Sea Loch Survey: an analysis of the marine molluscs

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Introduction

This report presents the results of marine mollusc analysis carried out on four shell midden sites, test-pitted as part of the Sea Loch Survey. Two sites, Allt na Uamha and Meall na h Airde 2 were found in Loch Torridon and Loch Carron, and the other two sites, Doire na Guaile and Church Cave, were found on the island of Rona. From associated lithic material it is thought that the first 3 sites are prehistoric.

The **aims** of the shell analysis are

- To determine the procurement strategies and consumption activities of the people using these sites
- To reconstruct the shore environment
- To evaluate the methods that can be applied to a shell assemblage from a test pit and suggest strategies for analysis in future work

Objectives

- To assess which species are being exploited on each site and compare relative proportions, in order to determine which were the dominant species and how much variety there is within the assemblage and possibly the diet
- To estimate the amount of shell fragmentation which may be related to whether some species (dogwhelks and periwinkles) are being used for bait.
- To determine the sizes of the limpets being collected and where on the shoreline they are collected from, which can be related to dietary choice or shellfish as bait
- To determine the size of the dogwhelk which can be used to indicate whether the beach from which they were collected was sheltered or exposed
- To assess the methods used and determine whether they can provide reliable and useful conclusions for a test pitting survey project

Methods

1. The shells are sorted according to species and the presence of each species noted.

2. The MNI (minimum number of individuals) is calculated by counting the apices for the gastropods, and the umbones of the bivalves are sorted into umbilici, left and right halves and counted (for each test pit the left and rights are summed and the highest number used as the MNI).

3. The shells are weighed by species. This is carried out to compare the results with the MNI. Counting MNI is much more time consuming that weighing bags of shell. The problem with weighing is the loss of weight with diagenesis which will affect different species at different rates. There is also the problem with the coiled gastropods like the dogwhelk and the periwinkle that soil, small pieces of shell, fish bone etc hide inside the shell making it heavier. In addition the heavier-shelled species are disproportionately represented, although the weights can be adjusted appropriately. A mean weight of each species is calculated by weighing a bag of 10 complete shells and then dividing by 10. The total weight of each species is then divided by the mean weight of the species to give an approximation of the MNI.

4. Measurements are taken on the limpets, dogwhelks and periwinkles:
   Limpet: Length (L1) and height (L2) of limpets are taken in order to ascertain where on the shore the limpets were being collected from. The ratio is calculated by dividing the length by the height (L1/L2). Squat limpets (with a high ratio) are usually found on the middle and lower shore and need to be collected at low tide and taller limpets (with a lower ratio) are found on the upper shore. This can be seen from the results of measuring modern limpets, figure 1.

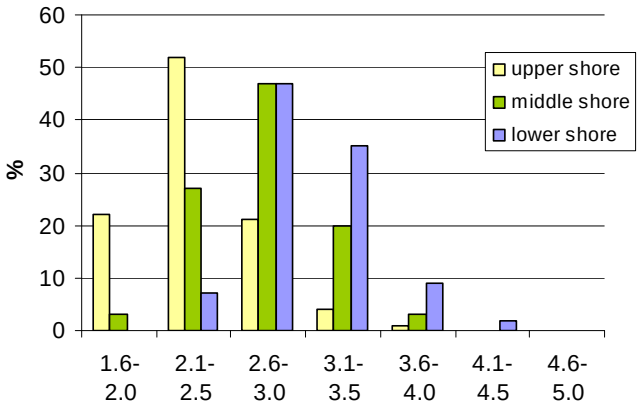

Figure 1: Frequency histogram of length/height ratios of limpet shells from the modern shore of Ulva (upper shore, N=559, middle shore N=642 and lower shore N=438). Data extrapolated from Russell et al (1995) figure 10.

Dogwhelk: The ratio of the height of the shell (L1) to the height of the aperture (L2) of the dogwhelk can provide information on the exposure of the shore from which the shellfish were collected: elongated dogwhelks suggest sheltered shores and squat dogwhelks are found in more exposed locations.

The above measurements of the dogwhelks and limpets and the lengths of the periwinkles can be compared between contexts and sites in order to determine whether there is any change in size through time which may be indicative of intensive human predation or changing environment. It is unlikely that any change will be noted from the test pits because they are so small but there may be differences between sites.

In all cases of measuring the maximum number of shells measured from a single context was 100. There is no significant change in the statistics with larger sample sizes.

5. Fragmentation of shell is assessed by calculating the percentage of complete shells in relation to the MNI (the number of complete shells are divided by the MNI). Only samples with over 10 MNI are included in this analysis (any smaller numbers may skew the results). Shells such as dogwhelks are sometimes broken in order to extract the animal, perhaps when being used for bait. There are however, other methods that can be used including heating the shell. This prevents small pieces of shell getting into the food. Therefore a high level of fragmentation may indicate that shells being broken for bait. On the other hand, fragmentation may be also be caused by people walking over the shellmidden, or natural post depositional events and weakening of the shell through diagenesis.

Before considering the analysis there is a description of the species found and their habitat. This report is then structured by site. For each site the species, the relative proportion of species (through analysis of MNI), the measurements and the fragmentation will be discussed. The weighing of the shells will be analysed in the conclusion. In the conclusion, the results will be discussed, a comparison will be made between the sites and recommendations for future work will be made.

Species identified

Identifications and descriptions are made from Barrett and Yonge (1958).

Limpet: *Patella* sp. – these are the commonest genus of limpet, found on the high, middle and low rocky shores in large numbers. They have rough and ribbed shells. There are three species: *P. vulgata*, *P. intermedia* and *P. aspera*. It is difficult to distinguish between the three without the animal inside or the colouring inside the shell, which archaeological specimens do not have. It is thought that the majority of specimens in these middens are the most common species, *Patella vulgata*. Limpets are fairly easy to exploit but need to be knocked off the rocks where they cling tightly, particularly when the tide is out.

Periwinkle (winkles): *Littorina* sp. – periwinkles tend to be found on rocky shores or stones. There are several different species of periwinkle but the ones found on the archaeological sites are *L. littorea*, the common or edible periwinkle, and *L. littoralis*, the flat periwinkle. The common periwinkle is the larger of the two and lives on rocks and weed on the middle shore and below. The flat periwinkle is much smaller and is flat-topped, usually colourful (yellow, red, green etc) and is more likely to be collected because of aesthetic qualities or attached to weed, rather than for consumption purposes. It lives on the middle and top shore, especially on the *Fucus* weed. Periwinkles are easy to pick off the rocks and because they congregate in large numbers a great number can be scooped off at once.

Dogwhelk (whelks): *Nucella lapillus* – these are found on rocks usually in large numbers. They are the chief predator of barnacles. As with periwinkles these can be scooped off the rocks.

Topshell: *Gibbula sp* – there are many species of topshell. They are distinctive if worn because they show mother-of-pearl layers. The few shells that have been found at these sites look to be *Gibbula cineraria*, the grey top shell. These live on rock or weed and are found on the middle and lower shores.

Oyster: *Ostrea edulis* – oysters occur in dense sub-littoral beds in creeks and estuaries. They are bivalves with different morphology to each valve; the left or lower valve is cupped and cements itself to the substrate. The upper valve is flat. These shells have to be prised off the oyster bed, perhaps with a tool such as a stick.

Mussel: *Mytilus edulis* – this is a very common shore animal found in dense beds on rocky, stony and muddy shore on the middle shore and below. It is easily gathered.

Scallop shell: *Pecten maximus* – As with the oyster, these shells are inequivalve; the right (under) valve is convex and the top valve is flat. This species can swim by flapping of the valves. They are very common offshore but the shells are often washed up. Occasionally specimens can be found on the lower shore. As well as being edible the cupped shells are useful as containers.

Razor shell: *Ensis sp*. – the razor shell is highly characteristic; up to eight times as long as broad. The shells found here are probably *Ensis ensis*. These are found on sandy shores. They are not easy to gather because they burrow so deeply and can move rapidly through the sand but the shells can often be found washed up on the shore.

Otter shell: *Lutraria lutraria* – the common otter shell is a large white bivalve which, like the razor shell, is difficult to find alive as it burrows deep in sand or mud. It can be found washed up and as with the scallop the large shells are useful as containers.

Carpet shell: *Venerupis sp*.(also known as *Tapes*) – sometimes termed a clam, these shells belong to the *Veneridae* family, one of the major families of bivalves. *Venerupis* sp. are common between tide marks and in shallow water. It is hard to be sure of the species found at these sites because they are represented by a few fragmented pieces.

Barnacle: These are crustacea rather than molluscs. They attach themselves to a firm surface although they remain mobile and they become protected by a series of plates. It is difficult to be sure of the species of barnacle found at the sites. They are probably present in the middens because they have been brought in accidentally; on seaweed, stones or other shells.

Operculum: the operculum is present in almost all marine snails. It is a plate carried on the foot which covers the shell aperture when the body is withdrawn. These are not commonly found on archaeological sites.

Allt na Uamha (SFS 10)

Allt na Uamha is a northwest facing boulder shelter with a large shell midden in front. One test pit was dug into the shell midden and contained 5 contexts, 4 of which contained shell material. No lithics were found but on a second visit lithics were recorded from the surface of the midden, a small shovel pit was made and more lithics recovered suggestive of an early prehistoric date.

- **Species and MNIs**

The predominant species in this midden is limpets followed by the periwinkle. The ratio of species is consistent through the testpit, see figure 2. There are a few other species but these have a very low MNI: dogwhelk, flat periwinkle and the otter shell, see table 1. Razor shell, topshell, and scallop were also present but could not be included in the MNI due to lack of apices or umbones. These other species have very low weights and may represent few individuals, in some cases only 1. Significantly perhaps there are more dogwhelks in pit 2 (N=8), see figure 3.

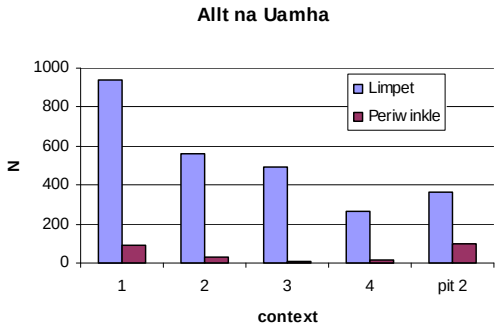

Figure 2: Bar chart to show the proportions of the 2 most prevalent species; the limpet and the periwinkle.

Context	Limpet	Periwinkle	Dogwhelk	Flat winkle	otter shell
1	941	89	0	2	0
2	560	29	0	0	0
3	489	11	1	0	1
4	264	12	0	0	0
pit 2	366	96	8	0	0

Table 1: The MNI of species from each context

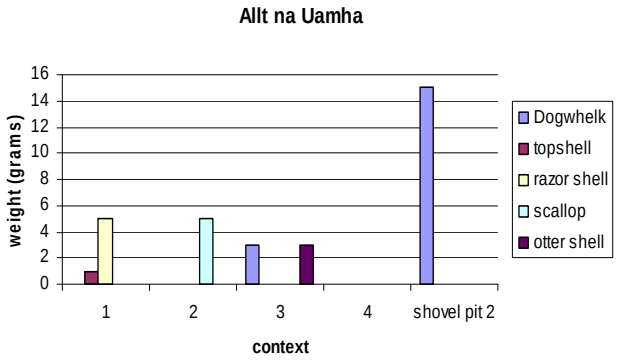

Figure 3: Bar chart to show the weight in grams of other species present. In most cases these will represent a very small number of shells.

- **Measurements**

A frequency histogram has been created to compare the length/height ratio of limpets from the different contexts. Figure 4 demonstrates the relative percentage per context of limpets in each size group. The limpets from each context display a clear similarity and in each context most of them fall into the ratio group 2.6-3.0. When this is compared to modern limpets collected from the West coast of Scotland from the Ulva area (Russell et al 1995), figure 1, it can be seen that this is indicative of limpets found in the middle to lower shore zones.

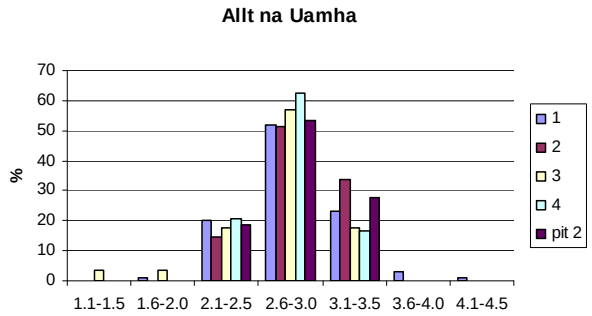

Figure 4: frequency histogram of length/height ratios of limpet shells

There were very few dogwhelks and not enough to make any meaningful interpretation on size. The average length of periwinkles and limpets in each context have been calculated and the mean and standard deviation is shown in figure 5. For the periwinkles it is difficult to compare all of the contexts because there were so few from 3 and 4, which may be why they appear to be slightly larger. On the other hand the upper levels may have smaller shells because they had been exploited heavily. Overall, the average size of the periwinkles is fairly similar throughout the midden indicating no major change in exploitation or environment. The average size of the limpets is similar through all the contexts.

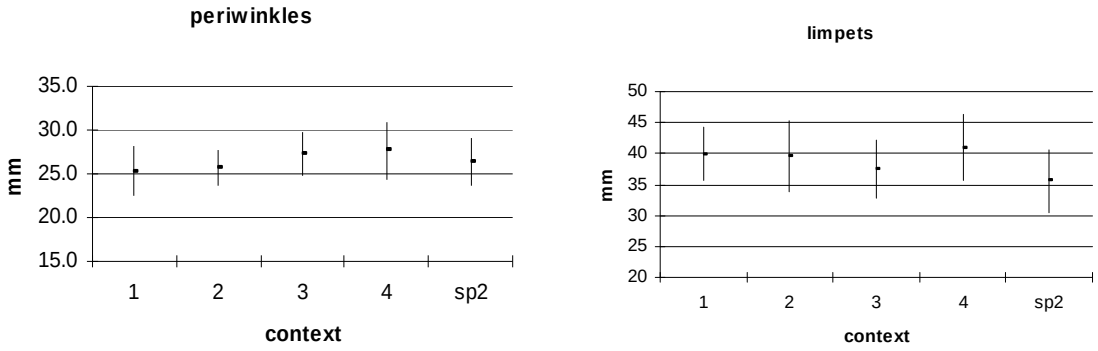

Figure 5: average and standard deviation of the lengths of periwinkles and limpets from each context. Periwinkles- context 1: N=64, 2:N=25, 3:N=8, 4:N=7, sp2:N=48, limpets- 1:N=100, 2:N=68, 3:N=28, 4:N=24, sp2:N=43

- **Fragmentation**

The results of fragmentation analysis can be seen in figure 6. There was not enough data on dogwhelks to include them in the analysis. The limpets are highly fragmented (in most cases less than 20% are complete). The MNIs are all high from this site (see table 1) making the results very reliable. It is interesting that context 1 has about 25% of complete shells compared to the lower contexts which have less than 10% fragmented. This could be connected with the weight of the midden, or there being less trampling after the final deposition of shells.

The MNIs for the periwinkles are not as high (table 1) and therefore the results are more prone to being skewed. Nevertheless there does seem to be quite a drop in the number of whole shells in shovel pit 2 (only about 50% are whole, compared with 70% and higher in context 1 and 2). Without further examination of the site it is impossible to say why this is the case.

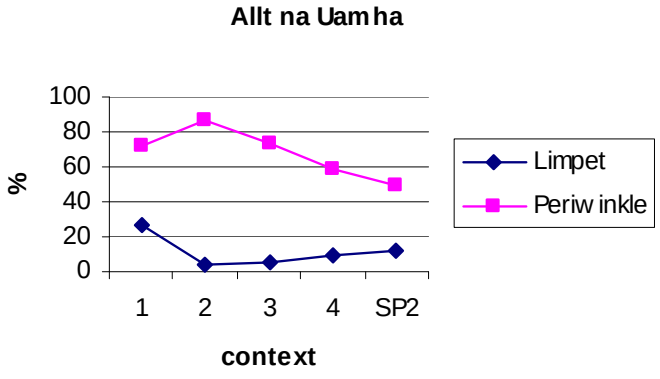

Figure 6: Chart to show the fragmentation of limpets and periwinkles.

Meall na h Airde 2 (SFS 171)

This site is a south west facing cave with a small area of midden at the rear. It may have been subjected to sea ingress at high tides because it is only 2m OD. A test pit was dug into the midden and 4 contexts assigned. A 50% sample of excavated material was dry sieved on site. Lithics were present on site suggesting an early prehistoric age.

- **Species and MNIs**

The main species in this midden are limpets, followed by dogwhelks and then periwinkle, see figure 7. There are also a small number of oysters, topshells and there are some mussels (mussels have no MNI count but about 6 grams in weight from context 2), table 2. The vast majority of shells come from spit 2 and the shells from this testpit should probably all be counted together.

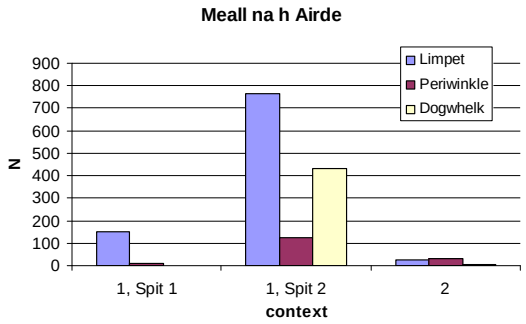

Figure 7: Bar chart to show the proportions of each of the 3 main species

	Limpet	Periwinkle	Dogwhelk	Oyster	topshell
1, Spit 1	150	9	0	0	0
1, Spit 2	765	123	434	0	3
2	27	33	3	2	0

Table 2: Table of the MNI counts for each species

- **Measurements**

A frequency histogram has been created to compare the limpets from the 2 spits in context 1 (there were not enough complete limpets to use as a comparison in context 2). Figure 8 demonstrates the relative percentage per context of limpets in each size group. The limpets from each context display a similarity and in both contexts most of them fall into the ratio group 2.6-3.0. When this is compared to modern limpets collected from the West coast of Scotland from the Ulva area (Russell et al 1995), figure 1 it can be seen that this is indicative of limpets found in the middle to lower shore zones.

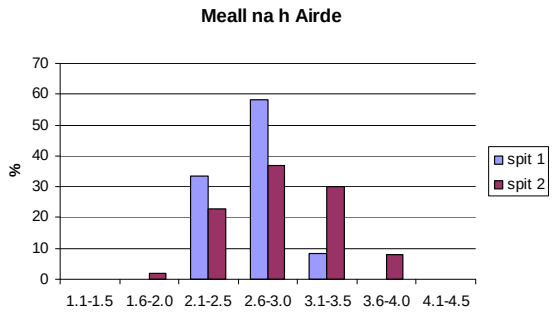

Figure 8: frequency histogram of length/height ratios of limpet shells

The average lengths and standard deviations of periwinkle, dogwhelk and limpet were calculated and the results are shown in figure 9. Spits 1 and 2 in context 1 were combined in this analysis. Overall, the average size of the periwinkles and limpets is fairly similar between the 2 contexts indicating no real change in exploitation or environment and as mentioned above, the majority of shells come from spit 2 and probably all the contexts should be grouped together. There was only a substantial number of dogwhelks present from context 1 so no comparison can be made between contexts, however there are enough dogwhelks to test the degree of exposure on the shore. Figure 10 shows the relative frequency of dogwhelk length/aperture length (L1/L2) ratios. Compared to other studies (e.g. Russell et al. 1995), these dogwhelks are fairly elongate with small apertures. This is common on more sheltered shores. An elongate form also provides a defense against crabs which are more abundant on these shores.

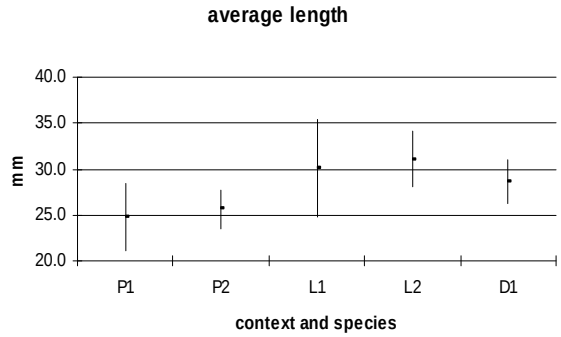

Figure 9: average and standard deviation for periwinkles (P), limpets (L) and dogwhelks (D) from the two contexts (1 and 2). P1:N=98, P2:N=31, L1:N=124, L2:N=12, D1:N=95

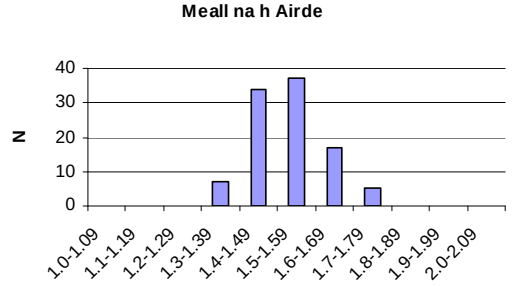

Figure 10: frequency histogram of dogwhelk length/aperture length ratios

- **Fragmentation**

The results of fragmentation analysis can be seen in figure 11. From this graph limpets are shown to be very fragmented (less than 20% are whole). About 50% of the dogwhelks are broken, but the periwinkles in general tend to be whole (70% and above).

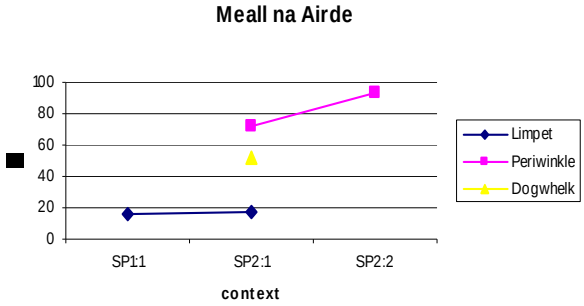

Figure 11: Chart to show the fragmentation of limpets, periwinkles and dogwhelks, although calculations were not made for every context because the sample sizes were too small in some cases.

Doire na Gualie (SFS 152)

Doire na Gualie is a north facing rockshelter on Rona. An initial test pit produced lithics (suggestive of a prehistoric presence), pottery and shell material.

- **Species and MNIs**

Most of the molluscs were found in context 3, the main shell midden, which also contained the lithics, pottery and bone. The predominant species in this context is the limpet, see figure 12. There were also a number of dogwhelks but very few periwinkles, table 3. No other species were present.

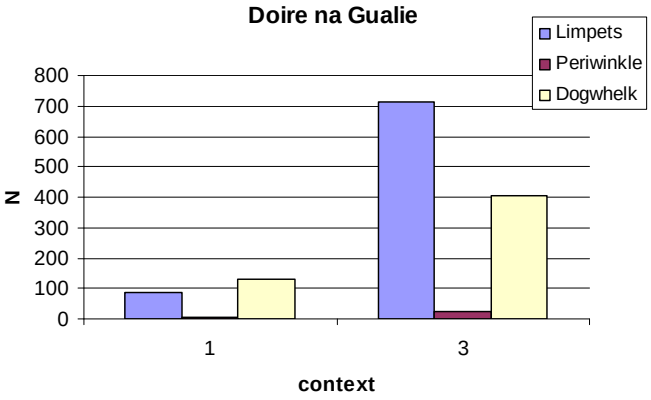

Figure 12: Bar chart to show the proportions of each of the 3 main species

context		Limpets	Periwinkle	Dogwhelk
1		88	7	131
3		712	23	405

Table 3: Table of the MNI counts for each species

- **Measurements**

The sample size of complete shells was only large enough in context 3 to assess limpet morphology. Figure 13 shows that the limpets from this site mainly fall into the ratio group 2.6-3.0 and greater. When this is compared to modern limpets it can be seen that this is indicative of limpets found in the middle to lower shore zones (see figure 1).

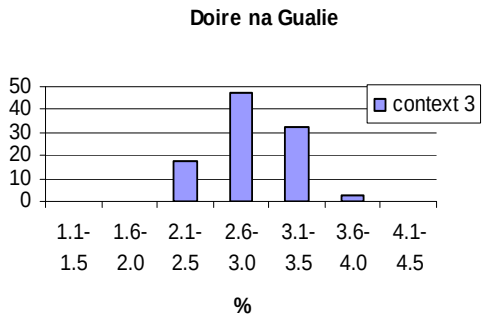

Figure 13: frequency histogram of length/height ratios of limpet shells

The average lengths and standard deviations of periwinkle, dogwhelk and limpet were calculated and the results are shown in figure 14. Even though some of the sample sizes are small, overall the average sizes are fairly similar between the 2 contexts indicating no real change in exploitation or environment. The degree of exposure seen in the dogwhelk morphology was also tested. Figure 15 shows the relative frequency of dogwhelk length/aperture length (L1/L2) ratios. The dogwhelks from both contexts are very similar. Compared to other studies (e.g. Russell et al. 1995), these dogwhelks are fairly elongate with small apertures. This is common on more sheltered shores. An elongate form also provides a defense against crabs which are more abundant on these shores.

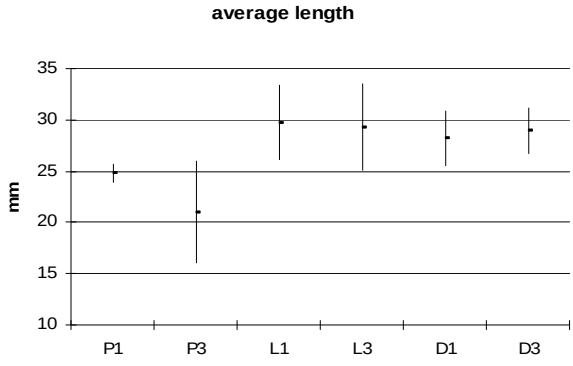

Figure 14: average and standard deviation for periwinkles (P), limpets (L) and dogwhelks (D) from the two contexts (1 and 3). P1 (N=5), P3 (N=16), L1 (N=8), L3 (N=70), D1 and D3 (N=100)

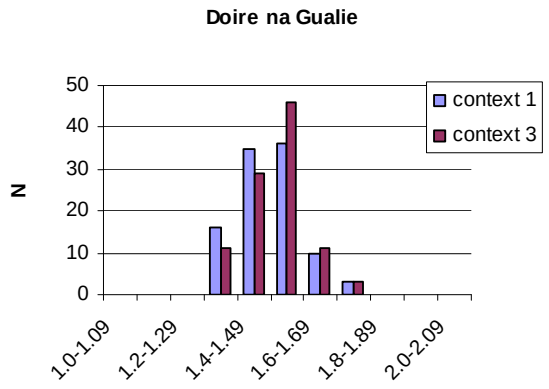

Figure 15: frequency histogram of dogwhelk length/aperture length ratios

- **Fragmentation**

The results of fragmentation analysis can be seen in figure 16. It can be seen that the limpets are very fragmented (10% or less are complete shells). A fairly high proportion of the dogwhelks are whole (especially in context 1: 80%). The periwinkles also tend to be whole (70%).

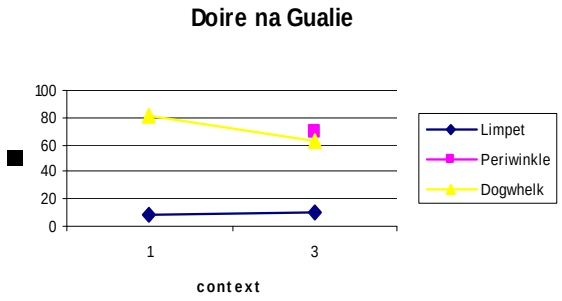

Figure 16: Chart to show the fragmentation of limpets, periwinkles and dogwhelks, although calculations were only made for context 3 in the case of the periwinkles because the sample size was too small for context 1.

Church Cave (SFS 17)

Church cave is situated on the island of Rona. The cave is so-called because up until 1912 it was used regularly as a Church and it still houses a row of stone pews and a low stone pillar altar at the entrance. The results of the survey show that in the past is has also been used for other purposes. A test pit was dug in an area of cave earth in front of the seating towards the back of the cave. Test pit 2 was dug nearer the entrance in the area of shellmidden. Shells were found in both areas.

- **Species and MNIs**

In test pit 1 there were very few shells, see table 4. Periwinkles predominate (figure 17), there are some limpets, a couple of oysters, a dogwhelk and some opercula (but the species to which these belong is unknown). In comparison, in test pit 2 there are many more shells, table 5. Limpets predominate (figure 17), particularly in context 2, there are also a number of periwinkles but far fewer other species. What is interesting here is that there are a number of oysters and mussels which are preserved fairly well. The presence of these species is not so common from the Mesolithic sites in this region (e.g Sand) although not unknown, but they are in good condition, and as mussels in particular do not survive well this suggests that the midden dates to a historical period, rather than prehistoric. The other species occur in very small numbers. It is unlikely that these were collected for food and the topshell and flat periwinkles may even have been collected for their aesthetic qualities: they tend to be attractive colours and the topshell can look like mother of pearl.

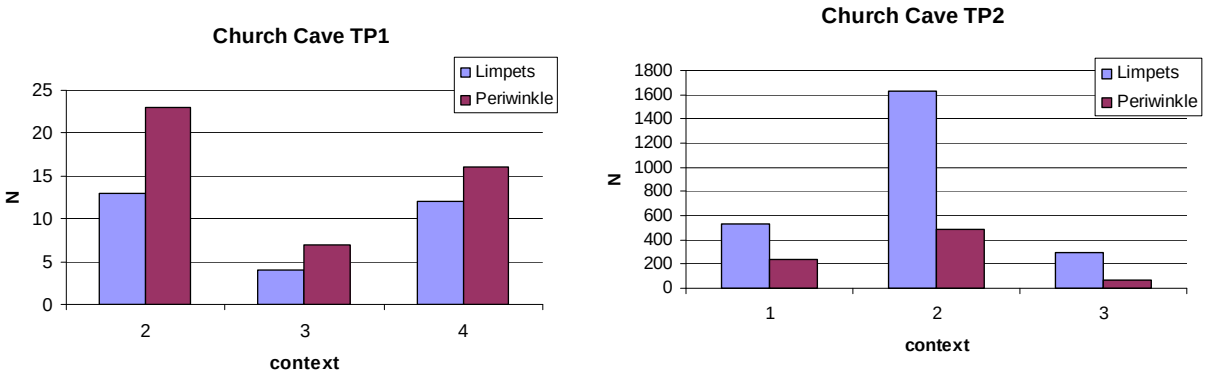

Figure 17: Test pit 1 shows a predominance of periwinkles, test pit 2 a predominance of periwinkles.

Context	Limpets	Periwinkle	Dogwhelk	Oyster	operculum
2	13	23	1	1	4
3	4	7			
4	12	16		1	1

Table 4: Table showing the MNI of species in test pit 1

Context	Limpets	Periwinkle	Dogwhelk	Flat periwinkle	Top shell	Oyster	Mussel	Barnacle	Carpet shell	Operculum
1	535	234	4	3	1	10	1	2		
2	1632	484	9	6		13	20		1	2
3	293	66	3			1	12			

Table 5: Table showing the MNI of species in test pit 2

- **Measurements**

The sample size of complete shells was only large enough in testpit 2 to assess limpet morphology and comparisons were made through the three contexts. Figure 18 shows that the limpets from this site peak in the ratio group 2.6-3.0 and greater. When this is compared to modern limpets it can be seen that this is indicative of limpets found in the middle to lower shore zones.

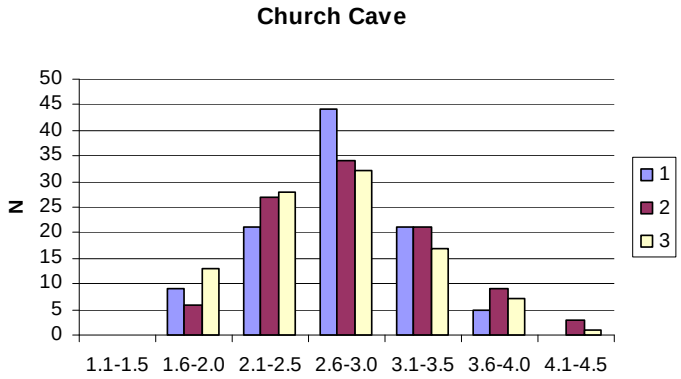

Figure 18: frequency histogram of length/height ratios of limpet shells from test pit 2, contexts 1, 2 and 3 (N= 100, 100 and 98 respectively)

The average lengths and standard deviations of periwinkle and limpet were calculated and the results are shown in figure 19. In test pit 1 the periwinkles look to be slightly larger than in test pit 2, however the sample size is very small and probably not representative. Overall the average sizes are fairly similar between contexts indicating no real change in exploitation or environment. There were not enough dogwhelks to test the degree of exposure on the shore.

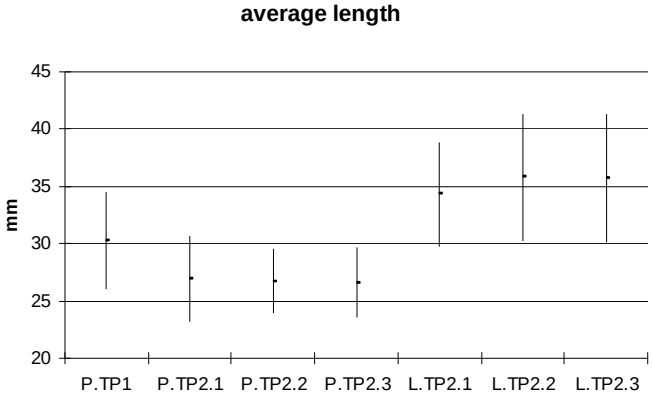

Figure 19: average and standard deviation for periwinkles (P) and limpets (L) from the two testpits (TP1 and 2) and the 3 contexts within test pit 2. P.TP1 (N=12), P.TP2.3 (N=62), L.TP2.3 (N=98), all other N=100

- **Fragmentation**

The results of fragmentation analysis can be seen in figure 20. The limpets are fairly fragmented (mostly between 20 and 40%). It seems that the limpets at the base of the midden in testpit 2 are less fragmented than those at the top, perhaps suggesting fairly rapid accumulation. The periwinkles in testpit 2 also tend to be whole (between 75% and 94%), whereas those in testpit 1 appear to be more fragmented.

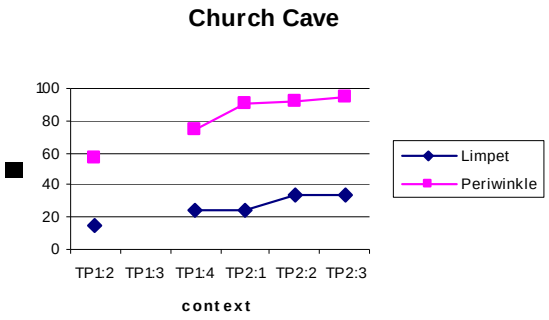

Figure 20: Chart to show the fragmentation of limpets and periwinkles in both testpits. There were not enough samples from TP1:3 to make any reliable calculation

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Discussion

- Procurement strategies and consumption activities

One of the main aims of this research was to determine the procurement strategies and consumption activities of the people using these sites. At all the sites the main species exploited is the limpet. The only test pit where this is not the predominate species is test pit 1 at Church Cave where periwinkles are more common, however this is a very small sample overall and limpets are still a major component. In all cases analysis of limpet morphology has shown that this species is being collected from the middle and lower shore zones[1]. These results are perhaps not suprising because many other midden sites demonstrate similar patterns e.g. Sand (Milner unpublished data), Ulva Cave (Russell et al 1995), Ferriter's Cove (Woodman et al 1999). It is said that limpets when flatter and smaller are less chewy and more palatable. It is also much easier to collect the limpets from the middle and lower zones, especially when they have been immersed beneath the sea. Here they can be lifted off the rocks with ease, in comparison with trying to prise or knock off the limpets on the rocks on the upper shore; these limpets hold fast in order to retain moisture. The only limiting factor with collecting limpets from further down the shore is that they can only be collected when the tide is out or going out. This may mean walking further, although if people are using boats they will often be at the edge of the sea anyway.

[1] The middle shore is the region between the average high tide and the average low tide and so therefore it tends to experience twice daily submersions under the sea. The lower shore is the region below the average low tide level (Barrett and Yonge 1958, 17).

In terms of the other species there tend to be many periwinkles and dogwhelks. At Allt na Uamha and Church Cave the second most prevalent species are periwinkles and at Meall na h Airde and Doire na Gualie the dogwhelk is more common. The latter site is especially interesting because it is the only one with no species other than these three. All the other sites have a few other species in much smaller numbers. It is perhaps not unexpected that the limpet, periwinkle and dogwhelk are common together. They are all found easily on rocks, often together, figure 21. It is perhaps surprising that there are so few mussels because they also tend to congregate in similar environments. For some of the other species like oyster, razor shell and otter shell it would seem that either they were not present naturally in great numbers or, perhaps more likely, they were just not targeted because they are harder to gather.

Figure 21: a rock with periwinkles, limpets and dogwhelks at Sand, Applecross.

In terms of taste, limpets and dogwhelks are not always regarded as a foodstuff and it has sometimes been argued that these species would have been used as bait rather than for direct consumption. There is however, plenty of evidence that both species can be eaten (Russell et al 1995; Wickham-Jones 2003). The shells are also transported back to the sites and perhaps they would be processed nearer the shore if they were to be used for bait. It is possible that if these species are being used for bait there may be some other indicators. It could be suggested that the larger limpets, perhaps from the upper shore, would have been selected for bait because they are larger; this may be happening at Quoygrew, a Viking site in the Orkneys (Milner unpublished data). The fragmentation of the main species may also provide a clue. There were only enough dogwhelks to analyse in this way from Meall na Airde and Doire na Gualie. At the former site half the dogwhelks were fragmented but at Doire na Gualie 60-80% were whole. Perhaps the dogwhelks at Meall na h Airde were being broken in order to extract the animal (and when using them for bait it does not matter so much if little bits of shell get into the meat) but it is also possible that these shells are being fragmented in other ways, such as trampling. Dogwhelks can be used for extracting a purple dye but an individual shellfish produces an extremely miniscule amount and it is unlikely that the relatively small

numbers of dogwhelks would have been used for this purpose. There is no evidence for cooking or applying heat in order to extract the meat but this is usually the case.

The fragmentation can be compared for the other main species. At Church Cave the limpets and periwinkles are not very fragmented compared to the other sites. In the case of the limpets between 20% and 40% are whole. At the other sites far fewer are whole: Allt na Uamha, less than 10% are whole (except in the top context where about 20% are whole); Doire na Gualie has less than 10% whole and Meall na h Airde , 20% are whole. When considering the periwinkles a similar pattern emerges. At Church Cave between 75% and 95% are whole and the periwinkles at Meall na h Airde are similar. At Doire na Gualie only 70% are whole and at Allt na Uamha approximately 60%-80% are whole, although only half the periwinkles in test pit 2 are whole. Fragmentation can be caused by all sorts of post depositional factors and is also linked with diagenesis. It is probably no coincidence that the limpets which are more prone to degradation are more fragmented than the other gastropods. It is also interesting that the shells from Church Cave are more complete considering that these deposits may be more recent (possibly historic rather than prehistoric) and therefore less post depositional alteration may have occurred.

- The shore environment

Another aim of this analysis was to reconstruct the shore environment. The measurements of the dogwhelks from Doire na Gualie and Meall na h Airde do show that they probably were collected from fairly sheltered shores but this analysis is subject to some variation and the ratio can vary from shore to shore (Crothers 1982). These results are comparable with those from Ulva cave (Russell et al 1995) where it was shown that the dogwhelks from the midden are more elongated than those from the present day. Unfortunately there are no modern comparisons from the sites studied here.

It is also possible to compare the sizes of the shells to look for evidence of over-exploitation or different environments. As discussed above, there is no conclusive evidence for this on an intra-site basis, however, it is also possible to compare sizes of shells between sites. There are no significant differences in size between the dogwhelks from the two sites but the limpets and periwinkles do vary, see figure 22. The limpets from Allt na Uamha are the largest and those from Doire na Guialle much smaller. The periwinkles from Doire na Guialle are also small. This is likely to be due to a slightly less favourable ambient environment than the other sites. Alternatively the shells from these shores may have been exploited for a long time resulting in a lowering of average size. Age data can elucidate this but it is not possible to age these species easily. There is a pattern to this data which suggests that the ambient environment is determining the size of the shells: the shells from Allt na Uamha are fairly large, those from Meall na h Airde are perhaps slightly smaller, then those from Church Cave are larger again and those from Doire na Guaile are small.

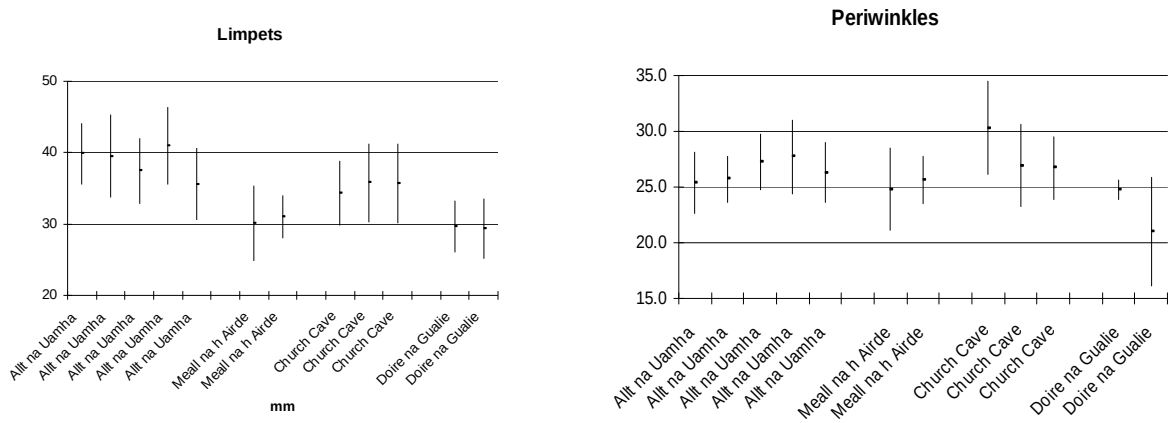

Figure 22: A comparison of average limpet and periwinkle sizes from all 4 sites.

- Strategies for analysis in future work

In sum, it can be shown that people at all these sites were exploiting rocky areas of the middle and lower shore zones but they were only targeting the easily accessible species and at all sites there appears the trio of limpets, dogwhelks and periwinkles in varying proportions. These people were not going to any lengths to harvest the burrowing shells or oysters, or at least they were not transporting them back to the middens. It is interesting that this trio occurs time and again and I would argue that it is useful to sort the species and calculate relative quantities in order to see how this pattern varies between sites and what other shell species are exploited- perhaps some patterns are related to certain time periods. However, rather than using an MNI method which is very time consuming and therefore costly it might be advantageous to develop a weighing method. The shells from these sites were weighed and then the totals were divided by an average weight which was calculated by weighing 10 of each species and then dividing by 10 (1 limpet=4.6grams, periwinkle=4.3g, dogwhelk=5.6g). The results of the estimated number (through weighing) and the MNI can be compared, see table 6. In some cases the estimated numbers match up well with the MNIs, e.g. the numbers of dogwhelks tally well, as do the periwinkles (with the exception of Church Cave). There seems to be less of a tally with the limpets however, but perhaps this method can be refined by weighing larger numbers to get more accurate averages and doing this for each site because there may be some inter-site variation. Fragmentation can also be calculated fairly quickly but is only approximate indicator and perhaps is a more useful method for an excavated site, although there again may be a pattern between the degree of fragmentation and the age of the site.

It is interesting to see that there is a pattern of collecting the limpets from the middle to lower shores but perhaps in a test pitting study fewer limpets could be measured e.g. only 100 per site. There seems less point in measuring the limpets, dogwhelks and periwinkles for average size because this tells us very little except that some sites may have slightly better ambient conditions for shell growth than others. Without age data there is little that can really be said about changing environments or intensive exploitation. There also seems to be little point in measuring dogwhelks at the test pit stage unless the data is

going to be combined with other environmental proxies. If this measuring is carried out a modern control is needed so at least the environments between modern day and the past can be compared.

In conclusion, the shells can provide a wealth of information, especially once they are combined with other data from the middens but for the test pit or shovel pit phases of a survey a full analysis provides less useful information. There is much more potential once the stratigraphic sequence across a site is known, the accumulation rate of the midden is better understood and the date of the midden is established. However, it is important that some analysis is carried out to add to the database of survey information; it may be that in the future some correlation between midden assemblages (with certain species, patterns of fragmentation and varying preservation of shells) and different archaeological periods comes to light.

		Estimate No.				MNI		
		Limpet	**Periwinkle**	**Dog**		**Limpet**	**Periwinkle**	**Dog**
Church Cave	**TP1:2**	13	54	1		13	23	1
	TP1:3	2	22	0		4	7	0
	TP1:4	13	31	0		12	16	0
	TP2:1	307	332	3		535	234	4
	TP2:2	1073	667	8		1632	484	9
	TP2:3	218	90	3		293	66	3
Alt na Uamha	**1**	668	85	0		941	89	0
	2	429	28	0		560	29	0
	3	340	15	1		489	11	1
	4	217	19	0		264	12	0
	SP2	196	103	10		366	96	8
Doire na Gualie	**1**	28	6	175		88	7	131
	3	189	16	409		712	23	405
Meall na Airde	**SP1:1**	75	14	0		150	9	0
	SP2:1	261	130	359		765	123	434
	SP2:2	14	35	2		27	33	3

Table 6: table showing the estimated number of shells within a context (calculated by adjusting the weights of the shells) compared with the MNI count.

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