589		3.84	
otolith	saithe or pollack	main shell midden	SFS4-11590		4.12	
otolith	saithe or pollack	main shell midden	SFS4-11591		3.89	
otolith	saithe or pollack	main shell midden	SFS4-11593		3.81	
otolith	saithe or pollack	main shell midden	SFS4-11594		3.61	
otolith	saithe or pollack	main shell midden	SFS4-11595		3.49	
otolith	saithe or pollack	main shell midden	SFS4-11596		4.02	
otolith	saithe or pollack	main shell midden	SFS4-11597		3.45	
otolith	saithe or pollack	main shell midden	SFS4-11598		3.8	
otolith	saithe or pollack	main shell midden	SFS4-11599	8.99	3.45	
otolith	saithe or pollack	main shell midden	SFS4-11600		4.19	
otolith	saithe or pollack	main shell midden	SFS4-11601		3.99	
otolith	saithe or pollack	main shell midden	SFS4-11602		3.22	
otolith	saithe or pollack	main shell midden	SFS4-11603		3.46	
otolith	saithe or pollack	main shell midden	SFS4-11604		4.08	
otolith	saithe or pollack	main shell midden	SFS4-11605	7.26	3.05	
otolith	saithe or pollack	main shell midden	SFS4-11606	8.51	3.44	
otolith	saithe or pollack	main shell midden	SFS4-11607		3.37	
otolith	saithe or pollack	main shell midden	SFS4-11608		3.29	
otolith	saithe or pollack	main shell midden	SFS4-11609		3.61	
otolith	saithe or pollack	main shell midden	SFS4-11610		3.39	
otolith	saithe or pollack	main shell midden	SFS4-11611		3.99	
otolith	saithe or pollack	main shell midden	SFS4-11612	9.25	3.64	
otolith	saithe or pollack	main shell midden	SFS4-11614		3.28	
otolith	saithe or pollack	main shell midden	SFS4-11615		2.46	
otolith	saithe or pollack	main shell midden	SFS4-11616		3.2	
otolith	saithe or pollack	main shell midden	SFS4-11617		4.7	
otolith	saithe or pollack	main shell midden	SFS4-15482	12.99	5.02	
otolith	saithe or pollack	main shell midden	SFS4-15483		4.19	
otolith	saithe or pollack	main shell midden	SFS4-15484		4.92	
otolith	saithe or pollack	main shell midden	SFS4-15485		4.07	
otolith	saithe or pollack	main shell midden	SFS4-15487		4.12	
otolith	saithe or pollack	main shell midden	SFS4-15491		5.12	
otolith	saithe or pollack	main shell midden	SFS4-15492		2.91	
otolith	saithe or pollack	main shell midden	SFS4-15493		3.44	
otolith	saithe or pollack	main shell midden	SFS4-15494		2.6	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	main shell midden	SFS4-15495		3.7	
otolith	saithe or pollack	main shell midden	SFS4-15496		3.27	
otolith	saithe or pollack	main shell midden	SFS4-15498		2.88	
otolith	saithe or pollack	main shell midden	SFS4-15499		2.79	
otolith	saithe or pollack	main shell midden	SFS4-15502	8.98	3.34	
otolith	saithe or pollack	main shell midden	SFS4-15504		2.11	
otolith	saithe or pollack	main shell midden	SFS4-15505		3.1	
otolith	saithe or pollack	main shell midden	SFS4-15506		3.68	
otolith	saithe or pollack	main shell midden	SFS4-15507		2.97	
otolith	saithe or pollack	main shell midden	SFS4-15514		3.74	
otolith	saithe or pollack	main shell midden	SFS4-15515		2.44	
otolith	saithe or pollack	main shell midden	SFS4-15517		2.48	
otolith	saithe or pollack	main shell midden	SFS4-15518		3.82	
otolith	saithe or pollack	main shell midden	SFS4-15532		5.18	
otolith	saithe or pollack	main shell midden	SFS4-15537	11.09	3.99	
otolith	saithe or pollack	main shell midden	SFS4-15538		3.36	
otolith	saithe or pollack	main shell midden	SFS4-15539		3.58	
otolith	saithe or pollack	main shell midden	SFS4-15541		2.53	
otolith	saithe or pollack	main shell midden	SFS4-15545		3.56	
otolith	saithe or pollack	main shell midden	SFS4-15549		2.87	
otolith	saithe or pollack	main shell midden	SFS4-15604		3.94	
otolith	saithe or pollack	main shell midden	SFS4-15608		3.98	
otolith	saithe or pollack	main shell midden	SFS4-15610		2.74	
otolith	saithe or pollack	main shell midden	SFS4-15611		2.3	
otolith	saithe or pollack	main shell midden	SFS4-15616		2.49	
otolith	saithe or pollack	main shell midden	SFS4-15621	6.11	2.44	
otolith	saithe or pollack	main shell midden	SFS4-15622		3.9	
otolith	saithe or pollack	main shell midden	SFS4-15555		2.19	
otolith	saithe or pollack	main shell midden	SFS4-15559		3.95	
otolith	saithe or pollack	main shell midden	SFS4-15564	6.49	2.54	
otolith	saithe or pollack	main shell midden	SFS4-15566	7.04	2.76	
otolith	saithe or pollack	main shell midden	SFS4-15568	7.05	2.82	
otolith	saithe or pollack	main shell midden	SFS4-15572	6.6	2.54	
otolith	saithe or pollack	main shell midden	SFS4-15577		2.53	
otolith	saithe or pollack	main shell midden	SFS4-15580		2.66	
otolith	saithe or pollack	main shell midden	SFS4-14529		4.63	
otolith	saithe or pollack	main shell midden	SFS4-14531	5.63	2.16	
otolith	saithe or pollack	main shell midden	SFS4-14537	6.2	2.48	
otolith	saithe or pollack	main shell midden	SFS4-14555		4.7	
otolith	saithe or pollack	main shell midden	SFS4-14556	6.57	2.47	
otolith	saithe or pollack	main shell midden	SFS4-14557		2.41	
otolith	saithe or pollack	main shell midden	SFS4-14558		2.63	
otolith	saithe or pollack	main shell midden	SFS4-14560		3.99	
otolith	saithe or pollack	main shell midden	SFS4-14561		2.77	
otolith	saithe or pollack	main shell midden	SFS4-14562		2.04	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	main shell midden	SFS4-14564		3.66	
otolith	saithe or pollack	main shell midden	SFS4-14565	8.22	2.96	
otolith	saithe or pollack	main shell midden	SFS4-14566		2.36	
otolith	saithe or pollack	main shell midden	SFS4-14568		2.51	
otolith	saithe or pollack	main shell midden	SFS4-14571	8.18	2.98	
otolith	saithe or pollack	main shell midden	SFS4-14542		2.7	
otolith	saithe or pollack	main shell midden	SFS4-14550		2.39	
otolith	saithe or pollack	main shell midden	SFS4-14160		3.86	
otolith	saithe or pollack	main shell midden	SFS4-14161		3.62	
otolith	saithe or pollack	main shell midden	SFS4-14162		3.71	
otolith	saithe or pollack	main shell midden	SFS4-14159		3.76	
otolith	saithe or pollack	main shell midden	SFS4-15371	5.62	2.14	
otolith	saithe or pollack	main shell midden	SFS4-15379	15.86	5.94	
otolith	saithe or pollack	main shell midden	SFS4-15380	15.73	5.68	
otolith	saithe or pollack	main shell midden	SFS4-15385		3.74	
otolith	saithe or pollack	main shell midden	SFS4-14121	13.55	5.3	
otolith	saithe or pollack	main shell midden	SFS4-14122	6.11	2.34	
otolith	saithe or pollack	main shell midden	SFS4-14123		2.25	
otolith	saithe or pollack	main shell midden	SFS4-14100	16.41	6.75	
otolith	saithe or pollack	main shell midden	SFS4-14101	10.19	4.28	
otolith	saithe or pollack	main shell midden	SFS4-14102		3.8	
otolith	saithe or pollack	main shell midden	SFS4-14103	6.44	2.44	
otolith	saithe or pollack	main shell midden	SFS4-14104	6.6	2.88	
otolith	saithe or pollack	main shell midden	SFS4-14105		3.89	
otolith	saithe or pollack	main shell midden	SFS4-14108		3.57	
otolith	saithe or pollack	main shell midden	SFS4-14109		3.6	
otolith	saithe or pollack	main shell midden	SFS4-14110		2.29	
otolith	saithe or pollack	main shell midden	SFS4-14080		3.82	
otolith	saithe or pollack	main shell midden	SFS4-14081	9.39	3.71	
otolith	saithe or pollack	main shell midden	SFS4-14082		3.47	
otolith	saithe or pollack	main shell midden	SFS4-14084		2.6	
otolith	saithe or pollack	main shell midden	SFS4-14086		2.29	
otolith	saithe or pollack	main shell midden	SFS4-14088		3.92	
otolith	saithe or pollack	main shell midden	SFS4-14089		3.57	
otolith	saithe or pollack	main shell midden	SFS4-14090	6.09	2.47	
otolith	saithe or pollack	main shell midden	SFS4-14091		2.27	
otolith	saithe or pollack	main shell midden	SFS4-14067		6.03	
otolith	saithe or pollack	main shell midden	SFS4-14068		3.46	
otolith	saithe or pollack	main shell midden	SFS4-14069		3.52	
otolith	saithe or pollack	main shell midden	SFS4-14070	9.33	3.47	
otolith	saithe or pollack	main shell midden	SFS4-14008	10.16	3.66	
otolith	saithe or pollack	main shell midden	SFS4-14009		3.47	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	main shell midden	SFS4-14011	9.52	3.93	
otolith	saithe or pollack	main shell midden	SFS4-14012	8.64	3.44	
otolith	saithe or pollack	main shell midden	SFS4-14013		2.39	
otolith	saithe or pollack	main shell midden	SFS4-14014		3.3	
otolith	saithe or pollack	main shell midden	SFS4-14006	7.2	2.67	
otolith	saithe or pollack	main shell midden	SFS4-14007		3.36	
otolith	saithe or pollack	main shell midden	SFS4-15419	7.36	2.7	
otolith	saithe or pollack	main shell midden	SFS4-13981	12.35	4.97	
otolith	saithe or pollack	main shell midden	SFS4-13984	6.61	2.69	
otolith	saithe or pollack	main shell midden	SFS4-13985	6.47	2.38	
otolith	saithe or pollack	main shell midden	SFS4-13986		3.11	
otolith	saithe or pollack	main shell midden	SFS4-13987	5.43	2.06	
otolith	saithe or pollack	main shell midden	SFS4-13988		2.17	
otolith	saithe or pollack	main shell midden	SFS4-13992		2.75	
otolith	saithe or pollack	main shell midden	SFS4-13993		3.39	
otolith	saithe or pollack	main shell midden	SFS4-15376	6.05	2.21	
otolith	saithe or pollack	main shell midden	SFS4-15214		2.54	
otolith	saithe or pollack	main shell midden	SFS4-15365	10.13	3.84	
otolith	saithe or pollack	main shell midden	SFS4-15367	5.64	2.21	
otolith	saithe or pollack	main shell midden	SFS4-15352		6.93	
otolith	saithe or pollack	main shell midden	SFS4-15353		5.28	
otolith	saithe or pollack	main shell midden	SFS4-15358		2.67	
otolith	saithe or pollack	main shell midden	SFS4-15312		3.37	
otolith	saithe or pollack	main shell midden	SFS4-15314	6.43	2.56	
otolith	saithe or pollack	main shell midden	SFS4-15317		3.65	
otolith	saithe or pollack	main shell midden	SFS4-15319		2.29	
otolith	saithe or pollack	main shell midden	SFS4-15324		6.51	
otolith	saithe or pollack	main shell midden	SFS4-15325		3.98	
otolith	saithe or pollack	main shell midden	SFS4-15328		4.13	
otolith	saithe or pollack	main shell midden	SFS4-15331		2.69	
otolith	saithe or pollack	main shell midden	SFS4-15335		3.81	
otolith	saithe or pollack	main shell midden	SFS4-15339		3.66	
otolith	saithe or pollack	main shell midden	SFS4-15346	5.84	2.26	
otolith	saithe or pollack	main shell midden	SFS4-15347		2.51	
otolith	saithe or pollack	main shell midden	SFS4-14946		2.81	
otolith	saithe or pollack	main shell midden	SFS4-14952		3.63	
otolith	saithe or pollack	main shell midden	SFS4-14954		2.28	
otolith	saithe or pollack	main shell midden	SFS4-14931	16.22	6.15	
otolith	saithe or pollack	main shell midden	SFS4-14934		2.4	
otolith	saithe or pollack	main shell midden	SFS4-15210	9.88	3.76	
otolith	saithe or pollack	main shell midden	SFS4-14989		3.76	
otolith	saithe or pollack	main shell midden	SFS4-14990		3.78	
otolith	saithe or pollack	main shell midden	SFS4-14991		3.65	
otolith	saithe or pollack	main shell midden	SFS4-14992		3.57	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	main shell midden	SFS4-14993		3.59	
otolith	saithe or pollack	main shell midden	SFS4-14994	11.46	4.71	
otolith	saithe or pollack	main shell midden	SFS4-14996		3.72	
otolith	saithe or pollack	main shell midden	SFS4-14998	8.74	3.34	
otolith	saithe or pollack	main shell midden	SFS4-14999		2	
otolith	saithe or pollack	main shell midden	SFS4-15003	11.05	4.07	
otolith	saithe or pollack	main shell midden	SFS4-15004		3.24	
otolith	saithe or pollack	main shell midden	SFS4-15006		3.54	
otolith	saithe or pollack	main shell midden	SFS4-15009	5.69	2.34	
otolith	saithe or pollack	main shell midden	SFS4-15298		2.28	
otolith	saithe or pollack	main shell midden	SFS4-15025		2.28	
otolith	saithe or pollack	main shell midden	SFS4-15028		3.63	
otolith	saithe or pollack	main shell midden	SFS4-15050		7.61	
otolith	saithe or pollack	main shell midden	SFS4-15051		5.73	
otolith	saithe or pollack	main shell midden	SFS4-15052		5.85	
otolith	saithe or pollack	main shell midden	SFS4-15054		3.47	
otolith	saithe or pollack	main shell midden	SFS4-15055		3.51	
otolith	saithe or pollack	main shell midden	SFS4-15056		4.47	
otolith	saithe or pollack	main shell midden	SFS4-15058		3.48	
otolith	saithe or pollack	main shell midden	SFS4-15059		3.76	
otolith	saithe or pollack	main shell midden	SFS4-15060		3.6	
otolith	saithe or pollack	main shell midden	SFS4-15061		2.53	
otolith	saithe or pollack	main shell midden	SFS4-15063		3.77	
otolith	saithe or pollack	main shell midden	SFS4-15066		2.38	
otolith	saithe or pollack	main shell midden	SFS4-15067		2.5	
otolith	saithe or pollack	main shell midden	SFS4-15068		3.2	
otolith	saithe or pollack	main shell midden	SFS4-15071		2.4	
otolith	saithe or pollack	main shell midden	SFS4-15072	5.88	2.21	
otolith	saithe or pollack	main shell midden	SFS4-15373	5.82	2.27	
otolith	saithe or pollack	organic rich layer	SFS4-14674		3.05	
otolith	saithe or pollack	organic rich layer	SFS4-14667		2.66	
otolith	saithe or pollack	organic rich layer	SFS4-14668		2.23	
otolith	saithe or pollack	sandy soil	SFS4-12120		3.39	
otolith	saithe or pollack	sandy soil	SFS4-12114		3.54	
otolith	saithe or pollack	shell midden	SFS4-14612		2.43	
otolith	saithe or pollack	shell midden	SFS4-14615		3.52	
otolith	saithe or pollack	shell midden	SFS4-14623		3.6	
otolith	saithe or pollack	shell midden	SFS4-14708		4.92	
otolith	saithe or pollack	shell midden	SFS4-14698		3.38	
otolith	saithe or pollack	shell midden	SFS4-14703		3	
otolith	saithe or pollack	shell midden	SFS4-15093	7.12	2.85	
otolith	saithe or pollack	topsoil	SFS4-6793		3.7	
otolith	saithe or pollack	topsoil	SFS4-15034	9.83	3.81	
otolith	saithe or pollack	topsoil	SFS4-15036		3.81	
otolith	saithe or pollack	topsoil	SFS4-15037		2.49	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	topsoil	SFS4-15038		2.27	
otolith	saithe or pollack	topsoil	SFS4-15042		3.57	
otolith	saithe or pollack	topsoil	SFS4-15043		2.44	
otolith	saithe or pollack	topsoil	SFS4-15048		3.52	
otolith	saithe or pollack	topsoil	SFS4-14628		3.19	
otolith	saithe or pollack	topsoil	SFS4-14631		2.7	
otolith	saithe or pollack	topsoil	SFS4-14632		2.61	
otolith	saithe or pollack	topsoil	SFS4-14658		3.78	
otolith	saithe or pollack	topsoil	SFS4-14661		3.61	
otolith	saithe or pollack	topsoil	SFS4-14646		4.02	
otolith	saithe or pollack	topsoil	SFS4-14648		2.73	
otolith	saithe or pollack	topsoil	SFS4-14639		3.53	
otolith	saithe or pollack	topsoil	SFS4-15096		3.89	
otolith	saithe or pollack	topsoil	SFS4-15097		3.02	
otolith	saithe or pollack	topsoil	SFS4-15102		2.39	
otolith	saithe or pollack	topsoil	SFS4-15118		3.39	
otolith	saithe or pollack	topsoil	SFS4-15109		3.19	
otolith	saithe or pollack	topsoil	SFS4-15110		2.4	
otolith	saithe or pollack	topsoil	SFS4-15114		3.26	
otolith	saithe or pollack	topsoil	SFS4-14838		3.52	
otolith	saithe or pollack	topsoil	SFS4-14840		2.71	
otolith	saithe or pollack	topsoil	SFS4-14841		3.58	
otolith	saithe or pollack	topsoil	SFS4-14842		2.34	
otolith	saithe or pollack	topsoil	SFS4-14845		2.39	
otolith	saithe or pollack	topsoil	SFS4-14846		2.68	
otolith	saithe or pollack	topsoil	SFS4-14847	6.29	2.37	
otolith	saithe or pollack	topsoil	SFS4-14848		2.65	
otolith	saithe or pollack	topsoil	SFS4-14849		2.7	
otolith	saithe or pollack	topsoil	SFS4-14851		3.5	
otolith	saithe or pollack	topsoil	SFS4-14853		3.98	
otolith	saithe or pollack	topsoil	SFS4-14857		2.46	
otolith	saithe or pollack	topsoil	SFS4-14858		3.52	
otolith	saithe or pollack	topsoil	SFS4-14862		2.62	
otolith	saithe or pollack	topsoil	SFS4-14864		2.26	
otolith	saithe or pollack	topsoil	SFS4-16046		3.82	
otolith	saithe or pollack	topsoil	SFS4-16047		2.41	
otolith	saithe or pollack	topsoil	SFS4-14499	10.56	4.1	
otolith	saithe or pollack	topsoil	SFS4-14504		3.82	
otolith	saithe or pollack	topsoil	SFS4-14505		2.53	
otolith	saithe or pollack	topsoil	SFS4-14508		3.39	
otolith	saithe or pollack	topsoil	SFS4-14509		2.66	
otolith	saithe or pollack	topsoil	SFS4-14512		2.41	
otolith	saithe or pollack	topsoil	SFS4-15146		3.59	
otolith	saithe or pollack	topsoil	SFS4-15150	6.5	2.65	
otolith	saithe or pollack	topsoil	SFS4-15152		3.41	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	topsoil	SFS4-15386		3.75	
otolith	saithe or pollack	topsoil	SFS4-13925		3.8	
otolith	saithe or pollack	topsoil	SFS4-13926		3.86	
otolith	saithe or pollack	topsoil	SFS4-13929	9.23	3.34	
otolith	saithe or pollack	topsoil	SFS4-13933		3.18	
otolith	saithe or pollack	topsoil	SFS4-13934	9.28	3.71	
otolith	saithe or pollack	topsoil	SFS4-13935		3.56	
otolith	saithe or pollack	topsoil	SFS4-13936		4.02	
otolith	saithe or pollack	topsoil	SFS4-13937		3.48	
otolith	saithe or pollack	topsoil	SFS4-13938	5.95	2.44	
otolith	saithe or pollack	topsoil	SFS4-13939		2.47	
otolith	saithe or pollack	topsoil	SFS4-14020		4.94	
otolith	saithe or pollack	topsoil	SFS4-14021		3.62	
otolith	saithe or pollack	topsoil	SFS4-14022		3.87	
otolith	saithe or pollack	topsoil	SFS4-14023		4.07	
otolith	saithe or pollack	topsoil	SFS4-14025		3.84	
otolith	saithe or pollack	topsoil	SFS4-14028		3.4	
otolith	saithe or pollack	topsoil	SFS4-14029		3.92	
otolith	saithe or pollack	topsoil	SFS4-14031		3.42	
otolith	saithe or pollack	topsoil	SFS4-14032		4.09	
otolith	saithe or pollack	topsoil	SFS4-14036		2.63	
otolith	saithe or pollack	topsoil	SFS4-14037		3.33	
otolith	saithe or pollack	topsoil	SFS4-14038		3.53	
otolith	saithe or pollack	topsoil	SFS4-14041		3.66	
otolith	saithe or pollack	topsoil	SFS4-14042		2.57	
otolith	saithe or pollack	topsoil	SFS4-14044		3.64	
otolith	saithe or pollack	topsoil	SFS4-14045		3.35	
otolith	saithe or pollack	topsoil	SFS4-14046		3.59	
otolith	saithe or pollack	topsoil	SFS4-14048		2.49	
otolith	saithe or pollack	topsoil	SFS4-14049		2.31	
otolith	saithe or pollack	topsoil	SFS4-15158		2.9	
otolith	saithe or pollack	topsoil	SFS4-15166		3.52	
otolith	saithe or pollack	topsoil	SFS4-15170		3.61	
otolith	saithe or pollack	topsoil	SFS4-15171		2.43	
otolith	saithe or pollack	topsoil	SFS4-15186	6.25	2.38	
otolith	saithe or pollack	topsoil	SFS4-15188		3.01	
otolith	saithe or pollack	topsoil	SFS4-15189		2.54	
otolith	saithe or pollack	topsoil	SFS4-15190		3.53	
otolith	saithe or pollack	topsoil	SFS4-15191	10.3 2	3.69	
otolith	saithe or pollack	topsoil	SFS4-15468		3.27	
otolith	saithe or pollack	topsoil	SFS4-15469		3.59	
otolith	saithe or pollack	topsoil	SFS4-15471		3.98	
otolith	saithe or pollack	topsoil	SFS4-15475		3.37	
otolith	saithe or pollack	topsoil	SFS4-15476		2.4	
otolith	saithe or pollack	topsoil	SFS4-15477		2.27	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	topsoil	SFS4-15449		3.22	
otolith	saithe or pollack	topsoil	SFS4-15450		3.82	
otolith	saithe or pollack	topsoil	SFS4-15451		3.38	
otolith	saithe or pollack	topsoil	SFS4-15453		2.97	
otolith	saithe or pollack	topsoil	SFS4-15460	6	2.34	
otolith	saithe or pollack	topsoil	SFS4-15461		2.46	
otolith	saithe or pollack	topsoil	SFS4-13921		3.83	
otolith	saithe or pollack	topsoil	SFS4-14681	6.12	2.33	
otolith	saithe or pollack	topsoil	SFS4-14683		3.44	
otolith	saithe or pollack	topsoil	SFS4-14685	6.1	2.35	
otolith	saithe or pollack	topsoil	SFS4-14690		3.49	
otolith	saithe or pollack	topsoil	SFS4-14603		3.83	
otolith	saithe or pollack	topsoil	SFS4-14593		2.29	
otolith	saithe or pollack	topsoil	SFS4-14594		3.19	
otolith	saithe or pollack	topsoil	SFS4-14595		3.7	
otolith	saithe or pollack	topsoil	SFS4-14596		2.99	
otolith	saithe or pollack	topsoil	SFS4-14598		2.21	
otolith	saithe or pollack	topsoil	SFS4-14577		4.09	
otolith	saithe or pollack	topsoil	SFS4-14578		2.79	
otolith	saithe or pollack	topsoil	SFS4-14581		2.16	
otolith	saithe or pollack	topsoil	SFS4-14587		3.4	
otolith	saithe or pollack	topsoil	SFS4-14589		3.32	
otolith	saithe or pollack	topsoil	SFS4-15390		2.44	
otolith	saithe or pollack	topsoil	SFS4-15391		2.55	
otolith	saithe or pollack	topsoil	SFS4-15395		2.3	
otolith	saithe or pollack	topsoil	SFS4-15300		5.16	
otolith	saithe or pollack	topsoil	SFS4-15301		3.3	
otolith	saithe or pollack	topsoil	SFS4-15473	6.26	2.44	
otolith	saithe or pollack	topsoil	SFS4-15304		3.44	
otolith	saithe or pollack	topsoil	SFS4-13948	16.6	6.54	
otolith	saithe or pollack	topsoil	SFS4-13950		5.12	
otolith	saithe or pollack	topsoil	SFS4-13951	10.28	3.68	
otolith	saithe or pollack	topsoil	SFS4-13952		4.24	
otolith	saithe or pollack	topsoil	SFS4-13955	10.72	4.4	
otolith	saithe or pollack	topsoil	SFS4-13956	10.67	3.77	
otolith	saithe or pollack	topsoil	SFS4-13957	7.57	2.96	
otolith	saithe or pollack	topsoil	SFS4-13958		3.67	
otolith	saithe or pollack	topsoil	SFS4-13963		3.06	
otolith	saithe or pollack	topsoil	SFS4-13964		2.36	
otolith	saithe or pollack	topsoil	SFS4-13965		2.78	
otolith	saithe or pollack	topsoil	SFS4-13966		2.3	
otolith	saithe or pollack	topsoil	SFS4-13968		3.62	
otolith	saithe or pollack	topsoil	SFS4-14981		2.46	
otolith	saithe or pollack	topsoil	SFS4-14982	5.82	2.25	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	topsoil	SFS4-14983		3.4	
otolith	saithe or pollack	topsoil	SFS4-14960		3.62	
otolith	saithe or pollack	topsoil	SFS4-14961		2.91	
otolith	saithe or pollack	topsoil	SFS4-14962	5.87	2.48	
otolith	saithe or pollack	topsoil	SFS4-14971		3.45	
otolith	saithe or pollack	topsoil	SFS4-14972		3.76	
otolith	saithe or pollack	topsoil	SFS4-14975		2.4	
otolith	saithe or pollack	topsoil	SFS4-14957	9.27	3.43	
otolith	saithe or pollack	topsoil	SFS4-15639		4.8	
otolith	saithe or pollack	topsoil	SFS4-15643		3.46	
otolith	saithe or pollack	topsoil	SFS4-15646		2.25	
otolith	saithe or pollack	topsoil	SFS4-15593		2.77	
otolith	saithe or pollack	topsoil	SFS4-15594		3.57	
otolith	saithe or pollack	topsoil	SFS4-15596	5.77	2.12	
otolith	saithe or pollack	topsoil	SFS4-15597		2.37	
otolith	saithe or pollack	topsoil	SFS4-15599		2.34	
otolith	saithe or pollack	topsoil	SFS4-15659		3.62	
otolith	saithe or pollack	topsoil	SFS4-15661		3.56	
otolith	saithe or pollack	topsoil	SFS4-15662		2.69	
otolith	saithe or pollack	topsoil	SFS4-15649		4.59	
otolith	saithe or pollack	topsoil	SFS4-15650		3.53	
otolith	saithe or pollack	topsoil	SFS4-14065		3.19	
otolith	saithe or pollack	topsoil	SFS4-15396		5.65	
otolith	saithe or pollack	topsoil	SFS4-15403		2.97	
otolith	saithe or pollack	topsoil	SFS4-15406	9.33	3.41	
otolith	saithe or pollack	topsoil	SFS4-15407		3.47	
otolith	saithe or pollack	topsoil	SFS4-15409		3.65	
otolith	saithe or pollack	topsoil	SFS4-15410	5.84	2.17	
otolith	saithe or pollack	topsoil	SFS4-15413		2.44	
otolith	saithe or pollack	topsoil	SFS4-14875		2.82	
otolith	saithe or pollack	topsoil	SFS4-14917		4.72	
otolith	saithe or pollack	topsoil	SFS4-14919		3.33	
otolith	saithe or pollack	topsoil	SFS4-14920		2.63	
otolith	saithe or pollack	topsoil	SFS4-14921		2.5	
otolith	saithe or pollack	topsoil	SFS4-14883		3.93	
otolith	saithe or pollack	topsoil	SFS4-14885		4.17	
otolith	saithe or pollack	topsoil	SFS4-14886		2.95	
otolith	saithe or pollack	topsoil	SFS4-14887		2.48	
otolith	saithe or pollack	topsoil	SFS4-14888		2.41	
otolith	saithe or pollack	topsoil	SFS4-14889		3.44	
otolith	saithe or pollack	topsoil	SFS4-14890	6.29	2.61	
otolith	saithe or pollack	topsoil	SFS4-14891	5.72	2.27	
otolith	saithe or pollack	topsoil	SFS4-14892		2.61	
otolith	saithe or pollack	topsoil	SFS4-14894		2.79	
otolith	saithe or pollack	topsoil	SFS4-14897		3.92	
otolith	saithe or pollack	topsoil	SFS4-14901		3.14	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	saithe or pollack	topsoil	SFS4-14903		2.86	
otolith	saithe or pollack	topsoil	SFS4-14905		2.36	
otolith	saithe or pollack	topsoil	SFS4-15677		3.37	
otolith	saithe or pollack	topsoil	SFS4-15678		2.6	
otolith	saithe or pollack	topsoil	SFS4-15679		3.59	
otolith	saithe or pollack	topsoil	SFS4-15682		2.72	
otolith	saithe or pollack	topsoil	SFS4-15637		2.57	
otolith	saithe or pollack	topsoil	SFS4-15638		2.41	
otolith	saithe or pollack	topsoil	SFS4-15667		3.36	
otolith	saithe or pollack	topsoil	SFS4-15668		2.48	
otolith	saithe or pollack	topsoil	SFS4-15670		2.66	
otolith	saithe or pollack	topsoil	SFS4-15671		2.27	
otolith	saithe or pollack	topsoil	SFS4-15674		3.3	
otolith	saithe or pollack	topsoil	SFS4-15675		2.49	
otolith	saithe or pollack	topsoil	SFS4-15631		2.47	
otolith	saithe or pollack	topsoil	SFS4-15420		3.52	
otolith	saithe or pollack	topsoil	SFS4-15421	9.54	3.81	
otolith	saithe or pollack	topsoil	SFS4-15425	6.2	2.35	
otolith	saithe or pollack	topsoil	SFS4-15427		3.86	
otolith	saithe or pollack	topsoil	SFS4-15428		2.64	
otolith	saithe or pollack	topsoil	SFS4-15430		3.3	
otolith	saithe or pollack	topsoil	SFS4-15431		2.77	
otolith	saithe or pollack	topsoil	SFS4-15432		3.5	
otolith	saithe or pollack	topsoil	SFS4-15435		2.37	
otolith	saithe or pollack	topsoil	SFS4-15436		1.98	
otolith	saithe or pollack	unprov	SFS4-15127		3.76	
otolith	saithe or pollack	unprov	SFS4-15129		2.62	
otolith	saithe or pollack	unprov	SFS4-15130		2	
otolith	saithe or pollack	unprov	SFS4-15131		3.51	
otolith	saithe or pollack	unprov	SFS4-15138		2.65	
otolith	saithe or pollack	unprov	SFS4-15140		3.41	
otolith	saithe or pollack	unprov	SFS4-15141		3.51	
otolith	saithe or pollack	unprov	SFS4-15143		2.28	
otolith	cod	main shell midden	SFS4-15263		5.17	
otolith	cod	main shell midden	SFS4-15529		4.8	
otolith	cod	main shell midden	SFS4-15533	10.82	5.12	
otolith	cod	main shell midden	SFS4-15381		4.17	
otolith	cod	main shell midden	SFS4-15378	9.89	4.3	
otolith	cod	main shell midden	SFS4-15323		5.16	
otolith	cod	shell midden	SFS4-14611		4.76	
otolith	cod	topsoil	SFS4-13924	10.2	4.53	
otolith	cod	topsoil	SFS4-14024	11.96	5.19	
otolith	cod, saithe or pollack	main shell midden	SFS4-15282		3.59	
otolith	cod, saithe or pollack	main shell midden	SFS4-15360	11.28	4.82	

Element	Taxon	Context	Bone id	M1	M2	M3
otolith	cod, saithe or pollack	main shell midden	SFS4-14015		2.47	
otolith	cod, saithe or pollack	main shell midden	SFS4-15374		3.6	
otolith	cod, saithe or pollack	main shell midden	SFS4-15332		4.3	
otolith	cod, saithe or pollack	topsoil	SFS4-15116		2.35	
otolith	cod, saithe or pollack	topsoil	SFS4-14033	5.86	2.3	
otolith	cod, saithe or pollack	topsoil	SFS4-15168		4	
otolith	cod, saithe or pollack	topsoil	SFS4-14679		4.69	
otolith	cod, saithe or pollack	topsoil	SFS4-15388		3.52	
otolith	cod, saithe or pollack	topsoil	SFS4-15401		3.39	
otolith	cod, saithe or pollack	topsoil	SFS4-15402		3.98	
otolith	cod, saithe or pollack	topsoil	SFS4-15408		3.48	
otolith	cod, saithe or pollack	topsoil	SFS4-14914		2.34	
otolith	cod, saithe or pollack	topsoil	SFS4-15433	7.62	3.18	
otolith	haddock	main shell midden	SFS4-14158		3.69	
otolith	poor cod	main shell midden	SFS4-14809	8.34	4.38	
otolith	poor cod	main shell midden	SFS4-14810	8.24	4.15	
otolith	poor cod	main shell midden	SFS4-11584		4.37	
otolith	cod family	main shell midden	SFS4-13902		3.06	
otolith	cod family	main shell midden	SFS4-15284		3.56	
otolith	cod family	main shell midden	SFS4-15285	9.68	3.56	
otolith	cod family	main shell midden	SFS4-15286		3.38	
otolith	cod family	main shell midden	SFS4-15287		3.42	
otolith	cod family	main shell midden	SFS4-15288	6.16	2.34	
otolith	cod family	main shell midden	SFS4-15289		2.12	
otolith	cod family	main shell midden	SFS4-15290		2.24	
otolith	cod family	main shell midden	SFS4-14163		2.57	
otolith	cod family	main shell midden	SFS4-15350		2.43	
otolith	cod family	organic rich layer	SFS4-14673		2.08	
premaxilla	saithe	main shell midden	SFS4-1030	3.53		3.76
premaxilla	saithe	main shell midden	SFS4-1031	2.41		3.02
premaxilla	saithe	main shell midden	SFS4-1032	4.05		
premaxilla	saithe	main shell midden	SFS4-1035	4.39		
premaxilla	saithe	main shell midden	SFS4-1036	3.5		4.43
premaxilla	saithe	main shell midden	SFS4-1037	3.19		4.05
premaxilla	saithe	main shell midden	SFS4-1039	3.79		4.41
premaxilla	saithe	main shell midden	SFS4-7203	7.43		
premaxilla	saithe	main shell midden	SFS4-16189	2.93		
premaxilla	saithe	main shell midden	SFS4-593	2.39		
premaxilla	saithe	main shell midden	SFS4-891	2.72		4.13
premaxilla	saithe	main shell midden	SFS4-12184	4.05		
premaxilla	saithe	main shell midden	SFS4-7306	2.6		
premaxilla	saithe	main shell midden	SFS4-6143	3.41		
premaxilla	saithe	main shell midden	SFS4-13373	2.62		
premaxilla	saithe	main shell midden	SFS4-1673	3.43		
premaxilla	saithe	main shell midden	SFS4-7416			4.43

Element	Taxon	Context	Bone id	M1	M2	M3
premaxilla	saithe	main shell midden	SFS4-7417	2.02		2.87
premaxilla	saithe	main shell midden	SFS4-6885	3.77		
premaxilla	saithe	main shell midden	SFS4-6910	3.42		
premaxilla	saithe	main shell midden	SFS4-6911	3.08		
premaxilla	saithe	main shell midden	SFS4-7052	3.16		
premaxilla	saithe	sandy soil	SFS4-7631	2.41		3.83
premaxilla	saithe	topsoil	SFS4-6738	2.45		
premaxilla	saithe	topsoil	SFS4-6739	2.42		
premaxilla	saithe	topsoil	SFS4-6740	2.58		
premaxilla	saithe	topsoil	SFS4-6132	5.25		
premaxilla	saithe	topsoil	SFS4-7155	2.91		
premaxilla	saithe	topsoil	SFS4-7482	2.78		
premaxilla	saithe	topsoil	SFS4-6156	4.13		
premaxilla	saithe	topsoil	SFS4-13295	2.98		
premaxilla	saithe	topsoil	SFS4-13220	3.24		4.37
premaxilla	saithe	topsoil	SFS4-13130	3.05		
premaxilla	pollack	main shell midden	SFS4-1038	2.78		
premaxilla	pollack	main shell midden	SFS4-1040	3.79		
premaxilla	pollack	main shell midden	SFS4-15750	5.13		
premaxilla	pollack	main shell midden	SFS4-888	3.5		
premaxilla	pollack	main shell midden	SFS4-889	3.4		4.02
premaxilla	pollack	main shell midden	SFS4-890	2.45		1.58
premaxilla	pollack	main shell midden	SFS4-2631	2.55		
premaxilla	pollack	main shell midden	SFS4-2924	3.66		4.47
premaxilla	saithe or pollack	main shell midden	SFS4-592	3.3		4.4
premaxilla	saithe or pollack	main shell midden	SFS4-595	1.82		4.35
premaxilla	saithe or pollack	main shell midden	SFS4-598	2.04		
premaxilla	saithe or pollack	main shell midden	SFS4-12234	2.92		
premaxilla	saithe or pollack	main shell midden	SFS4-12350	2.81		
premaxilla	saithe or pollack	main shell midden	SFS4-2690	2.36		3.6
premaxilla	saithe or pollack	main shell midden	SFS4-1220	3.24		3.6
premaxilla	saithe or pollack	main shell midden	SFS4-12961	3.3		
premaxilla	saithe or pollack	organic rich layer	SFS4-2393	3.35		4.34
premaxilla	saithe or pollack	topsoil	SFS4-16093	3.7		
premaxilla	saithe or pollack	topsoil	SFS4-16073	3.05		
premaxilla	saithe or pollack	topsoil	SFS4-7709	3.09		
premaxilla	saithe or pollack	topsoil	SFS4-13242	2.9		
premaxilla	saithe or pollack	topsoil	SFS4-12911	3.27		
premaxilla	cod	main shell midden	SFS4-1029	3.01		2.34
premaxilla	cod	main shell midden	SFS4-887	3.71		3.15
premaxilla	cod	main shell midden	SFS4-766	4.55		
premaxilla	cod	main shell midden	SFS4-2912	4.2		4.91
premaxilla	cod	sandy soil	SFS4-7783	4.41		
premaxilla	cod, saithe or pollack	main shell midden	SFS4-596	1.78		
premaxilla	cod, saithe or pollack	main shell midden	SFS4-886	4.42		
premaxilla	cod, saithe or pollack	main shell midden	SFS4-7305	3.68		

Element	Taxon	Context	Bone id	M1	M2	M3
premaxilla	cod, saithe or pollack	main shell midden	SFS4-1607	3.05		3.48
premaxilla	cod, saithe or pollack	main shell midden	SFS4-2847	2.9		
premaxilla	cod, saithe or pollack	main shell midden	SFS4-15704	3.7		
premaxilla	cod, saithe or pollack	sandy soil	SFS4-7782	2.75		
premaxilla	cod, saithe or pollack	sandy soil	SFS4-7632	2.93		
premaxilla	whiting	main shell midden	SFS4-1761	2.42		3.7
premaxilla	cod family	main shell midden	SFS4-600	0.93		
premaxilla	cod family	main shell midden	SFS4-706	3.51		
premaxilla	cod family	main shell midden	SFS4-770	4.18		
premaxilla	cod family	main shell midden	SFS4-2880	4.23		
premaxilla	corkwing	main shell midden	SFS4-591	2.65		
premaxilla	ballan wrasse	main shell midden	SFS4-15833	3.88		
premaxilla	ballan wrasse	main shell midden	SFS4-901	7.23		
premaxilla	ballan wrasse	main shell midden	SFS4-1619	3.58		
premaxilla	ballan wrasse	sandy soil	SFS4-6310	6.09	28.46	
premaxilla	wrasse family	main shell midden	SFS4-1272	2.2	8.42	6.07
premaxilla	wrasse family	main shell midden	SFS4-986	3.07		
premaxilla	wrasse family	main shell midden	SFS4-1581	3.22		
premaxilla	wrasse family	main shell midden	SFS4-1582	3.53	17.38	11.37
premaxilla	wrasse family	main shell midden	SFS4-6045	2.42	9.62	
premaxilla	wrasse family	main shell midden	SFS4-1741	4.15		
premaxilla	wrasse family	main shell midden	SFS4-1118	3.72		
premaxilla	wrasse family	main shell midden	SFS4-1082	5.07		
premaxilla	wrasse family	main shell midden	SFS4-1542	3.09		
premaxilla	wrasse family	main shell midden	SFS4-1301	12.47		
premaxilla	wrasse family	topsoil	SFS4-16212	2.34		
quadrate	saithe	main shell midden	SFS4-7206	4.09		
quadrate	saithe	main shell midden	SFS4-12177	3.29		
quadrate	saithe	main shell midden	SFS4-7312	3.96		
quadrate	saithe	main shell midden	SFS4-6148	3.25		
quadrate	saithe	main shell midden	SFS4-15783	4.26		
quadrate	saithe	main shell midden	SFS4-7368	3.84		
quadrate	saithe	main shell midden	SFS4-6909	2.29		
quadrate	saithe	main shell midden	SFS4-7069	2.09		
quadrate	saithe	topsoil	SFS4-6697	3.57		
quadrate	saithe	topsoil	SFS4-7193	6.13		
quadrate	saithe	topsoil	SFS4-7134	3.75		
quadrate	saithe	topsoil	SFS4-6129	3.07		
quadrate	saithe	topsoil	SFS4-6130	3.61		
quadrate	saithe	topsoil	SFS4-6155	4.09		
quadrate	saithe	topsoil	SFS4-6167	2.92		
quadrate	saithe	topsoil	SFS4-6578	2.51		
quadrate	pollack	main shell midden	SFS4-2767	3.2		
quadrate	cod	main shell midden	SFS4-7201	10.0		

Element	Taxon	Context	Bone id	M1	M2	M3
				5		
quadrate	cod	main shell midden	SFS4-12415	3.67		
quadrate	cod	main shell midden	SFS4-7311	2.76		
quadrate	cod	topsoil	SFS4-16034	5.28		
quadrate	cod	topsoil	SFS4-13716	3.23		
quadrate	cod, saithe or pollack	main shell midden	SFS4-16344	2.69		
quadrate	cod, saithe or pollack	topsoil	SFS4-7763	2.9		
quadrate	cod family	main shell midden	SFS4-6141	2.6		
quadrate	cod family	main shell midden	SFS4-6149	3.99		
quadrate	cod family	topsoil	SFS4-6826	2.22		
quadrate	corkwing	main shell midden	SFS4-1369	2.04		
quadrate	corkwing	main shell midden	SFS4-1720	2.42		
quadrate	ballan wrasse	main shell midden	SFS4-12230	4.62		
quadrate	ballan wrasse	main shell midden	SFS4-12231	4.96		
quadrate	ballan wrasse	main shell midden	SFS4-6200	6.77		
quadrate	ballan wrasse	main shell midden	SFS4-16200	4.87		
quadrate	ballan wrasse	main shell midden	SFS4-2804	6.2		
quadrate	ballan wrasse	main shell midden	SFS4-12734	3.96		
quadrate	ballan wrasse	main shell midden	SFS4-12319	5.99		
quadrate	ballan wrasse	main shell midden	SFS4-6673	3.32		
quadrate	ballan wrasse	main shell midden	SFS4-1063	4.83		
quadrate	ballan wrasse	main shell midden	SFS4-12967	3.7		
quadrate	ballan wrasse	main shell midden	SFS4-7097	5.81		
quadrate	ballan wrasse	organic rich layer	SFS4-2219	4.7		
quadrate	ballan wrasse	shell midden	SFS4-6236	4.42		
quadrate	ballan wrasse	topsoil	SFS4-6719	3.85		
quadrate	ballan wrasse	topsoil	SFS4-6720	3.67		
quadrate	ballan or cuckoo wrasse	main shell midden	SFS4-12315	2.11		
quadrate	wrasse family	main shell midden	SFS4-1278	4.65		
quadrate	wrasse family	main shell midden	SFS4-605	3.71		
quadrate	wrasse family	main shell midden	SFS4-11989	2.3		
quadrate	wrasse family	main shell midden	SFS4-2854	4.22		
quadrate	wrasse family	main shell midden	SFS4-12203	2.59		
quadrate	wrasse family	main shell midden	SFS4-6201	2.26		
quadrate	wrasse family	main shell midden	SFS4-7252	2.2		
quadrate	wrasse family	main shell midden	SFS4-7666	2.31		
quadrate	wrasse family	main shell midden	SFS4-11880	3.31		
quadrate	wrasse family	main shell midden	SFS4-11899	2.65		
quadrate	wrasse family	main shell midden	SFS4-1606	2.05		
quadrate	wrasse family	main shell midden	SFS4-1287	4.18		
quadrate	wrasse family	main shell midden	SFS4-1245	4.11		
quadrate	wrasse family	main shell midden	SFS4-1117	3.59		
quadrate	wrasse family	main shell midden	SFS4-1143	3.08		
quadrate	wrasse family	main shell midden	SFS4-1505	2.88		
quadrate	wrasse family	main shell midden	SFS4-12312	3.03		
quadrate	wrasse family	main shell midden	SFS4-12314	2.52		
quadrate	wrasse family	main shell midden	SFS4-1348	3.15		

Element	Taxon	Context	Bone id	M1	M2	M3
quadrate	wrasse family	main shell midden	SFS4-2873	3.66		
quadrate	wrasse family	organic rich layer	SFS4-2244	3.53		
quadrate	wrasse family	organic rich layer	SFS4-2158	2.88		
quadrate	wrasse family	sandy soil	SFS4-6249	3.08		
quadrate	wrasse family	sandy soil	SFS4-6291	1.63		
quadrate	wrasse family	shell midden	SFS4-7594	3.5		
quadrate	wrasse family	topsoil	SFS4-6700	4.75		
quadrate	wrasse family	topsoil	SFS4-12960	2.37		
quadrate	wrasse family	topsoil	SFS4-6230	2.47		
quadrate	wrasse family	topsoil	SFS4-6205	3.06		
scapula	ballan wrasse	main shell midden	SFS4-12322	2.61		
scapula	ballan or cuckoo wrasse	main shell midden	SFS4-12245	2.17		
scapula	ballan or cuckoo wrasse	main shell midden	SFS4-12196	2.04		
scapula	ballan or cuckoo wrasse	main shell midden	SFS4-12342	2.36		
scapula	wrasse family	main shell midden	SFS4-13378	1.58		
scapula	wrasse family	main shell midden	SFS4-12356	2.06		
scapula	wrasse family	main shell midden	SFS4-7396	1.53		
scapula	wrasse family	main shell midden	SFS4-6182	1.74		
scapula	wrasse family	sandy soil	SFS4-7819	2.05		
scapula	wrasse family	sandy soil	SFS4-6277	1.92		
scapula	wrasse family	topsoil	SFS4-7712	1.54		

Appendix 4. **Latin names for Sand taxa mentioned in text**

Common name	Latin name
Mammal	
whale sp.	unidentified whale
dog or wolf	*Canis* sp.
fox	*Vulpes vulpes*
dog family	Canidae
badger	*Meles meles*
otter	*Lutra lutra*
seal sp.	unidentified seal
wild boar	*Sus scrofa*
red deer	*Cervus elaphus*
roe deer	*Capreolus capreolus*
deer family	Cervidae
Bos sp.	
sheep	*Ovis aries*
sheep or goat	Caprine
large mammal	
medium mammal 1	
medium mammal 2	
unidentified mammal	
Small mammal and amphibian	
common shrew	*Sorex araneus*
pygymy shrew	*Sorex minutes*
shrew sp.	*Sorex* sp.
bank vole	*Clethrionomys glareolus*
field vole	*Microtus agrestis*
vole sp.	unidentified vole
wood mouse	*Apodemus sylvaticus*
yellow-necked mouse	*Apodemus flavicollis*
mouse sp.	*Murinae*
vole or mouse	unidentified vole or mouse
small mammal	
common frog	*Rana temporaria*
Bird	
cormorant or shag	*Phalacrocorax carbo/aristotelis*
razorbill	*Alca torda*
guillemot	*Uria aalge*
razorbill or guillemot	*Alca torda/Uria aalge*
little auk	*Alle alle*
puffin?	*Fratercula arctica?*
great auk	*Pinguinus impennis*
auk family	Alcidae
thrush and chat family	Turdidae
unidentified bird	

Common name	Latin name
Fish	
tope shark	*Galeorhinus galeus*
dogfish families	Scyliorhinidae/Squalidae
ray family	Rajidae
elasmobranch	Elasmobranch
herring	*Clupea harengus*
eel	*Anguilla Anguilla*
conger eel	*Conger conger*
salmon family	Salmonidae
rockling sp.	*Ciliata/Gaidropsarus*
saithe	*Pollchius virens*
pollack	*Pollachius pollachius*
saithe or pollack	*Pollachius*
cod	*Gadus morhua*
cod, saithe or pollack	*Gadus/Pollachius*
haddock	*Melanogrammus aeglefinus*
whiting	*Merlangius merlangus*
poor cod	*Trisopterus minutes*
Norway pout, bib or poor cod	*Trisopterus*
cod family	Gadidae
gurnard family	Triglidae
sea scorpion family	Cottidae
Atlantic horse mackerel	*Trachurus trachurus*
sea bream family	Sparidae
sea bream family?	Sparidae?
corkwing wrasse	*Symphodus (Crenilabrus) melops*
goldsinny	*Ctenolabrus rupestris*
corkwing wrasse or goldsinny	*Symphodus (Crenilabrus) melops/ Ctenolabrus rupestris*
ballan wrasse	*Labrus bergylta*
cuckoo wrasse	*Labrus bimaculatus*
ballan wrasse or cuckoo wrasse	*Labrus bergylta/ Labrus bimaculatus*
wrasse family	Labridae
eelpout	Zoarcidae
butterfish	*Pholis gunnellus*
sandeel family	Ammodytidae
Atlantic mackerel	*Scomber scrombus*
perch order	Perciformes
plaice	*Pleuronectes platessa*
plaice family	Pleuronectidae
flatfish order	Heterosomata (Pleuronectiformes)
unidentified fish	

Appendix 5. **Estimated total length of saithe, pollack and *Pollachius* based on otolith measurement 2 from the Sand main shell midden contexts**

otolith M2	total length estimate
6.31	663.81
3.77	300.31
3.58	277.32
3.89	315.15
3.61	280.91
3.8	304.00
3.45	261.96
4.19	353.35
3.46	263.13
3.05	216.68
3.2	233.31
4.7	421.73
2.34	144.08
2.35	145.03
3.16	228.83
3.35	250.36
2.53	162.48
2.43	152.70
2.32	142.18
4.97	459.61
2.69	178.57
2.38	147.89
3.11	223.28
2.06	118.40
2.17	128.28
2.75	184.74
3.39	254.98
2.67	176.53
3.36	251.51
3.66	286.92
3.47	264.31
3.93	320.16
3.44	260.80
2.39	148.84
3.3	244.63
6.03	619.00
3.46	263.13
3.52	270.19
3.47	264.31
3.82	306.46
3.71	292.98

otolith M2	total length estimate
3.47	264.31
2.6	169.46
2.29	139.36
3.92	318.90
3.57	276.13
2.47	156.59
2.27	137.49
6.75	736.42
4.28	365.11
3.8	304.00
2.44	153.67
2.88	198.36
3.89	315.15
3.57	276.13
3.6	279.71
2.29	139.36
5.3	507.44
2.34	144.08
2.25	135.63
3.91	317.65
3.72	294.20
3.45	261.96
3.74	296.63
3.27	241.21
3.44	260.80
3.51	269.01
3.76	299.08
3.34	249.21
3.16	228.83
2.37	146.93
3.76	299.08
3.86	311.42
3.62	282.11
3.71	292.98
4.63	412.09
2.16	127.37
2.48	157.56
2.7	179.60
2.39	148.84
4.7	421.73
2.47	156.59
2.41	150.77
2.63	172.48
3.99	327.72
2.77	186.82
2.04	116.64
3.66	286.92

otolith M2	total length estimate
2.96	206.91
2.36	145.98
2.51	160.51
2.98	209.07
3.12	224.39
7.14	802.96
6.54	701.44
3.85	310.18
4.32	370.38
3.64	284.51
3.35	250.36
3.34	249.21
2.32	142.18
3.53	271.38
4.37	377.00
3.51	269.01
4.09	340.45
4.09	340.45
4.11	343.02
3.99	327.72
3.88	313.91
3.2	233.31
2.55	164.46
2.63	172.48
3.92	318.90
3.75	297.86
3.25	238.95
2.91	201.56
3.23	236.69
2.17	128.28
3.81	305.23
3.33	248.06
2.62	171.47
2.53	162.48
2.37	146.93
3.28	242.35
2.87	197.31
2.6	169.46
2.66	175.52
2.58	167.45
2.27	137.49
3.82	306.46
2.48	157.56
2.65	174.50
2.3	140.30
2.82	192.04
2.67	176.53

otolith M2	total length estimate
2.48	157.56
2.95	205.84
2.97	207.99
2.66	175.52
3.34	249.21
2.46	155.61
2.41	150.77
6.15	638.07
2.4	149.80
2.81	190.99
3.63	283.31
2.28	138.43
3.76	299.08
3.78	301.53
3.65	285.71
3.57	276.13
3.59	278.51
4.71	423.11
3.72	294.20
3.34	249.21
2	113.13
4.07	337.89
3.24	237.82
3.54	272.56
2.34	144.08
2.28	138.43
3.63	283.31
7.61	885.79
5.73	572.21
5.85	590.77
3.47	264.31
3.51	269.01
4.47	390.37
3.48	265.48
3.76	299.08
3.6	279.71
2.53	162.48
3.77	300.31
2.38	147.89
2.5	159.52
3.2	233.31
2.4	149.80
2.21	131.94
3.57	276.13
5.7	567.61
3.74	296.63
2.45	154.64

otolith M2	total length estimate
3.36	251.51
3.68	289.34
3.76	299.08
2.54	163.47
2.44	153.67
3.58	277.32
3.62	282.11
3.24	237.82
3.39	254.98
2.78	187.86
3.31	245.77
2.94	204.76
2.28	138.43
3.46	263.13
3.41	257.30
3.94	321.41
3.39	254.98
2.56	165.46
3.36	251.51
2.56	165.46
2.67	176.53
2.78	187.86
3.56	274.94
3.56	274.94
2.49	158.54
3.64	284.51
3.33	248.06
3.57	276.13
2.55	164.46
2.35	145.03
3.91	317.65
2.38	147.89
2.28	138.43
2.28	138.43
3.37	252.67
2.56	165.46
3.65	285.71
2.29	139.36
6.51	696.49
3.98	326.45
4.13	345.59
2.69	178.57
3.81	305.23
3.66	286.92
2.26	136.56
2.51	160.51
6.93	766.88

otolith M2	total length estimate
5.28	504.49
2.67	176.53
3.51	269.01
3.84	308.94
2.21	131.94
2.14	125.56
2.27	137.49
2.21	131.94
2.29	139.36
5.94	604.83
5.68	564.54
3.74	296.63
2.7	179.60
5.02	466.75
4.19	353.35
4.92	452.51
4.07	337.89
4.12	344.30
5.12	481.14
2.91	201.56
3.44	260.80
2.6	169.46
3.7	291.76
3.27	241.21
2.88	198.36
2.79	188.90
3.34	249.21
2.11	122.86
3.1	222.18
3.68	289.34
2.97	207.99
3.74	296.63
2.44	153.67
2.48	157.56
3.82	306.46
5.18	489.86
3.99	327.72
3.36	251.51
3.58	277.32
2.53	162.48
3.56	274.94
2.87	197.31
2.19	130.10
3.95	322.67
2.54	163.47
2.76	185.78
2.82	192.04

otolith M2	total length estimate
2.54	163.47
2.53	162.48
2.66	175.52
3.94	321.41
3.98	326.45
2.74	183.71
2.3	140.30
2.49	158.54
2.44	153.67
3.9	316.40
5.2	492.77
3.84	308.94
3.81	305.23
4.08	339.17
3.44	260.80
3.7	291.76
4.12	344.30
3.49	266.66
4.02	331.52
3.45	261.96
3.99	327.72
3.22	235.56
3.37	252.67
3.29	243.49
3.61	280.91
3.39	254.98
3.99	327.72
3.64	284.51
3.28	242.35
2.46	155.61

Appendix 6. **Cnoc Sligeach reanalysis estimated total length and otolith measurements *Pollachius***

Sample	Recovery	otolith M2	log TL	est TL
CSLIG-B31	2-4	3.38	2.404532	253.8234
CSLIG-B31	2-4	3.45	2.418241	261.9639
CSLIG-B31	2-4	3.6	2.446706	279.7086
CSLIG-B31	2-4	5.53	2.733797	541.7472
CSLIG-B31	2-4	1.82	1.99051	97.83853
CSLIG-B31	2-4	2.71	2.256773	180.6229
CSLIG-B31	2-4	2.22	2.123384	132.8567
CSLIG-B31	2-4	3.65	2.455931	285.7137
CSLIG-B31	2-4	2.63	2.236732	172.4773
CSLIG-B30	2-4	2.29	2.144147	139.3627
CSLIG-B30	2-4	2.43	2.183834	152.6981
CSLIG-B30	2-4	2.43	2.183834	152.6981
CSLIG-B30	2-4	2.15	2.101955	126.4606
CSLIG-B30	2-4	2.3	2.147061	140.301
CSLIG-B30	2-4	2.1	2.086218	121.9601
CSLIG-B30	2-4	2.26	2.135327	136.5611
CSLIG-B30	2-4	2.09	2.083025	121.0669
CSLIG-B30	2-4	2.21	2.120364	131.9362
CSLIG-B30	2-4	2.37	2.167112	146.9307
CSLIG-B30	2-4	2.26	2.135327	136.5611
CSLIG-B30	2-4	2.13	2.095705	124.6535
CSLIG-B30	2-4	3.56	2.439233	274.9369
CSLIG-B30	2-4	3.41	2.410442	257.3012
CSLIG-B30	2-4	3.59	2.444845	278.513
CSLIG-B30	2-4	3.61	2.448561	280.906
CSLIG-B30	2-4	3.3	2.388511	244.631
CSLIG-B30	2-4	3.27	2.382404	241.2146
CSLIG-B30	2-4	3.31	2.390535	245.7735
CSLIG-B30	2-4	2.62	2.234184	171.4684
CSLIG-B30	2-4	2.45	2.189316	154.6378
CSLIG-B30	2-4	3.62	2.450411	282.1053
CSLIG-B30	2-4	3.98	2.51382	326.4524
CSLIG-B30	2-4	3.47	2.422107	264.3062
CSLIG-B30	2-4	3.74	2.472222	296.6349
CSLIG-B29	2-4	2.31	2.149962	141.2415
CSLIG-B29	2-4	2.53	2.210806	162.4821
CSLIG-B29	2-4	2.16	2.105059	127.3675
CSLIG-B29	2-4	2.51	2.205498	160.5083
CSLIG-B29	2-4	2.36	2.164284	145.977
CSLIG-B29	2-4	3.69	2.463221	290.5498
CSLIG-B29	2-4	2.39	2.172733	148.8445
CSLIG-B29	2-4	3.18	2.363738	231.0669
CSLIG-B29	2-4	3.5	2.427865	267.8334
CSLIG-B29	2-4	3.39	2.406508	254.9808
CSLIG-B29	2-4	3.59	2.444845	278.513

Sample	Recovery	otolith M2	log TL	est TL
CSLIG-B29	2-4	3.51	2.429773	269.0128
CSLIG-B29	2-4	3.11	2.348851	223.2806
CSLIG-B29	2-4	2.34	2.158592	144.0763
CSLIG-B29	2-4	3.47	2.422107	264.3062
CSLIG-B29	2-4	2.49	2.200147	158.543
CSLIG-B29	2-4	3.32	2.392553	246.9179
CSLIG-B29	2-4	3.98	2.51382	326.4524
CSLIG-B29	2-4	3.33	2.394564	248.0642
CSLIG-B29	2-4	1.94	2.033215	107.948
CSLIG-B31	2-4	3.48	2.424032	265.4801
CSLIG-B31	2-4	3.32	2.392553	246.9179
CSLIG-B31	2-4	3.22	2.372098	235.5581
CSLIG-B31	2-4	3.02	2.329211	213.408
CSLIG-B31	2-4	3.42	2.4124	258.4641
CSLIG-B31	2-4	3.44	2.4163	260.7954
CSLIG-B31	2-4	2.92	2.30669	202.6234
CSLIG-B31	2-4	2.75	2.266572	184.7449
CSLIG-B31	2-4	2.57	2.221297	166.4551
CSLIG-B31	2-4	2.3	2.147061	140.301
CSLIG-B31	2-4	2.29	2.144147	139.3627
CSLIG-B31	2-4	2.32	2.152851	142.1843
CSLIG-B31	2-4	2.12	2.092557	123.7534
CSLIG-B31	2-4	2.38	2.169929	147.8865
CSLIG-B31	2-4	3.62	2.450411	282.1053
CSLIG-B28	2-4	3.36	2.400562	251.5142
CSLIG-B28	2-4	3.53	2.433573	271.377
CSLIG-B28	2-4	3.61	2.448561	280.906
CSLIG-B28	2-4	3.62	2.450411	282.1053
CSLIG-B28	2-4	2.58	2.223894	167.4535
CSLIG-B28	2-4	2.75	2.266572	184.7449
CSLIG-B28	2-4	2.36	2.164284	145.977
CSLIG-B28	2-4	2.5	2.202828	159.5246
CSLIG-B28	2-4	2.45	2.189316	154.6378
CSLIG-B28	2-4	1.86	2.00505	101.1696
CSLIG-B28	2-4	2.87	2.295138	197.305
CSLIG-B28	2-4	1.94	2.033215	107.948
CSLIG-B28	2-4	2.44	2.18658	153.6669
CSLIG-B28	2-4	2.21	2.120364	131.9362
CSLIG-B28	2-4	3.39	2.406508	254.9808
CSLIG-B28	2-4	3.56	2.439233	274.9369
CSLIG-B28	2-4	3.56	2.439233	274.9369
CSLIG-B28	2-4	1.83	1.994175	98.66763
CSLIG-B28	2-4	2.37	2.167112	146.9307
CSLIG-B28	2-4	3.58	2.44298	277.3192
CSLIG-B28	2-4	2.74	2.264136	183.7113
CSLIG-B28	2-4	2.58	2.223894	167.4535
CSLIG-B28	2-4	3.9	2.500239	316.4022
CSLIG-B28	2-4	3.62	2.450411	282.1053
CSLIG-B28	2-4	3.03	2.331422	214.4972

Sample	Recovery	otolith M2	log TL	est TL
CSLIG-B28	2-4	3.42	2.4124	258.4641
CSLIG-B32	2-4	3.41	2.410442	257.3012
CSLIG-B32	2-4	3.55	2.437352	273.7484
CSLIG-B32	2-4	3.78	2.479337	301.5348
CSLIG-B32	2-4	2.33	2.155728	143.1292
CSLIG-B32	2-4	3.43	2.414353	259.6288
CSLIG-B32	2-4	3.91	2.501952	317.6524
CSLIG-B32	2-4	3.62	2.450411	282.1053
CSLIG-B32	2-4	3.43	2.414353	259.6288
CSLIG-B32	2-4	2.26	2.135327	136.5611
CSLIG-B32	2-4	2.28	2.14122	138.4266
CSLIG-B32	2-4	2.31	2.149962	141.2415
CSLIG-B31	1/8	3.49	2.425951	266.6559
CSLIG-B31	1/8	3.86	2.493344	311.4185
CSLIG-B31	1/8	3.45	2.418241	261.9639
CSLIG-B31	1/8	3.85	2.49161	310.177
CSLIG-B31	1/8	3.99	2.515498	327.7165
CSLIG-B31	1/8	4.7	2.625031	421.7263
CSLIG-B31	1/8	3.64	2.454096	284.5091
CSLIG-B31	1/8	3.65	2.455931	285.7137
CSLIG-B31	1/8	3.68	2.461406	289.3381
CSLIG-B30	1/8	3.81	2.484624	305.2281
CSLIG-B30	1/8	3.61	2.448561	280.906
CSLIG-B30	1/8	3.64	2.454096	284.5091
CSLIG-B30	1/8	3.88	2.496801	313.9069
CSLIG-B30	1/8	3.6	2.446706	279.7086
CSLIG-B30	1/8	3.48	2.424032	265.4801
CSLIG-B30	1/8	3.52	2.431676	270.194
CSLIG-B30	1/8	3.43	2.414353	259.6288
CSLIG-B30	1/8	3.64	2.454096	284.5091
CSLIG-B30	1/8	3.28	2.384446	242.3515
CSLIG-B30	1/8	3.63	2.452256	283.3063
CSLIG-B30	1/8	3.74	2.472222	296.6349
CSLIG-B30	1/8	4.16	2.543404	349.465
CSLIG-B30	1/8	3.74	2.472222	296.6349
CSLIG-B30	1/8	3.32	2.392553	246.9179
CSLIG-B30	1/8	4.86	2.64742	444.0377
CSLIG-B30	1/8	5.85	2.77142	590.7722
CSLIG-B30	1/8	5.5	2.730159	537.2279
CSLIG-B29	1/8	3.85	2.49161	310.177
CSLIG-B29	1/8	3.78	2.479337	301.5348
CSLIG-B29	1/8	3.82	2.486378	306.4627
CSLIG-B29	1/8	4.06	2.52713	336.6124
CSLIG-B29	1/8	3.65	2.455931	285.7137
CSLIG-B29	>1	2.14	2.098837	125.5559
CSLIG-B29	>1	1.97	2.043478	110.5294
CSLIG-B29	>1	2.17	2.108148	128.2768
CSLIG-B29	>1	1.67	1.932983	85.7005
CSLIG-B29	>1	2.1	2.086218	121.9601

Sample	Recovery	otolith M2	log TL	est TL
CSLIG-B29	>1	2.21	2.120364	131.9362
CSLIG-B29	>1	2	2.053586	113.1322
CSLIG-B29	>1	1.84	1.997819	99.49917
CSLIG-B29	>1	1.85	2.001444	100.3332
CSLIG-B29	>1	2.04	2.06683	116.6354
CSLIG-B29	>1	1.93	2.029758	107.0923
CSLIG-B29	>1	1.59	1.900152	79.46055
CSLIG-B29	>1	1.88	2.012203	102.8497
CSLIG-B29	>1	1.79	1.979394	95.36602
CSLIG-B29	>1	2.09	2.083025	121.0669
CSLIG-B29	>1	2.17	2.108148	128.2768
CSLIG-B29	>1	1.61	1.908512	81.005
CSLIG-B29	>1	1.89	2.015751	103.6934
CSLIG-B29	>1	2.29	2.144147	139.3627
CSLIG-B29	>1	2.21	2.120364	131.9362
CSLIG-B29	>1	1.71	1.948814	88.88204
CSLIG-B29	>1	2.08	2.079818	120.1759
CSLIG-B29	>1	2.16	2.105059	127.3675
CSLIG-B29	>1	2.11	2.089395	122.8556
CSLIG-B29	>1	1.79	1.979394	95.36602
CSLIG-B29	>1	1.6	1.904345	80.23147
CSLIG-B29	>1	2.03	2.063544	115.7561
CSLIG-B29	>1	2.19	2.114284	130.102
CSLIG-B29	>1	1.74	1.960446	91.29476
CSLIG-B29	>1	2.4	2.175525	149.8047
CSLIG-B31	>1	2.1	2.086218	121.9601
CSLIG-B31	>1	1.82	1.99051	97.83853
CSLIG-B31	>1	1.94	2.033215	107.948
CSLIG-B31	>1	1.83	1.994175	98.66763
CSLIG-B31	>1	2.18	2.111223	129.1882
CSLIG-B31	>1	2.33	2.155728	143.1292
CSLIG-B31	>1	2.23	2.126389	133.7795
CSLIG-B31	>1	2.2	2.117331	131.018
CSLIG-B31	>1	2.23	2.126389	133.7795
CSLIG-B31	>1	2.61	2.231626	170.4615
CSLIG-B31	>1	1.95	2.036653	108.8061
CSLIG-B31	>1	2.21	2.120364	131.9362
CSLIG-B31	>1	2.29	2.144147	139.3627
CSLIG-B31	>1	1.88	2.012203	102.8497
CSLIG-B31	>1	2	2.053586	113.1322
CSLIG-B31	>1	2.04	2.06683	116.6354
CSLIG-B31	>1	1.88	2.012203	102.8497
CSLIG-B31	>1	1.91	2.022791	105.3881
CSLIG-B31	>1	2.11	2.089395	122.8556
CSLIG-B28	>1	2.19	2.114284	130.102
CSLIG-B28	>1	2.12	2.092557	123.7534
CSLIG-B28	>1	1.85	2.001444	100.3332
CSLIG-B28	>1	2.07	2.076594	119.2873
CSLIG-B28	>1	2.11	2.089395	122.8556

Sample	Recovery	otolith M2	log TL	est TL
CSLIG-B28	>1	1.89	2.015751	103.6934
CSLIG-B28	>1	2.37	2.167112	146.9307
CSLIG-B28	>1	2.27	2.13828	137.4928
CSLIG-B28	>1	2.04	2.06683	116.6354
CSLIG-B28	>1	2.25	2.132361	135.6317
CSLIG-B28	>1	2.35	2.161445	145.0255
CSLIG-B28	>1	2.07	2.076594	119.2873
CSLIG-B28	>1	2.06	2.073356	118.401
CSLIG-B28	>1	1.75	1.964279	92.10402
CSLIG-B28	>1	1.78	1.975647	94.54679
CSLIG-B28	>1	1.96	2.040074	109.6666
CSLIG-B28	>1	2.22	2.123384	132.8567
CSLIG-B28	>1	2.37	2.167112	146.9307
CSLIG-B28	>1	2.06	2.073356	118.401
CSLIG-B28	>1	2.06	2.073356	118.401
CSLIG-B28	>1	2.02	2.060241	114.8791
CSLIG-B28	>1	1.64	1.92086	83.34116
CSLIG-B28	>1	1.9	2.019281	104.5395
CSLIG-B30	>1	1.85	2.001444	100.3332
CSLIG-B30	>1	1.8	1.98312	96.18773
CSLIG-B30	>1	2.1	2.086218	121.9601
CSLIG-B30	>1	2.14	2.098837	125.5559
CSLIG-B30	>1	2.21	2.120364	131.9362
CSLIG-B30	>1	2.36	2.164284	145.977
CSLIG-B30	>1	2.28	2.14122	138.4266
CSLIG-B30	>1	2.09	2.083025	121.0669
CSLIG-B30	>1	1.95	2.036653	108.8061
CSLIG-B30	>1	1.99	2.050234	112.2622
CSLIG-B30	>1	1.92	2.026284	106.239
CSLIG-B30	>1	1.97	2.043478	110.5294
CSLIG-B30	>1	1.77	1.971879	93.73005
CSLIG-B30	>1	2.17	2.108148	128.2768
CSLIG-B30	>1	2.19	2.114284	130.102
CSLIG-B30	>1	1.91	2.022791	105.3881
CSLIG-B30	>1	2.04	2.06683	116.6354
CSLIG-B30	>1	1.87	2.008636	102.0084
CSLIG-B30	>1	2.33	2.155728	143.1292
CSLIG-B30	>1	2.24	2.129382	134.7045
CSLIG-B30	>1	2.2	2.117331	131.018
CSLIG-B30	>1	1.83	1.994175	98.66763
CSLIG-B30	>1	2.17	2.108148	128.2768
CSLIG-B30	>1	1.98	2.046864	111.3947
CSLIG-B30	>1	1.87	2.008636	102.0084
CSLIG-B30	>1	1.68	1.936976	86.49207
CSLIG-B30	>1	2.09	2.083025	121.0669
CSLIG-B30	>1	2.03	2.063544	115.7561
CSLIG-B30	>1	1.58	1.895932	78.69224
CSLIG-B30	>1	1.93	2.029758	107.0923
CSLIG-B30	>1	1.95	2.036653	108.8061

Sample	Recovery	otolith M2	log TL	est TL
CSLIG-B30	>1	2.25	2.132361	135.6317
CSLIG-B30	>1	1.78	1.975647	94.54679
CSLIG-B30	>1	1.72	1.952714	89.68376
CSLIG-B30	>1	1.95	2.036653	108.8061
CSLIG-B30	>1	2	2.053586	113.1322
CSLIG-B30	>1	1.86	2.00505	101.1696
CSLIG-B30	>1	1.76	1.96809	92.91579
CSLIG-B30	>1	1.38	1.805414	63.88719
CSLIG-B30	>1	1.48	1.852203	71.15461
CSLIG-B30	>1	1.63	1.916769	82.55985
CSLIG-B30	>1	2.01	2.056922	114.0045
CSLIG-B30	>1	2.15	2.101955	126.4606
CSLIG-B30	>1	2.15	2.101955	126.4606
CSLIG-B30	>1	1.92	2.026284	106.239
CSLIG-B30	>1	1.84	1.997819	99.49917
CSLIG-B30	>1	1.55	1.883111	76.40307
CSLIG-B30	>1	2.23	2.126389	133.7795
CSLIG-B30	>1	1.78	1.975647	94.54679
CSLIG-B30	>1	2.16	2.105059	127.3675
CSLIG-B30	>1	2	2.053586	113.1322
CSLIG-B30	>1	1.78	1.975647	94.54679
CSLIG-B32	>1	1.77	1.971879	93.73005
CSLIG-B32	>1	1.93	2.029758	107.0923
CSLIG-B32	>1	2.04	2.06683	116.6354
CSLIG-B32	>1	1.81	1.986825	97.0119
CSLIG-B32	>1	1.71	1.948814	88.88204
CSLIG-B32	>1	2.3	2.147061	140.301
CSLIG-B32	>1	1.95	2.036653	108.8061
CSLIG-B32	>1	2.01	2.056922	114.0045
CSLIG-B32	>1	1.94	2.033215	107.948
CSLIG-B32	>1	1.83	1.994175	98.66763
CSLIG-B32	>1	2.02	2.060241	114.8791
CSLIG-B32	>1	2.1	2.086218	121.9601