Möðruvellir in Hörgárdalur, N. Iceland: General Overview of the Archaeofauna Analyzed from the 2006-08 Midden Mound Excavations.

Ramona Harrison

CUNY Human Ecodynamics Research Center
CUNY Northern Science and Education Center

HERC/NORSEC

Brooklyn College Zooarchaeology Laboratory
Hunter College Bioarchaeology Laboratory
CUNY Doctoral Program in Anthropology

HERC/NORSEC Zooarchaeology Laboratory REPORT No.59

July, 2011 *ramona.harrison@gmail.com*

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Summary

This report presents results on zooarchaeological analysis from the Möðruvellir Midden Mound, or Öskuhóll, adjacent to the site's extensive farm mound. Möðruvellir, likely a chieftain's farm during the Settlement period, became House of Canons/Augustinian Monastery in the late 13th C, and remained an important ecclesiastical center even after the Reformation. Beyond functioning as religious institution, it served as seat for the regional governor for the Danish Crown at least during the Early Modern Period, and also operated a practical secondary school from the later 1870s on (Karlsson 2000:258). Möðruvellir is still inhabited by the local priest, masses are still held, and among other things the estate is home to an Experimental Station of the Agricultural University in Iceland.

The Möðruvellir faunal collections include materials from the 13th to the 19th/20th c. Excavations on the Möðruvellir Ash Mound (Öskuhóll) were undertaken between 2006-08 and concentrated mainly on the contents of one large trench, TR1 and two smaller ones, TR2 and TR2b. The latter will be combined into TR2/2b as they are almost in identical place and produced materials from the same time period. While an attempt has been made by the author to present the available faunal data as thoroughly as possible, more analytical work including written resources, chemical analysis, inclusion of material culture analysis and context-activity association where possible is planned.

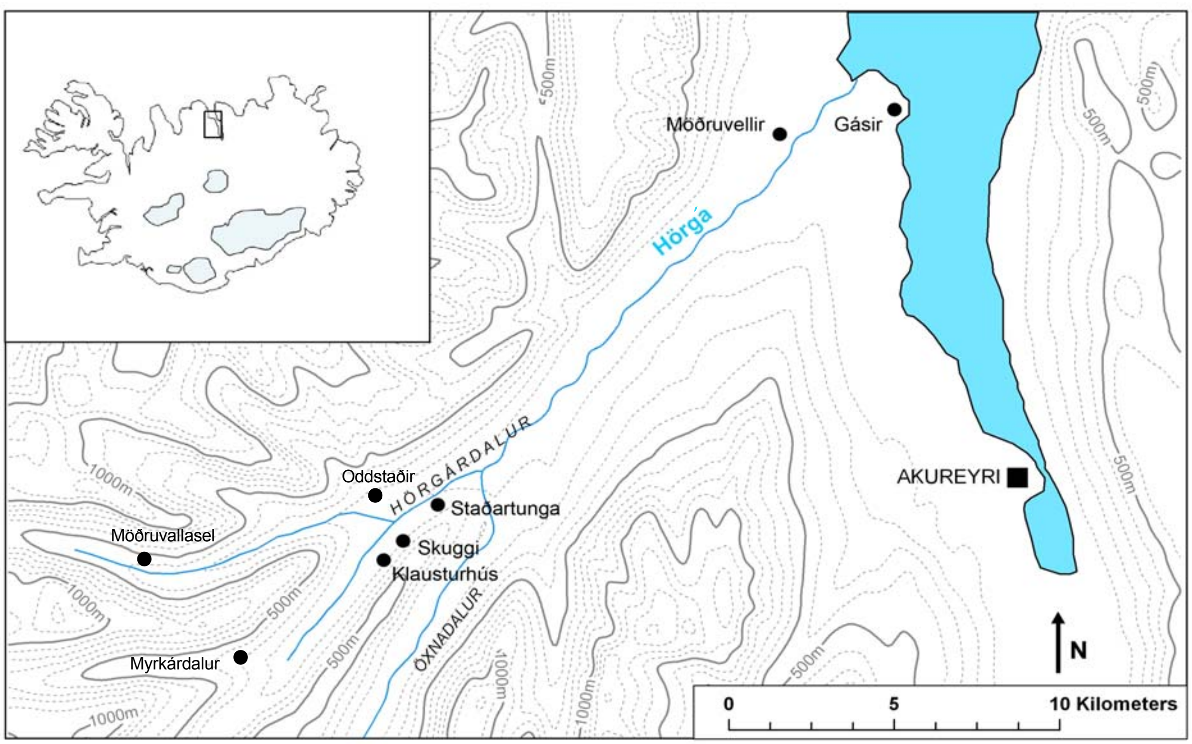

Figure 1. Map of Iceland, locating Möðruvellir, Möðruvallasel, Klausturhús, Staðartunga, and other sites mentioned located in Hörgárdalur, and Gásir, located at a coastal inlet in Eyjafjörður. (Orig. Map: Streeter, edited: Harrison).

Introduction

Möðruvellir:

Möðruvellir is located in Hörgárdalur, Eyjafjörður, Northern Iceland. It is situated on an open lowland pasture, just north of the river Hörgá, and ca. 13 kilometers north of the modern city of Akureyri (figure 1). The site lies close to the Hörgá river delta, and thus its eastern property is remotely part of a coastal environment.

The Möðruvellir estate has been an institution of considerable importance throughout Icelandic history. A church was established on its grounds at least as early as the second half of the 12th c. (Vésteinsson, 2001:10), and Möðruvellir became a House of Canons at the end of the 13th c. These religious activities were supported by the produce of a large and important farming estate.

The original farm and religious buildings have not been located with precision, but it is generally assumed that their remains are beneath the historic farm mound (Bæjarhóll) adjacent to the well-known Midden Mound or Ash Hill (Öskuhóll). The Möðruvellir farm mound and historic buildings represent a major cultural and archaeological monument with tremendous potential for future research. The farm mound itself measures some 80 m in diameter and centuries of occupational and construction remains have raised its top 4 – 5 meters above the surrounding farm land. The mound has seen continued use down to current times (Vésteinsson 2001), certainly a factor causing some minor disturbance to underlying archaeological deposits, not only to the structural deposits, but also the midden remains as is evidenced in the medieval midden phase (see below). Still, this large mound potentially can offer testament to a large portion of the estate's activities throughout its long history.

The modern church at Möðruvellir (see location plan in figure 2) was built in 1865 (www.skolavefurinn.is). It is a protected building of historic importance in its own right and stands as successor to a series of churches and other ecclesiastical buildings, many of which had burnt down.

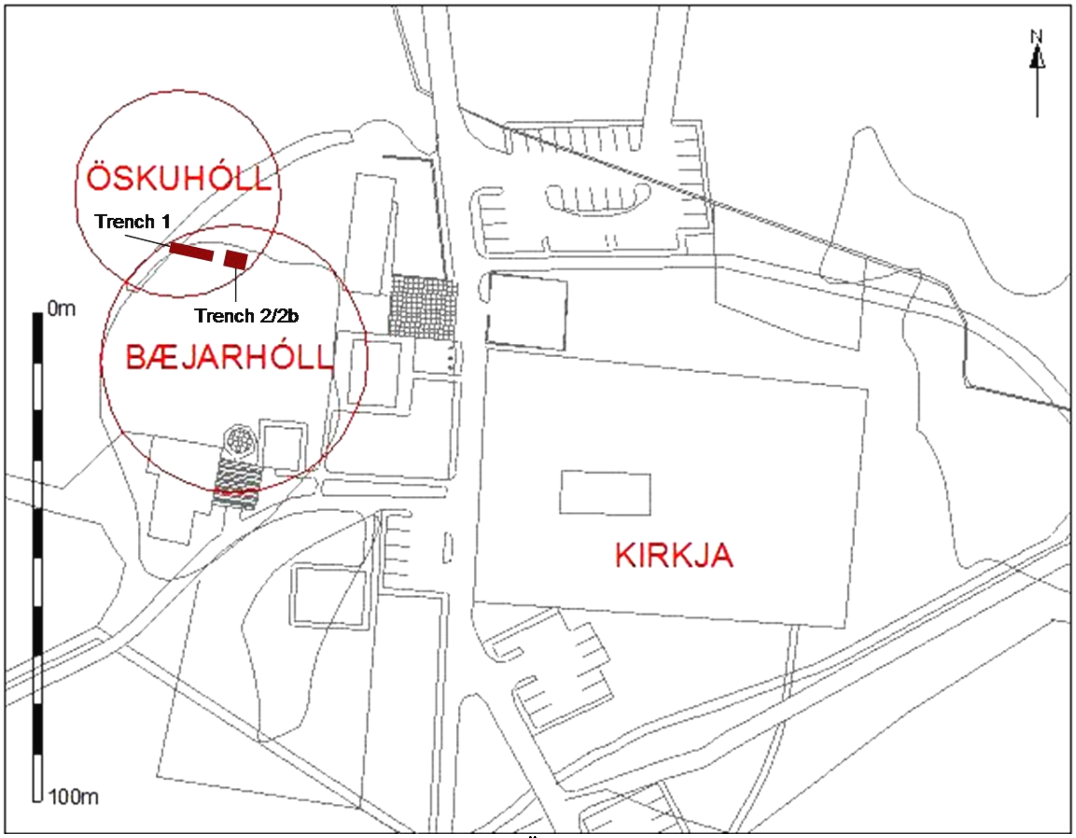

Figure 2. Approximate midden trench locations. Öskuhóll – Ash hill/Midden Mound, Bæjarhóll - Farm Mound. Kirkja – Church – modern building. (Map – HM Roberts (2004); trenches added by R Harrison).

The Möðruvellir Öskuhóll

Figure 2 locates the Möðruvellir historic farm mound and the midden mound to the north east of the modern church. The two areas are connected and therefore associated with one another. Prior to excavation, the midden mound was thought to have consisted of series of midden layers deposited over several centuries (Vésteinsson 2001), which turned out to be correct. The location of the midden trenches TR 1 and TR2/2b excavated between 2006 and 2008 at the edge of the mound(s) was chosen after thorough coring of the area and with the intent to avoid any structural remains.

Brief Research History

This is a brief summary of the Möðruvellir (excavation) history presented elsewhere (Vésteinsson 2001, Roberts 20005, Harrison & Roberts 2006, 2007, Harrison et al 2010).

Danish historiographer Kristian Kaalund undertook archaeological and historical research of the farm as early as the 19th c (Vésteinsson, 2001:7).

In the 19th c., a pagan burial mound (Kuml) was unearthed. This suggests that the area was settled (at least that people were buried there) before the year 1000 AD (Vésteinsson, 2001:10).

Guðmundur Ólafsson of the National Museum of Iceland surveyed the area in 1985 and registered a series of archaeological sites.

Work done by Fornleifastofnun Íslands:

- 2001 – Orri Vésteinsson, Extended archaeological survey and site registration that includes a summary of Möðruvellir´s history (Vésteinsson, 2001).
- 2004 – Howell Roberts & Orri Vésteinsson, Excavation of the Möðruvellir farm boundary trenches in advance of construction works (Roberts, 2004).
- 2005 - Howell Roberts, excavation of an evaluation trench in the churchyard; investigative work prior to planned ground works for central heating and path construction (Roberts, 2005)
- 2006 – Howell M. Roberts and Ramona Harrison, excavation of an evaluation trench (TR 1) into the Öskuhóll (Harrison & Roberts 2006).
- 2007 – Howell M. Roberts and Ramona Harrison, extension of evaluation trench (TR 1) (Harrison & Roberts 2007).
- 2008 –Howell Roberts and Ramona Harrison, continuation of excavation in evaluation trench TR1, and evaluation of TR 2/2b.

This portion of the 2008 Möðruvellir Midden Excavation project was part of the 2008 – 2009: Gásir Hinterlands Project (GHP), directed by Harrison and Roberts (Harrison 2008b).
The **Gásir Hinterlands Project**, funded by a **Dissertation Improvement Grant through the US National Science Foundation** (OPP ARC 0809033, PI: Harrison), is aimed at improving our understanding of the interactions of local farming strategies affected by changing climate and ongoing human impact with medieval overseas trade and long distance exchange centered on Gásir. GHP also focuses on the long term human ecodynamics in this historically important part of Iceland, contributing to the reconstruction of a detailed Eyjafjörður historical ecology from first settlement to modern times.

Midden evaluation and excavation at Möðruvellir

Möðruvellir, formerly an Augustine monastery and for centuries a high status farm was undoubtedly connected with the high medieval Gásir trading site during that site's active period and throughout its own history maintained a central role in the Eyjafjörður economy and politics. Excavations at the deep midden deposit on the edge of the substantial farm mound at Möðruvellir were started in 2006. Evaluation trench 1 or TR1, excavated since 2006, had reached depths of over 2 meters and allowed the recovery of a substantial archaeofauna dating from the high medieval period to the 19th/20th c. Below well preserved materials from the most recent period, the TR1 midden unit encountered a dramatic rise in soil acidity (a general local pH value around 6 dropped to a highly acidic 3.5) resulting from a massive concentration of peat ash in the lower layers.
While this acidic depositional environment effectively preserved several textile fragments, very little bone survived from the lowest excavated layers. The horizontal expansion of TR1 in form

of TR 2/2b succeeded in recovering additional c. artifacts and well preserved animal bone, but rapidly encountered substantial structural remains probably associated with 19th -20th c farm buildings. The more centrally placed TR 2/2b trench with a total size of 3 m (width) and 2 m (length) six meters east of TR 1 proved a good source of evidence for Early Modern midden activity at Möðruvellir. A trench dug for metrological research station at Möðruvellir was encountered and TR. 2 had to be moved 1 m north from its previous location for reasons of safety and stratigraphy. The few TR 2 materials retrieved were not found to have been compromised by the placement of the power line. The new trench, TR2b, revealed Early Modern structural remains and excavation had to be discontinued to avoid damaging these extensive and well preserved structural layers.
An excavation of structural remains from Möðruvellir is very desirable, but it was not part of the project goals, as an open area excavation of the farm mound would require far more funding available at that time.

Figure 2 clearly shows that TR1 and TR2/2b are relatively small areas sampling this large archaeological complex. Continued sampling of the midden and also excavation of the farm mound can improve the sampling bias. The samples that could be retrieved to date are however are large enough to offer a glimpse into people's lives at Möðruvellir.

Materials and Methods

All the midden materials were dry-sieved through 4mm mesh and where applicable materials were targeted for whole-soil sampling for post-excavation analysis, in accordance with NABO recommendations to study plant remains, industrial activities, and other aspects of the site formation process.
The faunal materials were processed at the CUNY Northern Science & Education Center (NORSEC) laboratories in New York City and Brooklyn. Recording and data curation followed the NABONE protocols followed for other archaeofauna from Iceland, Faeroes, Greenland, and northern Norway (NABONE, 2009, see www.nabohome.org for downloadable version 9). Following widespread North Atlantic tradition, bone fragment quantification makes use of the Number of Identified Specimens (NISP) method (Grayson 1984). Mammal measurements follow von den Driesch, (1976) and von den Driesch & Boessneck (1974), fish metrics follow Wheeler and Jones (2005) fish identifications follow FISHBONE 1.1 (2004, also at www.nabohome.org), bird identifications follow Cohen and Serjeantson (1996, 2nd Ed.), and Serjeantson (2009) and sheep/goat distinctions follow Boessneck, (1969) and Mainland and Halstead (2005), and Zeder and Pilaar (2010). Research on sheep/goat specimens from the AMNH Mammology Department further helped analyze and distinguish ovi/caprine mandibles when possible. Tooth-wear stage studies follow Grant (1982) and long-bone fusion stage calibrations follow Reitz and Wing (1999), with overall presentation of age reconstruction following Enghoff (2003).

Midden Chronology

The Harris Matrix in Appendix 1 indicates the various phases mentioned below:

Phase 4 – TR1 and TR2/2b

The midden layers from this phase were dated based on artifacts, with glass and ceramics providing the best temporal indicators (Lucas 2010).
Lucas was able to date the faunal and other materials from TR1 to ca. 1840-early 1900s; TR2/2b materials had a terminus *post quem* of ca. 1870, and thus provide a slightly later date of c. 1870s-early1900s. The label Phase 4 will be used interchangeably with '$19^{th}/20^{th}$ $19^{th}/20^{th}$ $19^{th}/20^{th}$ c. deposits' throughout this report. The archaeofauna from the upper most portion of the midden thus gives insight into a very recent part of Icelandic history and archaeology (Karlsson 2000).

Phase 3 – TR1

The middle portion of the Möðruvellir Midden Trench produced materials dating from about the Icelandic post-medieval (ca. 1550s – 1700s) to the Early Modern period (ca. 1700s-1900s). Additional radiocarbon dating done on faunal remains will allow for more specific phasing of this part of the collection, but a relative chronology based on stratigraphy and artifact analysis currently suggests these midden materials were deposited earlier in time than the ones from Phase 4 above and more recently than the ones from Phases 1 and 2 below. The label Phase 3 will be used interchangeably with 'post-medieval/Early Modern period' throughout this report.

The Gásir Hinterlands Project was able to locate a second site from Hörgárdalur providing a second post-medieval/Early Modern archaeofauna from the inner valley highland site of Myrkárdalur (Harrison et al 2010, Harrison 2011a).
Both sites' faunal remains from these periods are poorly preserved. The Myrkárdalur archaeofauna has not been included in this report.

Phases 1 and 2 - TR1

The lowest midden materials excavated from Möðruvellir were radiocarbon dated and can be placed into a time frame between the 13^{th} c. – early 15^{th} c. These lower faunal collections are thus contemporaneous with ones collected from the medieval trading station at Gásir, located along the coast some 3 km further southeast. Recent analysis of the Oddstaðir midden materials further in the Hörgárdalur interior (Harrison 2011b) provides another contemporaneous set of faunal remains.
Future work on the medieval archaeofauna from Möðruvellir will include comparisons with these two sites´ contemporaneous faunal remains. This report concentrates predominantly on gaining a better understanding of the Möðruvellir archaeofauna.

Phase 2: early 14^{th} – early 15^{th} c, (calAD)
Faunal materials from context [120] and above were all more clearly dated to a slightly later period than the ones below, with the exception of context [077], whose 13^{th} c. faunal remains

will only be included into general Phase 1 and 2 discussions, but not when discussing different trends observed between Phase 1 and Phase 2.
Phase 2 radiocarbon dates fall between ca. *the early 14th – the early 15th c.*, and faunal and other material remains from the included deposits are part of this later medieval period following Phase 1.

Phase 1: mid-13th – early 14th c, (calAD)
The radiocarbon multi-plot in figure 3 indicates a mid-13th – early14th date range for context [129], the stratigraphically lowest deposit excavated from TR1. Thus, contexts physically under the more recent context [120], fall into an earlier time period and were grouped into midden phase 1, dating from ca. *13th – early 14th c***.**

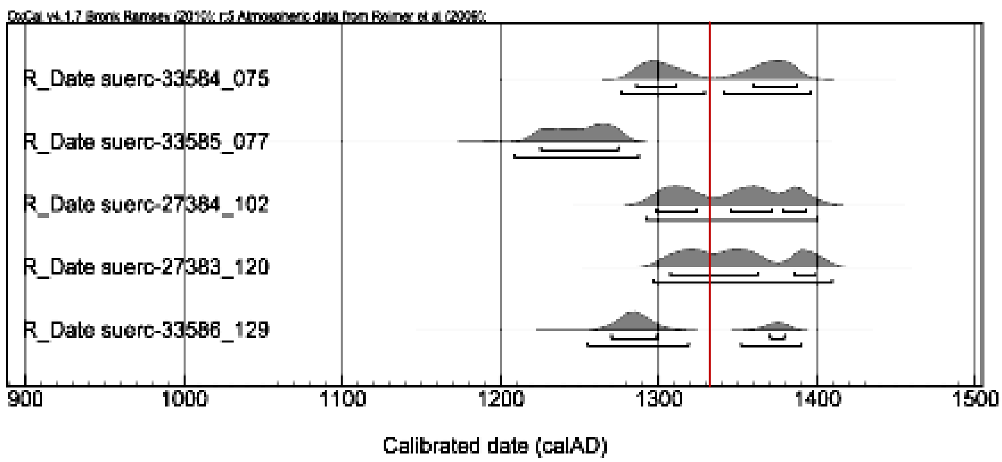

Figure 3. Möðruvellir Midden Trench I, Phase 1 and 1b Radiocarbon dates, the red line indicates division between the two medieval data sets (https://c14.arch.ox.ac.uk/oxcal/OxCal.html, v. 1.6, Bronk Ramsey 2010, Atmospheric data from Reimer et al. 2009).

- Context [077]

As mentioned, except for the one date from context [077], all radiocarbon dates from Phase 2 fall between the early 14th c. to the early 15th c. Materials from context [077] may represent reworked midden contents and are likely from a slightly earlier activity period associated with Phase 1.

Context [077] is described as '*orange-gray peat ash*' deposit. Not artifacts or textiles were registered from it, and the bone count from this context is small. Despite providing a slightly earlier date than the two contexts below it, the faunal materials still fall within the high medieval period and can be included in general statements on the entire medieval (Phases 1 and 2) archaeofauna.

SUERC #	GU #	Phase	Cont. #	Radiocarbon years BP	Age error	2 SIGMA (95.4 %) probability	1 SIGMA (68.2 %) probability	δ13C (‰)	δ15N (‰)
33584	23515	2	075	655	35	1276(45.8%)1329calAD 1341(49.6%)1396calAD	1286(32.1%)1311calAD 1360(36.1%)1387calAD	-21.9	5.60
33585	23516	1 & 2	077	770	35	1209(95.4%)1287calAD	1225(68.2%)1275calAD	-22	5.80
27384	20698	2	102	620	30	1292(95.4%)1400calAD	1298(27.3%)1324calAD 1346(26.7%)1371calAD 1379(14.1%)1393calAD	-20.3	8.10
27383	20697	2	120	600	30	1297(95.4%)1409calAD	1307(55.1%)1362calAD 1386(13.1%)1399calAD	-21.6	3.50
33586	23517	1	129	700	35	1255(72.0%)1319calAD 1352(23.4%)1390calAD	1270(57.5%)1299calAD 1370(10.7%)1380calAD	-21.1	4.00

Table 1. Phase 1; Isotopic data from analysis of C14, d13C, and d15N on animal bones and teeth (cattle and ovi/caprine), data made available by Dr. Gordon Cook and Dr. Philippa Ascough in February 2010 (SUERC#s 27384 and 33586) and March 2011; C14 calibration by Bronk Ramsey (https://c14.arch.ox.ac.uk/oxcal/OxCal.html, v. 1.6, Bronk Ramsey 2010, Atmospheric data from Reimer et al. 2009).

Results from the stable isotopes analysis are part of a larger investigation of the local and regional variation in Nitrogen levels and a study of the Marine Reservoir Effect as observed in marine and also fresh water resources (Ascough et al 2006, 2010).

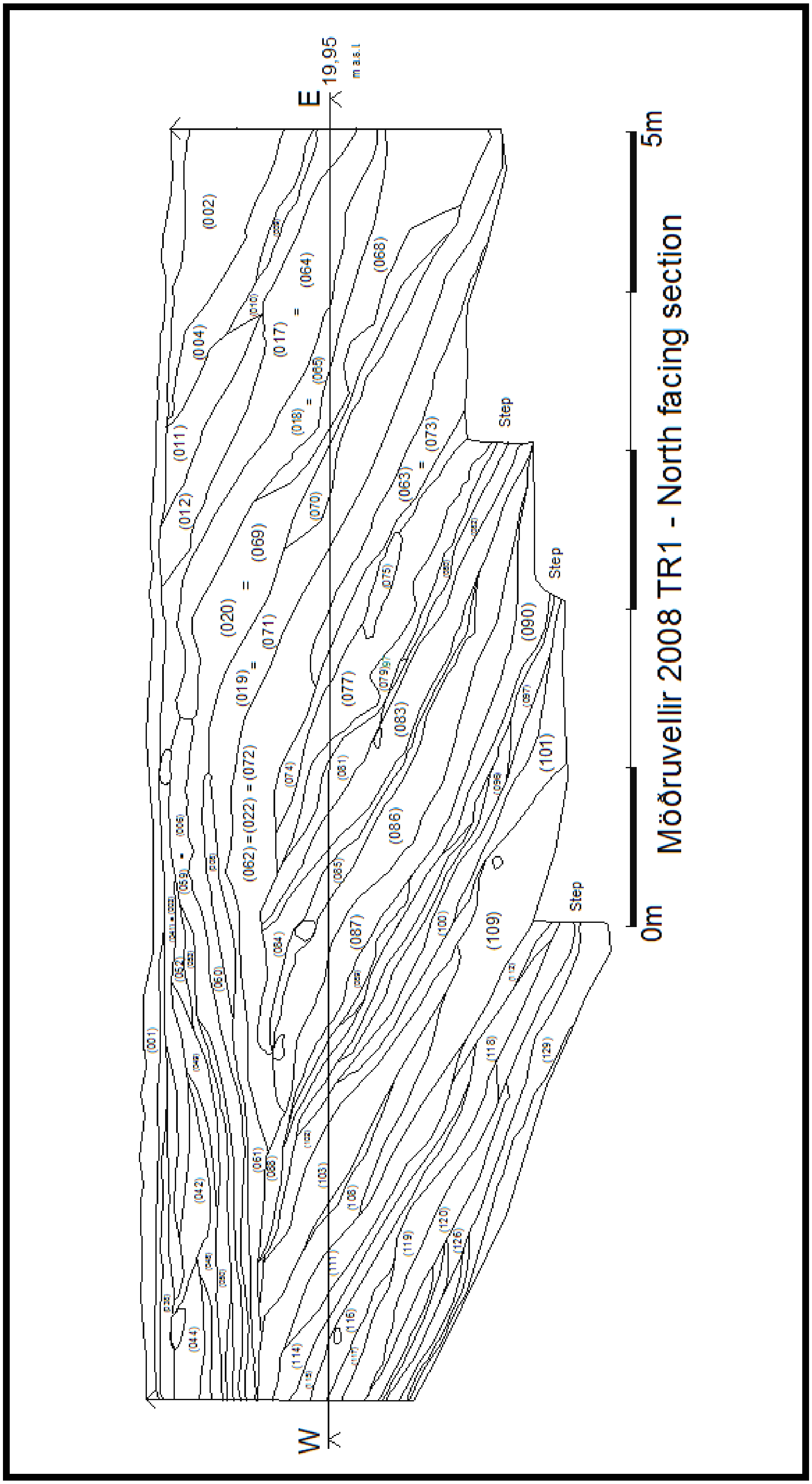

Figure 4. Möðruvellir Trench 1, North facing Section


Figure 5. Left: Möðruvellir TR1, Segment of northern profile. Right: Möðruvellir TR2b, viewed toward east.

The Möðruvellir archaeofauna

This NORSEC report presents a general overview on the faunal remains recovered from TR 1 and TR2/2b.
Circa 95% of the excavated Möðruvellir archaeofauna have been analyzed, resulting in an initial idea of site formation processes based on a sample of the deeply stratified midden mound. As mentioned in the introduction, the basal most midden layers could not be reached due to reasons of safety. Should there be a future attempt at reaching the basal midden layers, it is likely that the farm mound layers will have to be sampled also during this process.

Overview of Species Present

The Möðruvellir Midden Total Number of Fragments (**TNF**) count is **26,332**, with a Number of Identified Specimens (**NISP**) of **8,005.**
The bone preservation in the Early Modern layers is excellent but increasingly degraded in the earlier midden deposits. Centuries of peat and wood ash dumping episodes have created a highly acidic midden environment, leaving occasional bone butter behind in the basal layers encountered. In contrast, textile remains (analyzed by Michele Smith) could be retrieved from those layers where bone collection was problematic.

Further division of the total NISP according to phase results in:
- Phase 4 = a *NISP of 6,466;*
- Phase 3 = a *NISP of 302;*
- Phase 2 = a *NISP of 1,04;*
- Phase 1 = a *NISP of 150.*

<u>Context [077]</u> faunal analysis resulted in a *NISP of 42*.

The poor bone preservation in Phases 1, 2, and especially 3 vs. Phase 4 will be discussed later and is indicated by the TNFs vs. NISPs counted:

- Phase 1 had a TNF of 772; 19 % of that archaeofauna could be identified to family or species.
- Phase 2 had a TNF of 5,520; 19 % of that archaeofauna could be identified to family or species.
- Phase 3 had a TNF of 9,447; less than 5 % (3.2 %) of the faunal remains could be assigned to family or species level.
- Phase 4 had a TNF of 10,430; close to 2/3 (62 %) of that assemblage could be identified to family or species level.

In all four phases, the domesticate category was dominated by **caprines. Cattle** element numbers vary quite markedly between Phase 4 and the early phases. The Phase 4 domesticate archaeofauna only contained 7.83 % of cattle bone, while that of Phase 3 contained 21.69 %, and the medieval one 25.03 % of the domesticate group, with 27.3 % for Phase 2, and 10 % for Phase 1.
No pig remains were analyzed. This could be partially due to the poor bone preservation in phases 1, 2 and 3, but survival of skull or dental remains could be expected had a number of these animals been present or at least consumed on site. Except for Phase 1, **horse** bones were noted in all phases, most elements were teeth.
Phase 2 contained the only **dog** bone found in the collection; there were a number of bones in all phases but Phase 1, bearing dog **tooth marks**, especially in Phase 4. One of the Phase 4 elements showed tooth marks resulting from rodent gnawing (context [004].

Few **cetacean** and **seal** bones were recovered from Phases1 and 4; none could be analyzed to species level, but three were placed into the more specific porpoise/dolphin sized category.
No other **wild mammal** bones were analyzed from the Möðruvellir Midden.

Bird bones from Phases 2 and 4 were mostly from Auks; many could be analyzed to Uria sp. Level, and are either from Guillemot (*Uria aalge*) or Common Murre (*Uria lomvia*). These two phases also contained several Ptarmigan elements. Phase 4 contained the majority of an articulated Mallard skeleton (context [006]). The few birds grouped to species or family level in Phase 3, however, were Eider and Swan. Despite making up the smallest NISP number out of the three Phases, the Phase 3 birds take up a higher relative proportion of the total NISP collection than the avians in the other two phases.

Fish bone proportions differ quite clearly between Phase 1 (41.33 % of total archaeofauna) and Phase 2 (17.13 % of total archaeofauna), to increase slightly again for Phase 3 (21.19 % of total archaeofauna), to peak in Phase 4 (83.94 % of total archaeofauna), coinciding perhaps to some degree with a better bone preservation in the upper most phase. In contrast, with a small NISP as in Phase 1 and 3, the relative fish percentages get inflated somewhat. A clear decline in cattle consumption over time and possibly a marked shift from mammals to fish as major food supply resources can be observed from the multi-period faunal collections. It is possible that Möðruvellir was increasingly preparing fish caught in large numbers in Eyjafjörður during the $18^{th}/19^{th}$ c.

Mollusk proportions in all phases are below 10% of the total NISP counts, with Phase 3 producing the relatively highest percentage despite a low total NISP number. The mollusk species analyzed to species level the most frequently was the hard shell clam.

Table 2 presents the Möðruvellir archaeofauna as a Total Count. NISP (number of identified specimens) refers to all fragments that could be identified to a useful level. Here, only the major historic phases are compared: medieval, post-medieval/Early Modern, 19^{th}/20^{th} c. The medieval phase then is divided further into the Phase 1 and 2 data in table 3.
TNF is a count of all bone fragments (identifiable or not), MTM is “medium terrestrial mammal” (sheep-dog-pig sized), LTM is “large terrestrial mammal” (cattle-horse sized), MM is an “unidentifiable marine mammal” (i.e. whale, dolphin, walrus, seal), UNIM or unidentified mammal are small fragments that cannot be identified beyond this broad category. UNI or unidentifiable bone fragments simply indicate the existing degree of erosion.

Möðruvellir - Element Counts	**Midden Phases**							
Taxon	**Phases 1 & 2 - medieval**		**Phase 3 – post-medieval/Early Modern**		**Phase 4 – 19th/20th c.**		**All Phases Total NISP**	
Human *(Homo sapiens)* - 1 lower permanent molar					1 - not included in NISP count			
Domestic mammals	NISP	% NISP	NISP	% NISP	NISP	% NISP	NISP	% NISP
Cow (Bos taurus (L.))	228	18.43	41	13.58	71	1.10	340	4.25
Horse (Equus caballus (L.))	4	0.32	2	0.66	2	0.03	8	0.10
Dog (Canis lupus fam. (L.))	1	0.08					1	0.01
Goat (Capra hircus (L.))	2	0.16			6	0.09	8	0.10
Sheep (Ovis aries (L.))	33	2.67	14	4.64	85	1.31	132	1.65
Unidentified caprine	638	51.58	132	43.71	736	11.38	1,506	18.81
Total caprine	673	54.41	146	48.34	827	12.79	1,646	20.56
Total domestic	906	73.24	189	62.58	900	13.92	1,995	24.92
Wild Mammals								
Large seal	1	0.08					1	0.01
Unidentified seal species	2	0.16		0.00	8	0.12	10	0.12
Small cetacean / Porpoise or Dolphin	1	0.08		0.00	2	0.03	3	0.04
Unidentified whale species	1	0.08					1	0.01
Total wild mammal	5	0.40		0.00	10	0.15	15	0.19
Birds								
Guillemot sp. (Uria sp)	15	1.21			2	0.03	17	0.21
Auk family (Alcid sp.)	5	0.40			1	0.02	6	0.07
Eider (Somateria molissima (L.))			2	0.66			2	0.02
Mallard ((Anas platyrhynchos (L.))				0.00	1 (33)	0.02	0	0.00
Swan sp. (Cygnus sp.)			1	0.33			1	0.01
Goose sp. (Anser sp.)	1	0.08					1	0.01
Dom. chicken (*Gallus gallus (L.)*)					4	0.06	4	0.05
Ptarmigan (grouse) (*Lagopus muta (Montin))*	2	0.16			3	0.05	5	0.06
Unidentified bird species	23	1.86	23	7.62	45	0.70	91	1.14
Total bird	44	3.56	27	8.94	56	0.87	127	1.59
Fish		0.00		0.00		0.00	0	0.00
Cod (*Gadus morhua* (L.))	4	0.32	7	2.32	1,050	16.24	1,061	13.25
Haddock (*Melanogrammus aeglefinus* (L.))	29	2.34	2	0.66	480	7.42	511	6.38
Saithe (*Pollachius virens* (L.))	2	0.16	1	0.33	11	0.17	14	0.17
Cusk (*Brosme brosme* (L.))					1	0.02	1	0.01
Atlantic Halibut (*Hippoglossus hippoglossus* (L.))			1	0.33			1	0.01
Gadid species	86	6.95	23	7.62	1,211	18.73	1,320	16.49
Wolfish (*Anarhichas lupus* (L.))					33	0.51	33	0.41
Trout (*Salmo trutta* (L.))					1	0.02	1	0.01
Fish non-speciated	128	10.35	30	9.93	2,640	40.83	2,798	34.95
Total fish	249	20.13	64	21.19	5,427	83.93	5,740	71.71
Mollusca								
Soft shell clam (Mya spp.)					5	0.08	5	0.06

Hardshell clam (*Arctica islandica (L.)*)	23	1.86	4	1.32	18	0.28	45	0.56
Mussel (*Mytilus edulis* (L.))					15	0.23	15	0.19
Periwinkle species (Littorina sp.)		0.00	1	0.33			1	0.01
Common whelk (*Buccinum undatum (L.)*)	2	0.16			2	0.03	4	0.05
Whelk sp. (*Buccinidae*)	1	0.08			1	0.02	2	0.02
Unidentified mollusc species	7	0.57	17	5.63	32	0.49	56	0.70
Total mollusca	33	2.67	22	7.28	73	1.13	128	1.60
Total Number of Identified Species	**1,237**	**100**	**302**	**100**	**6,466**	**100**	**8,005**	**100**
Large terrestrial mammal	255		99		124		478	
Medium terrestrial mammal	678		676		1,077		2,431	
Small terrestrial mammal			3				3	
Unidentified mammal fragments	4,270		8,259		2,756		15,285	
Unidentified marine mammal fragments					5		5	
Unidentified fragment	15		108		2		125	
Total number of fragments	*6,455*		*9,447*		*10,430*		*26,332*	

Table 2. Möðruvellir archaeofauna listed by taxon/phase.

The Phase 1 data displayed in table 2 is broken down into Phase 1, Phase 2, and Context [077] in table 3 below.

Möðruvellir - Element Counts	Midden Phases						Total Medieval NISP
Taxon	Phase 1, 13th - early 14th c.		Phase 2, early 14th - early 15th c.		Context [077] - 13th c.		Total
Domestic mammals	NISP	% NISP	NISP	% NISP	NISP	% NISP	NISP
Cow (Bos taurus (L.))	8	5.33	217	20.77	3	7.14	228
Horse (Equus caballus (L.))			4	0.38			4
Dog (Canis lupus fam. (L.))			1	0.10			1
Goat (Capra hircus (L.))			2	0.19			2
Sheep (Ovis aries (L.))	1	0.67	30	2.87	2	4.76	33
Unidentified caprine	71	47.33	541	51.77	26	61.90	638
Total caprine	72	48.00	573	54.83	28	66.67	673
Total domestic	73	48.67	795	76.08	31	73.81	899
Wild Mammals							
Large seal			1	0.10			1
Unidentified seal species			2	0.19			2
Small cetacean / Porpoise or Dolphin			2	0.19			2

Total wild mammal			5	0.48			5
Birds							
Guillemot sp. (Uria sp)			15	1.44			15
Auk family (Alcid sp.)			5	0.48			5
Goose sp. (Anser sp.)			1	0.10			1
Ptarmigan (grouse) (Lagopus muta (Montin))			2	0.19			2
Unidentified bird species	4	2.67	15	1.44	2	4.76	21
Total bird	4	2.67	38	3.64	2	4.76	44
Fish							
Cod (Gadus morhua (L.))	2	1.33	2	0.19			4
Haddock (Melanogrammus aeglefinus (L.))	3	2.00	25	2.39	1	2.38	29
Saithe (Pollachius virens (L.))			2	0.19			2
Gadid species	19	12.67	65	6.22	2	4.76	86
Fish non-speciated	38	25.33	85	8.13	5	11.90	128
Total fish	62	41.33	179	17.13	8	19.05	249
Mollusca							
Hardshell clam (Arctica islandica (L.))			22	2.11	1	2.38	23
Common whelk (Buccinum undatum (L.))	1	0.67	1	0.10			2
Whelk sp. (Buccinidae)			1	0.10			1
Unidentified mollusc species	3	2.00	4	0.38			7
Total mollusca	4	2.67	28	2.68	1	2.38	33
Total Number of Identified Species	**150**	**100**	**1,045**	**100**	**42**	**100**	**1,237**

Table 3. Möðruvellir medieval archaeofauna listed by taxon.

Major Taxa

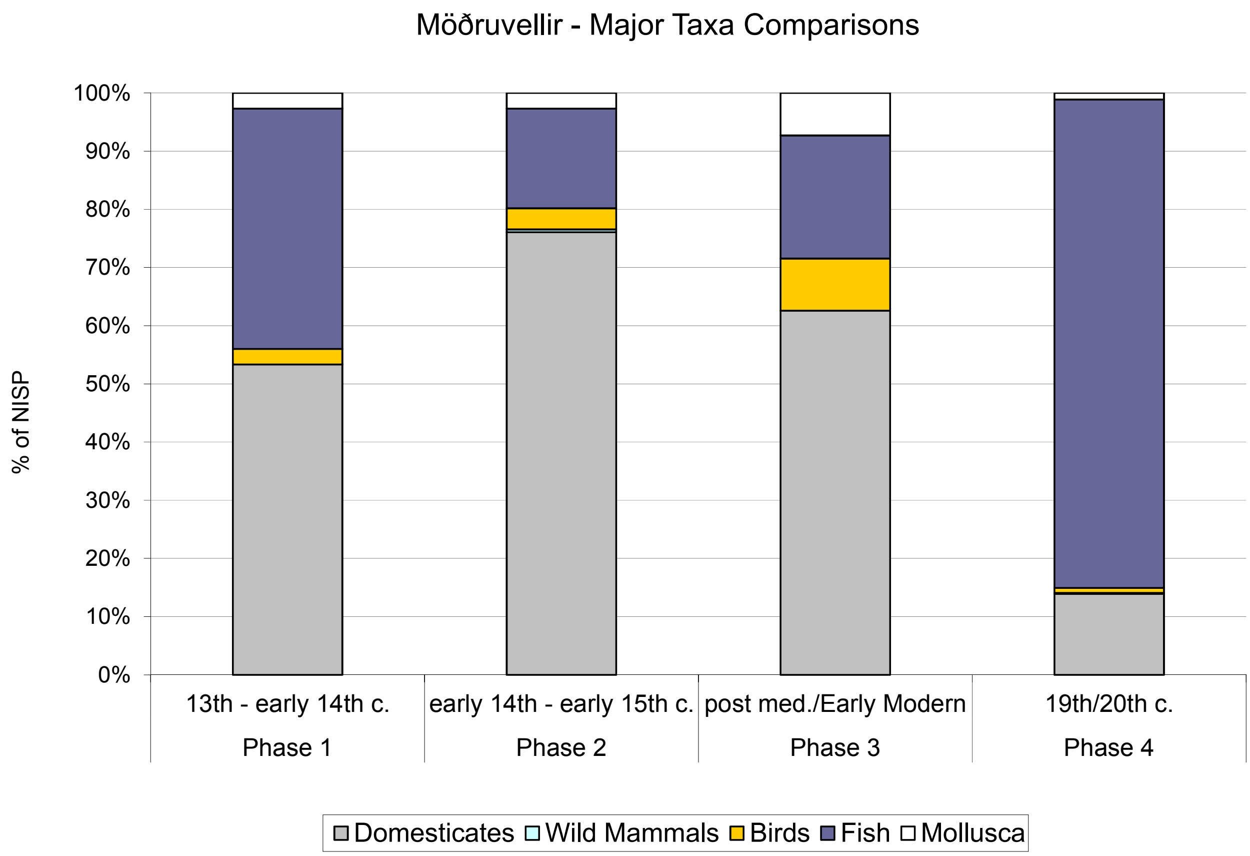

Figure 6. Möðruvellir major taxa graph.

The major taxa graph indicates domesticate proportions much higher in the medieval phases and also the post-medieval/Early Modern one than in the 19th/20th c. collection. Besides the obvious taphonomic issues, this is also an observable change in food source utilization. The low number of fish remains (except for Phase 1) in the earlier deposits indicates partially the preservation stage of those faunal remains (see burning, fragmentation and butchery discussions below), but there may have been a relatively smaller amount of fish present to begin with. Possibly, the fish bones were discarded at higher numbers elsewhere as the trenches dug into the large midden and farm mound areas only provide samples of all the materials deposited there. Alternatively, there may simply have been less fish consumed relative to domesticates during the earlier phases. Usually, gadid fish bones survive relatively well, even in poorly preserved contexts. They do, however, not withstand acidic soil conditions well (Wheeler and Jones 1989:63), and the ph levels for the lower Möðruvellir midden deposits were below 6 to 3.5.

Even if a portion of the missing fish can be explained through Taphonomy for phases 1, and especially 2 and 3, the fact that a large number of domesticates/mammals are preserved tells us that there is also an element of active decision making involved prior to either consumption or deposition of these taxa and before post-depositional taphonomic processes took place. Relatively high numbers of i.e. sheep/goat and cattle bones are still available from the two lower midden phases. While there is a difference in bone preservation quality, and while a large proportion of the upper midden bones could be analyzed to species and family level, the low number in cattle remains there compared to especially Phase 2 and Phase 3, but even the Phase 1 domesticate assemblage, is one indicator for changes in the occupants' consumption patterns over time.

Comparing the Möðruvellir cattle vs. caprine proportions, those from Phase 1 and Phase 4 are the most similar in relative terms, with a caprine percentage of 90 and 91.22, respectively.

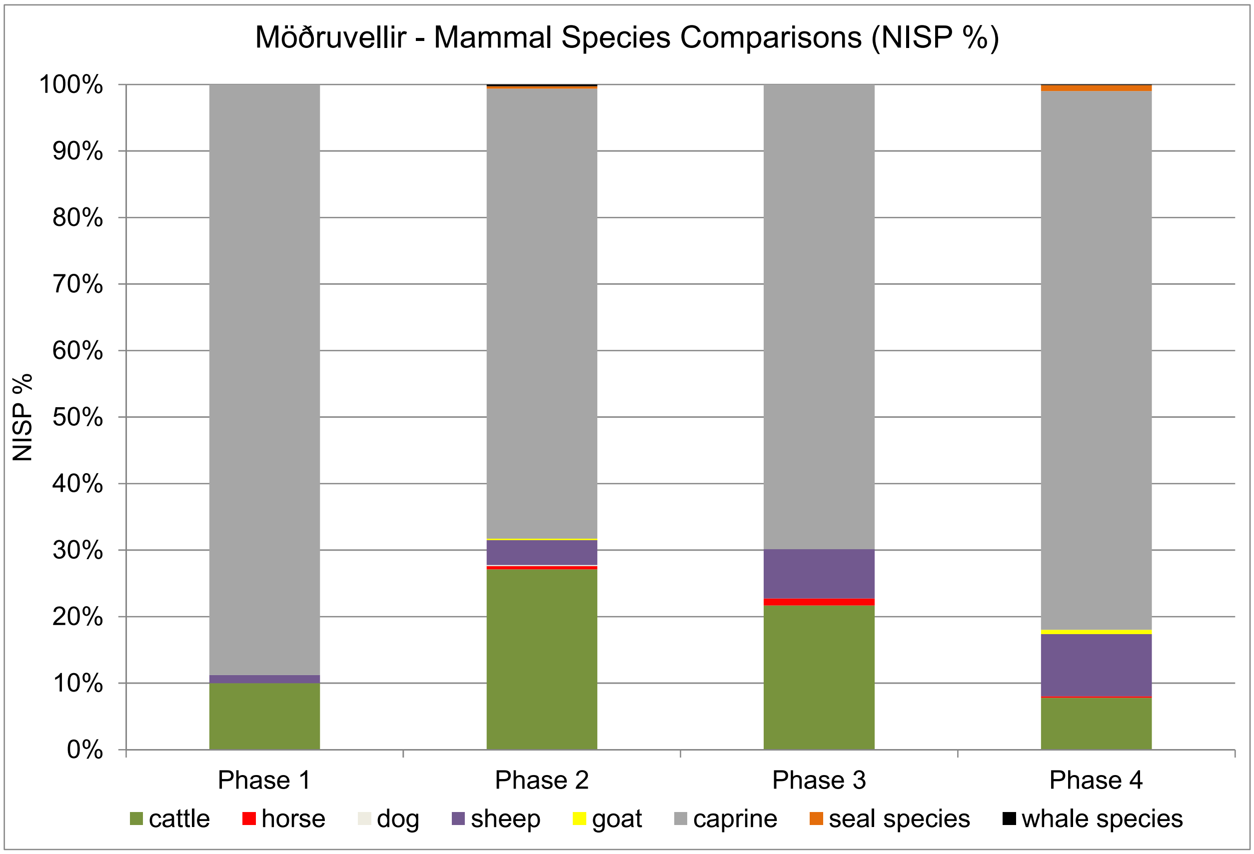

Figure 7. Möðruvellir mammal species distributions.

Domesticates

As in indicated already in the comparative mammals graph above, the relative proportion of cattle vs. caprines changes over time, with cattle numbers declining to below 10 % in the $19^{th}/20^{th}$ c.. Even the small NISP for the post medieval/Early Modern phase containing the middle midden layers indicates a much larger proportion of cattle than the most recent phase. In general, a medieval Icelandic farm with a caprine vs. cattle ratio of 3:1 as suggested for Phase 2 in figure 7, was likely of medium to high social standing, as it became harder and harder to maintain expensive cattle during the ever more unpredictable winter seasons (McGovern et al 2004, 2007, 2009, Harrison 2010a,b, 2006).

A few goat elements were collected from even the most recent period, whereas they generally disappeared in many areas of the post-medieval Icelandic farm economy (McGovern et al 2004, 2007, 2009). The differences in faunal preservation at the Möðruvellir Midden Mound do not allow for a stronger statement, as many of the elements from the medieval phase lumped into the ovi/caprine category might have been determined to be either goat or sheep species had they been in better preservation states. Therefore, the proportion of sheep vs. goat elements of ca. 14:1 in Phase 4 may be an accurate estimate of the actual ratios of these animals present on the estate during that time period

Taxon	Phase 1		Phase 2		Phase 3		Phase 4	
	NISP	% group	NISP	% group	NISP	% group	NISP	% group
Bos taurus (L.)	8	10.00	217.00	27.30	41	21.69	71	7.89
Equus caballus (L.)	0	0.00	4.00	0.50	2	1.06	2	0.22
Sus scrofa (L.)								
Canis familiaris (L.)	0	0.00	1.00	0.13		0.00	0	0.00
Capra hircus (L.)	0	0.00	2.00	0.25		0.00	6	0.67
Ovis aries (L.)	1	1.25	30.00	3.77	14	7.41	85	9.44
Ovis/Capra sp.	71	88.75	541.00	68.05	132	69.84	736	81.78

Table 4. Möðruvellir element count and relative % of domesticates per phase

The complete absence of pig bones from all phases is a very clear indicator that at least on this estate pork was not consumed in sizeable numbers, if at all. An important religious institution may have not condoned pork consumption.

Faunal analysis did not determine whether the one dog element recovered from the later medieval layers was the result of consumption. No butchery marks were observed on the element; it may have been randomly deposited on the midden.

Very occasional consumption of horse meat is indicated by the very low numbers of horse bones found in all the midden layers. In contrast, the people at Möðruvellir left considerable amounts of bovine and caprine bones as evidence for consumption of those species, as is usual for midden materials associated with Icelandic farms.

Reconstructing Domesticate Mortality Patterns

Cattle

Cattle neonatal comparisons

With a considerable number of cattle remains recovered from Möðruvellir lower levels (Phase 1), a comparison of this site's neonatal elements vs. other contemporaneous ones is presented in the graph below. The figure caption locates the various faunal collections in general time and place. With exception of the special-purpose sites at Gásir (trading center) and Bessastaðir (Seat of the Governor for the Danish Crown) (McGovern 1990, Amorosi et al 1992), and the 11th-13th c. lower status farms at Skuggi in Hörgárdalur (Harrison 2010a,b) and Sveigakot (McGovern et al 2004, 2007), and Steinbogi (Brewington et al 2004) in Mývatnssveit , all the sites mentioned were mid to high status farm estates (Stóraborg - Amorosi 1996, Hofstaðir – i.e. McGovern et al. 2009) at times associated with religious institutions (Víðey – Amorosi 1996).

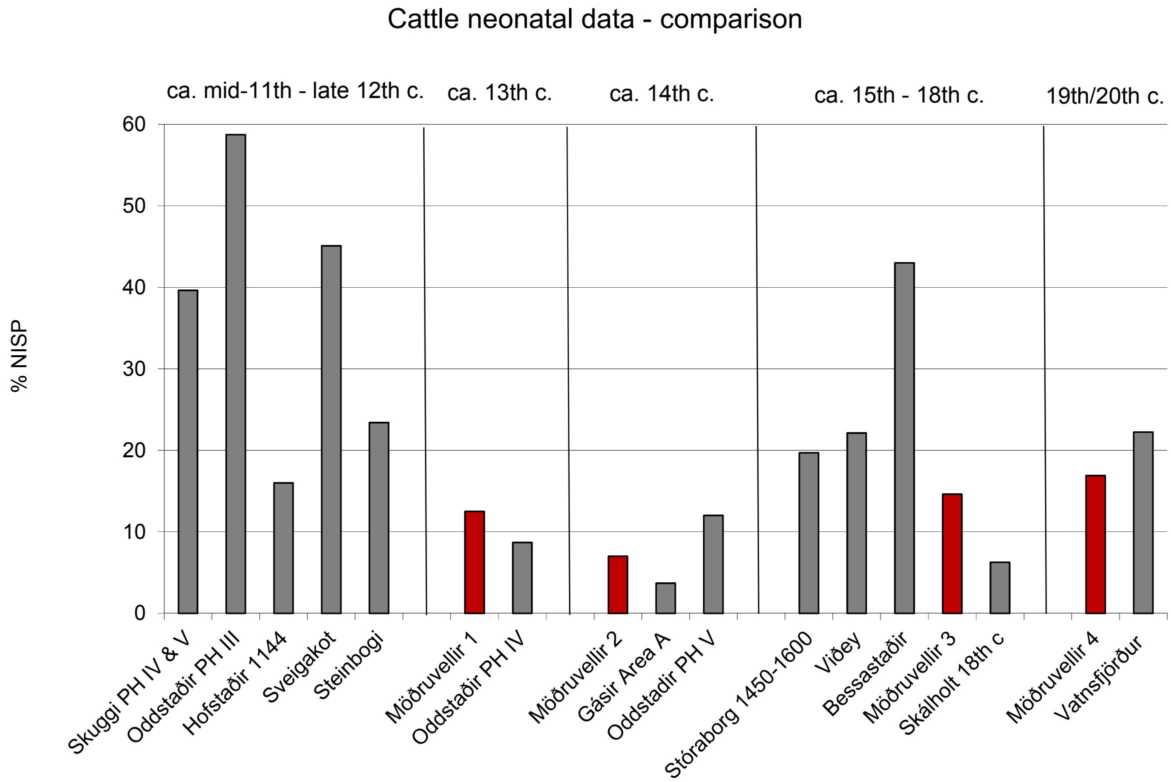

Figure 8. Möðruvellir bovine neonatal data.

Figure 8 presents a relative percentage of neonatal (newborn) calf bones in a number of sites from N and S Iceland. A range of ca. 15-50 % neonates among the total cattle bone count is generally interpreted as evidence of dairy herd management, with most milk being reserved for humans (Halstead 1998). The data presented here (red bars) suggests the Möðruvellir farm was not keeping the cattle whose elements were analyzed to date for primarily dairying purposes, at least not until the 19th/20th.

The graph compares the medieval Möðruvellir Midden fauna to sites within the region and in other regions of Iceland: contemporaneous Gásir and Oddstaðir collections (both Eyjafjörður); Stóraborg, Víðey, Bessastaðir, all later medieval mid-high status farm estates in the south of Iceland.
The post-medieval/Early Modern Möðruvellir archaeofauna is compared w. Early Modern faunal data from the high-status ecclesiastic farm estate at Skálholt.
The most recent Möðruvellir deposits are compared to the 19th/20th c. deposits from the high status Vatnsfjörður farm in the Icelandic Westfjords (NORSEC data used from VSF access database dating from 2007; this information will be updated with more recent work done by Celine Dupont-Hebert, U Laval). For earlier data from ca. 11th to 13th c., the lower status farm Skuggi in Eyjafjörður and the middle midden deposits from Oddstaðir, are compared to the post VA/earlier medieval layers at the church farm at Hofstaðir, and the lower status farms at Sveigakot and Steinbogi (all Mývatnssveit) are used for comparison (McGovern et al 2004, 2007, 2009, Harrison 2006, Harrison et al 2008, Hambrecht, 2007, Pálsdóttir et al 2008:4).

Compared to all other sites listed here, the Möðruvellir neonatal proportion of 3.51 % is the lowest one observed. A certain lack in neonatal bones due to taphonomic factors is to be considered, but the neonatal remains from the middle deposits at Möðruvellir, where the same bad faunal preservation exists (see TNF vs. NISP numbers above), demonstrate a clearly different pattern, with 14.63 % of neonatal cattle bones recorded. Also, the very well preserved faunal elements form the Oddstaðir midden trench presented in the same graph also suggest low percentages of cattle neonates during the 13th – early 15th c. Analysis of the 19th/20th c. Möðruvellir faunal collection resulted in a 16.90 % neonatal cattle proportion. Based on this data, at least the medieval faunal remains do not indicate large scale, on-site cattle dairying practices on this part of the Möðruvellir farm. The manorial estate had several animal winter shelters (i.e. Klausturhús, close to Skuggi in Hörgárdalur), tenant farms (possibly Skuggi in Hörgárdalur during the early medieval period), and also shieling sites (i.e. Möðruvallasel, also in Hörgárdalur). It is not known how long Möðruvellir may have owned Skuggi, if indeed it ever did. It is also not clear when Möðruvellir may have controlled the larger farmstead at Staðartunga, at present owning the land on which Skuggi and Klausturhús are located (for discussion on this issue see Harrison 2010a,b).
It is possible that the dairy products produced there and elsewhere in the valley were delivered to the Möðruvellir farm for consumption. This could have been so in payment of a church tithe from potentially independent farmsteads such as Oddstaðir (see for example Júlíusson 2007).

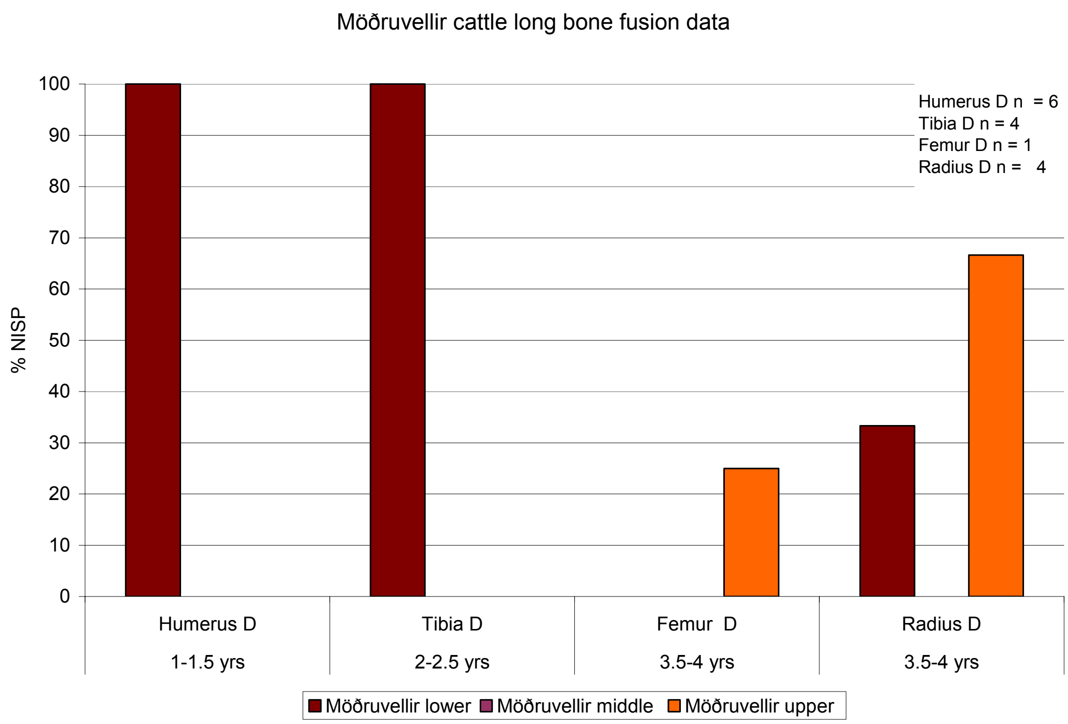

Figure 9. Möðruvellir cattle long bone fusion data. Möðruvellir lower = medieval phases (ca. 13th – early 15th c.); Möðruvellir middle = post-medieval/Early Modern phase; Möðruvellir upper = 19th/20th c.[1]
The text box indicates number of elements available per category. [2]

[1] This division into lower, middle, and upper midden phases will be continued throughout this report.

The combined number of Möðruvellir cattle elements available for long bone fusion analysis is 15. This low number does not allow for a discussion of the Möðruvellir cattle management based on the surviving long bone fragments. The most abundant yet still few (NISP = 10) c. elements suggest a 92 % survival of cattle beyond their 3rd and a 67 % beyond their 4th winter.
In this case, it may be more reliable to consult with documentary sources to learn about the farm's cattle economy.

The medieval data set is too small for any conclusions (NISP of 5 long bone fragments), except for a suggestion that 33 % of cattle survived their third winter. Since poor bone preservation favors preservation of certain elements over others, this pattern should not be accepted without caution.
The post-medieval/early modern cattle long bone data is completely absent. There, Jarðabók, an 18th c. land register (Magnússon & Vídalín, 1943) may be able to help gain a general idea about the period's farming strategies. Integration of these post-medieval information sources is planned for future research on Möðruvellir and Hörgárdalur long-term social, economic, and ecological developments.

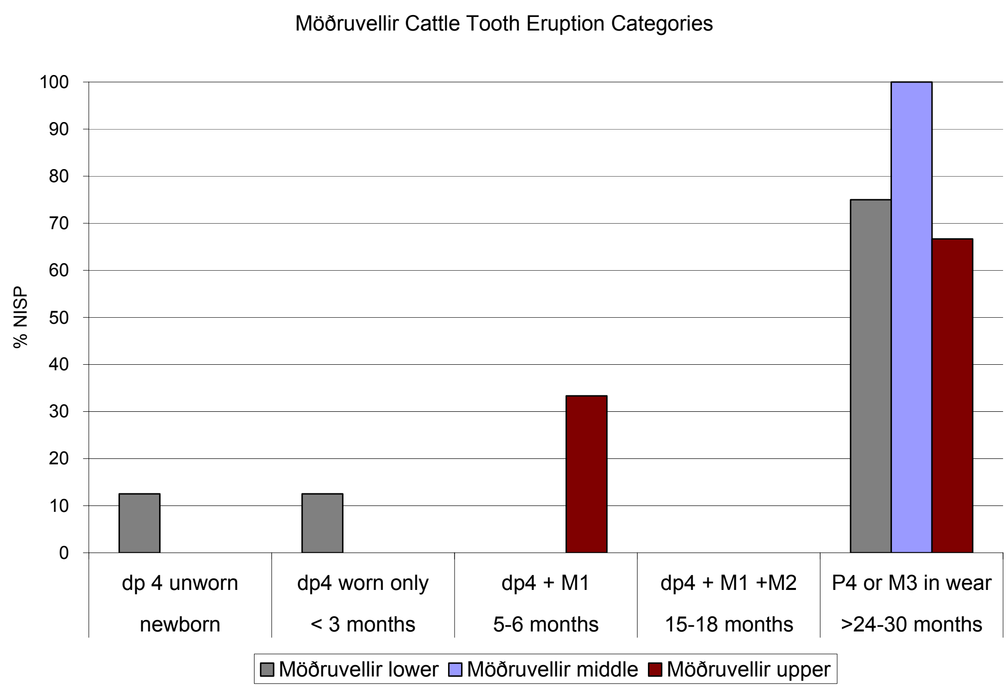

Figure 10**.** Möðruvellir cattle tooth eruption comparison.
Möðruvellir lower: NISP = 8; Möðruvellir middle: NISP = 1; Möðruvellir upper: NISP = 3.

Similar to the long bone fusion analysis, the Möðruvellir cattle teeth available for eruption analysis (for information on age calculations based on tooth eruption and wear stages see Hillson

[2] NB: For following portions of this Möðruvellir faunal report Phases 1 and 2 were lumped into the lower, or medieval phase, spanning a time period from ca. 13th – early 15th c. More work on discussing the medieval phases separately is planned for the future.

2005:223-253) were few in number. It is therefore not possible to suggest a general bovine age at death for the middle midden phase. With excellent bone preservation in the upper deposits, the very low number of usable cattle mandibular and maxillary elements available may be an approximate reflection of the very low cattle number recovered in total. The $19^{th}/20^{th}$ c. data indicate culling of 1/3 of the animals before their first winter, and the rest after their second winter. Numbers for the lower midden phase are higher and it seems that during medieval occupation of Möðruvellir, a majority of cattle (75 %) generally survived until past their second winter and third summer; with 12.5 % culled before, and another 12.5 % culled after their first summer.

The different age at death data presented above - despite preservation issues - suggest that cattle dairying was not practiced at a large degree at the then monastic medieval estate associated with the archaeofauna from Phase 1. Data sets for the post-medieval/Early Modern and $19^{th}/20^{th}$ c. collections are not suitable for any conclusion on the post-medieval cattle management strategy at Möðruvellir.
As already mentioned, Jarðabók and more recent farm registers may enhance the information available based on the faunal remains.

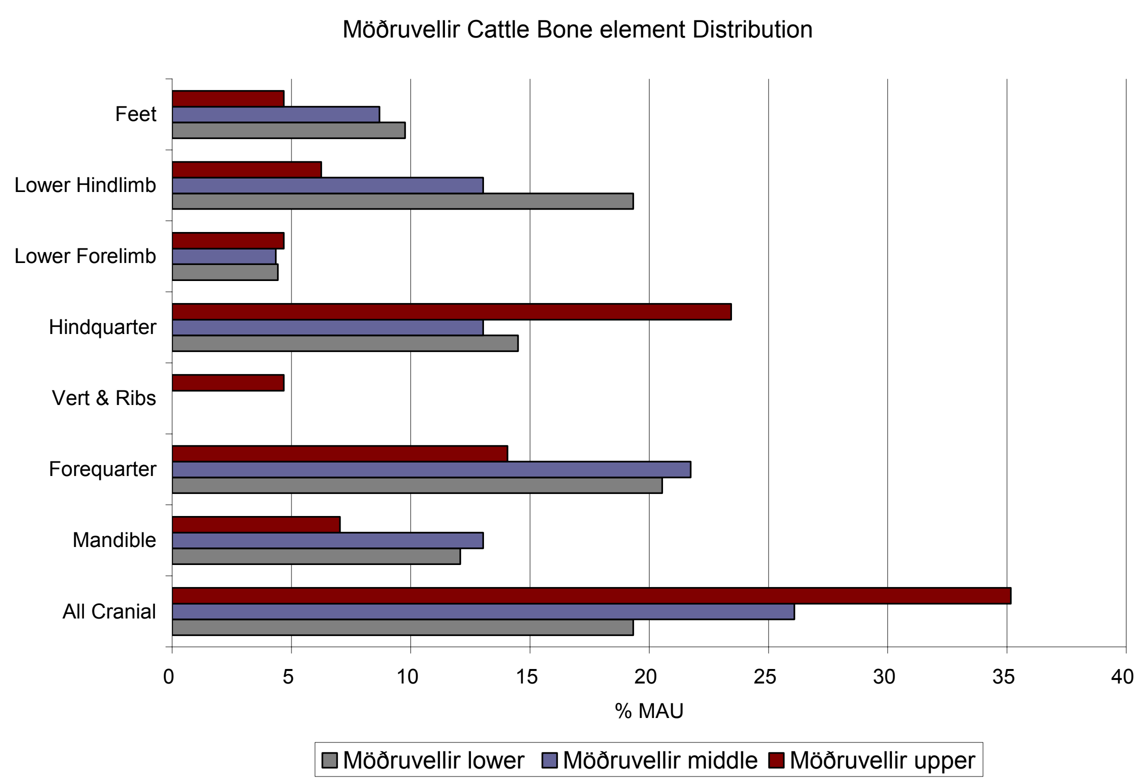

Figure 11. Möðruvellir cattle skeletal element distribution per phase. MAU is "the minimum number of animal units necessary to account for the specimens observed (Lyman 1994:511)."

Figure 11 presents the Möðruvellir bovine skeletal distribution by phase. Together with figure 12, this graph indicates which parts of the animals' skeleton were present in the midden layers. Missing data from the 'Vert & Ribs' category reflects the NORSEC practice of not assigning

vertebral elements (except for the very species-distinct axis and atlas) and ribs to specific faunal species or families, but rather to lump them into the very general MTM or LTM categories. It can be suggested that, reflecting the general Möðruvellir NISPs (Table 1), the majority of the vertebral and rib elements placed into these general categories derive from ovi/caprines (MTM) and cattle (LTM). Generally, the bovine skeletal distributions indicate that whole animals are likely slaughtered on site and parts of the entire body are represented in the graph. The denser skeletal elements (graph 12) better withstand the taphonomic processes deteriorating less dense hard tissue more rapidly than the stronger bones such as certain long bone endings and certain cranial elements and teeth (Lyman 1994). Also, cranial fragments tend to shatter and their high proportions may be a reflection of fragmentation.
The ranked bone density graph below generally suggests a strong connection of a whole animal skeleton exposed to taphonomic factors (especially soil acidity due to a peat ash environment (i.e. Wigh 2001) and resulting in a higher presence of a certain group of skeletal elements most impervious to taphonomy, and a progressively smaller percentage of skeletal elements more easily degraded. Especially the cattle bones from the medieval period seem to follow this pattern, with the faunal remains form the two more recent midden periods (Phase 3 and 4) slightly diverging from that pattern: a relatively larger percentage of the skeletal elements ranked third in their density properties over those ranked second might indicate slight favoring of less dense bones. This could also be indication of there being less choice in specific meat-cut consumption and more need for utilization of the entire animal for food (for detailed discussions on frequencies of skeletal parts in certain archaeological scenarios, see Lyman 1994:223-293).

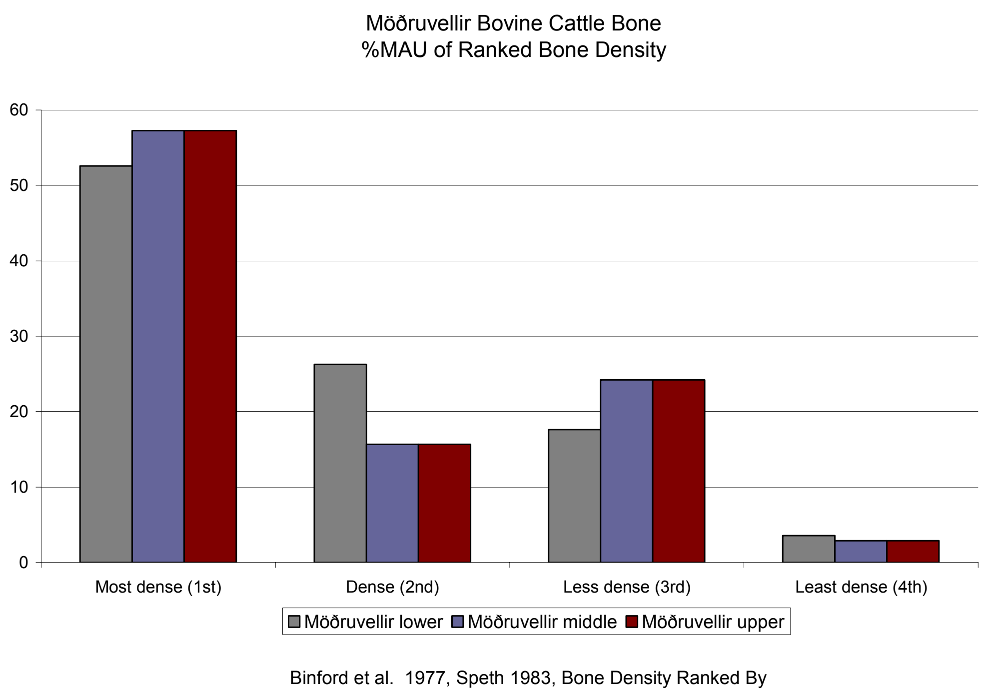

Figure 12. Möðruvellir – analysis of cattle bone density ranks.

The bone density ranking and the MGUI (Modified General Utility Index (Lyman 1994:227) ranking (below), or skeletal portions bearing the most food utility (i.e. muscle mass, but also marrow and sinews) indicate a certain preference for 3rd ranked elements over 2nd ranked elements in the post-medieval/early modern and 19th/20th c. cattle bone assemblages. These calculations can help identify levels of taphonomic effects and human choice for certain meat cuts, but they can only be of use to a certain degree (Lyman calls it ordinal scale), as they are based on few examples (Lyman 1994:231).

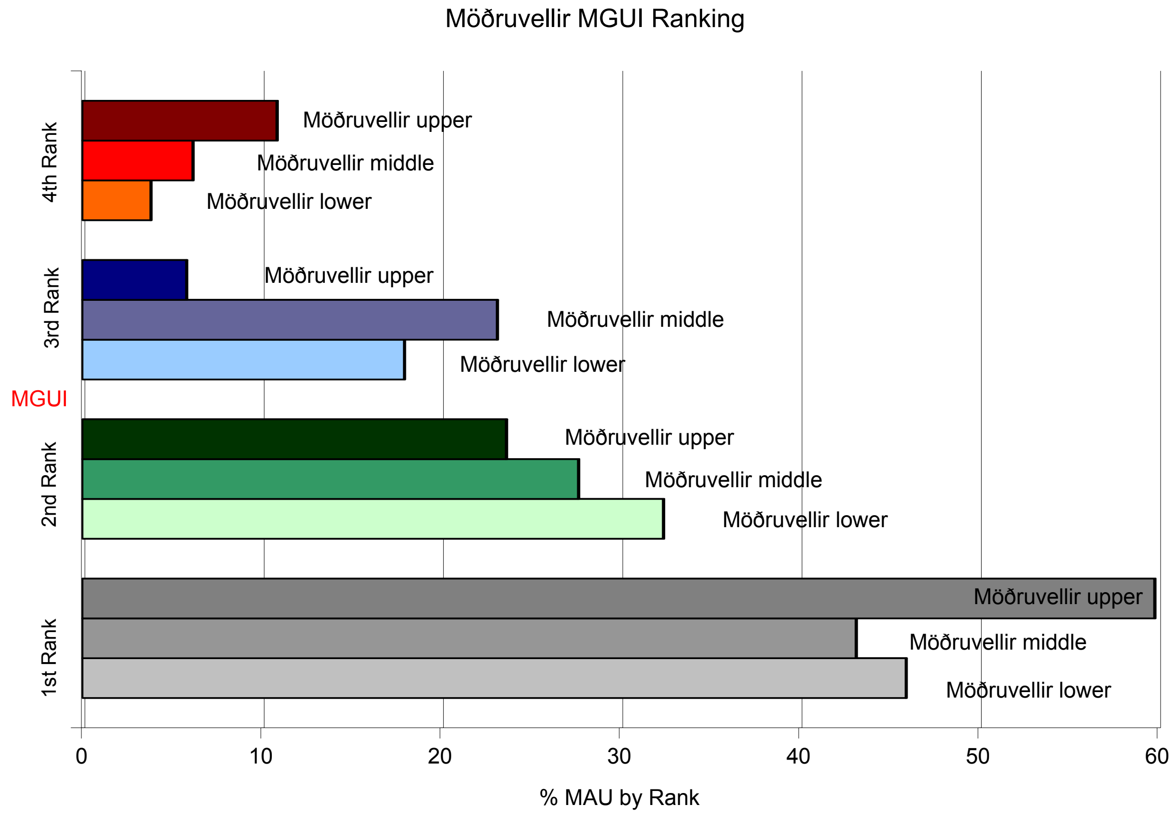

Figure 13. Möðruvellir – MGUI rankings.

Figure 13 associates the skeletal elements with their soft tissue, especially muscle mass and therefore food utility (MGUI). Although the bone density rankings need to be kept in mind to estimate taphonomic effects, this ranking of the skeletal elements indicates that the medieval Möðruvellir assemblage follows a rather straightforward pattern of most meat-bearing elements present at the highest number, and the less meat bearing elements not being as prevalent, although the difference between the first and second ranked food utility elements is not as large as in the upper deposits.

The post-medieval/early modern collection behaves slightly differently, with still the most numerous skeletal elements equivalent to highest ranking food utility. In this period, people consuming beef may have made use of lesser quality meat-bearing skeletal elements more frequently, whether for consumption or for other purposes. An analysis of burnt cattle bone may be helpful here to learn whether these elements were used for fuel and just happened to end up on the midden together with food remains.

The Möðruvellir upper layers from the 19th/20th c. contained mostly cattle skeletal elements of high food utility ranking. An elevated amount of least-meat-bearing elements is noted here, possibly indicating marrow and grease extraction?

Caprines

As displayed in tables 2 and 3, the Möðruvellir ovi/caprines numbers are considerably higher than those of cattle, and thus provide better data for age at death profiles.

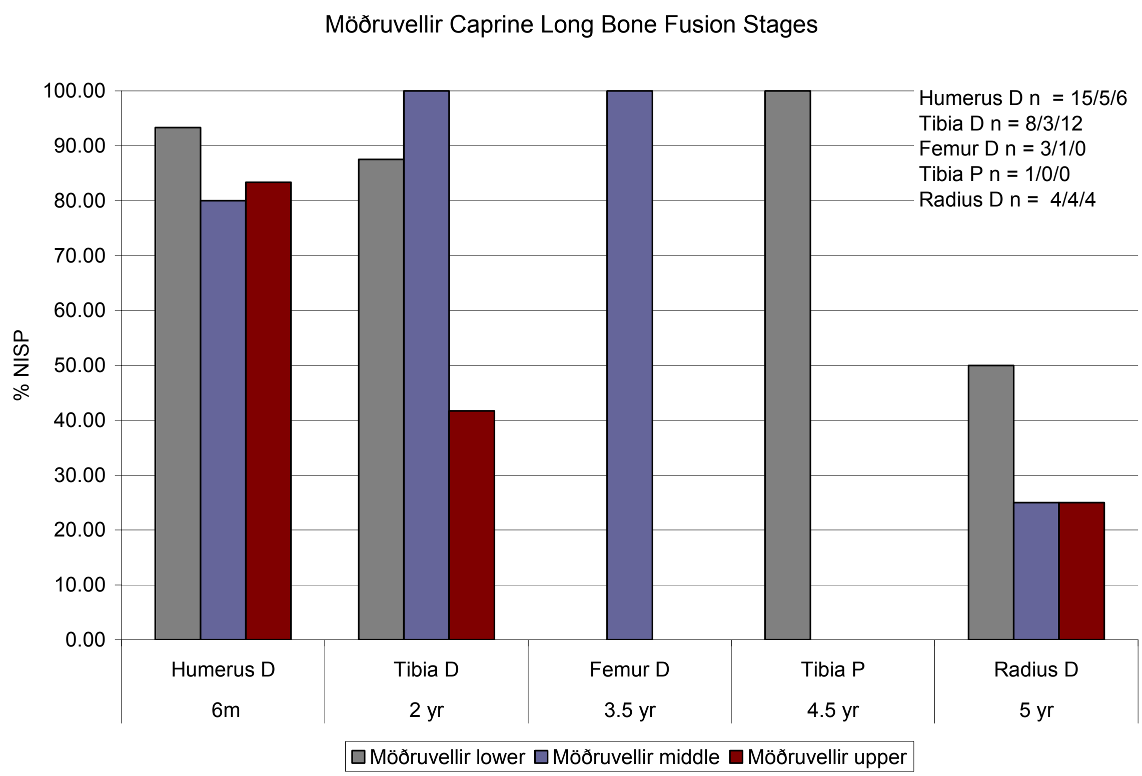

Figure 14. Möðruvellir caprine long bone fusion comparison
The text box indicates number of elements available per category and phase.

The caprine long bone fusion data is somewhat better suited for a comparison of specific long bone elements. Categories where one element makes up 100 % of the NISP are still present, however, and clearly no suggestion on animal age at death can be made in those instances. The graph suggests a first summer survival of 80 % of the Möðruvellir sheep/goats for all three phases. Data from the medieval archaeofauna suggest that still a large percentage (87.5 %) of animals survived past their second winter. The post-medieval/early modern data is not of use for this age category, but the 19th/20th c. data indicates a 40 % sheep/goat survival rate beyond their second winter, which is much lower than the medieval one. This graph indicates further that half of all medieval sheep and goats survived past the age of five. This contrasts with a survival rate of 25 % for post-medieval/Early Modern and 19th/20th c. caprines.

The data sets so far do not indicate a clear caprine management system. Perhaps the high survival rate to relatively older age of the caprines collected from the medieval period hints toward a wool producing economy (i.e. McGovern et al 2004). As with the cattle data, the lack in young animals may partially be due to poor post-depositional preservation conditions. Juvenile caprine bones are far less durable than those from larger-sized animals.

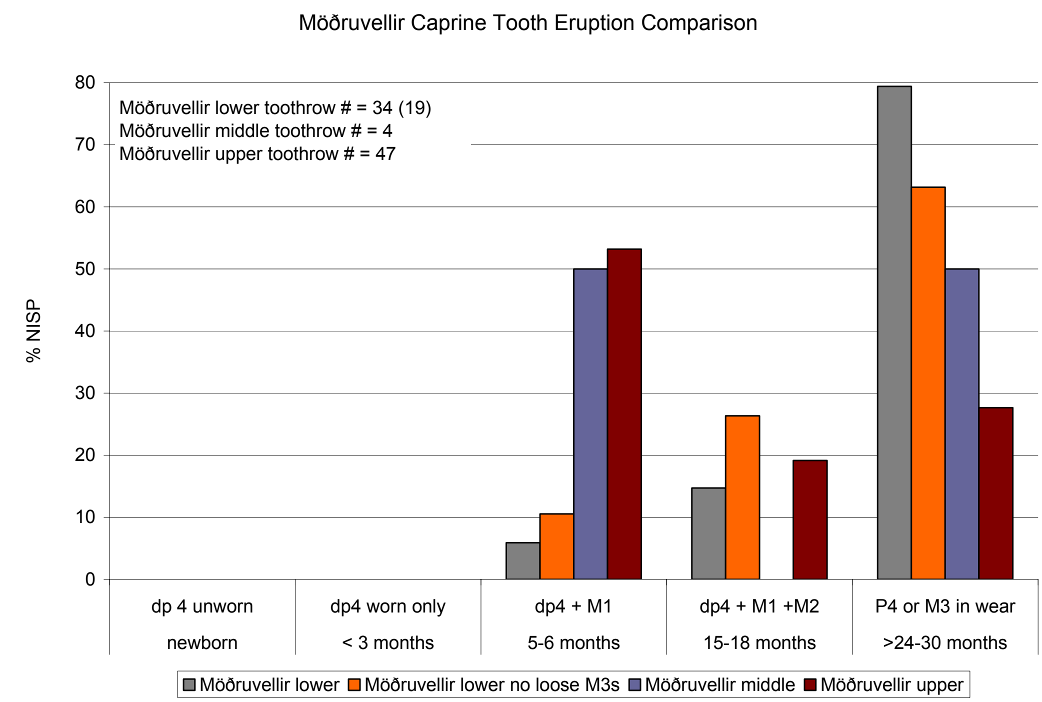

Figure 15. Möðruvellir **c**aprine tooth eruption comparison.

Figure 14 shows a phased Möðruvellir ovi/caprine mandibular and maxillary tooth eruption analysis, indicating that in all three phases, animals lived through their first summer; if a May date is assumed for the beginning of the lambing season. Clearly, the available tooth eruption data from the middle layers are not very conclusive due to small sample number. The available tooth wear data for the medieval faunal collection are presented including loose M3 teeth (gray bars) and excluding loose M3 teeth (orange bar) and the latter data set will be presented in parenthesis as it is merely used to correct for a potential error due to preservation issues. Since mandibular M3s are very good indicators for the eruption stages of an entire mandible, their inclusion need not be disregarded. The Möðruvellir sheep and goat dental eruption data from the medieval collections suggest a culling of 6 % (11 %) of animals before their first winter – a potential indication for the then monastic estate's access to abundant winter fodder. Another 15 % (26 %) were culled before their second winter, and 79 % (63 %) of caprines seem to have survived at least until the age of 2 to 2 ½ years.

The 19th/20th c. faunal collection suggest a different culling age for the majority of the Möðruvellir sheep/goats: 53 % were culled before their first winter, with 47 % surviving their first and 28 % surviving their second winter. The caprine culling patterns from the available faunal samples imply that dairying, at least at large scale, seems to not have been carried out at Möðruvellir. As observed from the cattle data, it is possible that animals belonging to the estate and delivering the dairy products supplying the estate were stationed elsewhere, possibly in shielings or animal winter shelters located further in the Hörgá valley's interior, but also likely in other valley systems, especially the adjacent Öxnadalur.

The patterns observed from the caprine tooth eruption data are more reliable than those from the long bone fusion analysis since teeth tend to survive best in archaeological deposits (Hillson

2005). Also, the very well preserved remains from the upper midden deposits can be used as indicator for what information might be missing from the poorer preserved earlier midden remains.

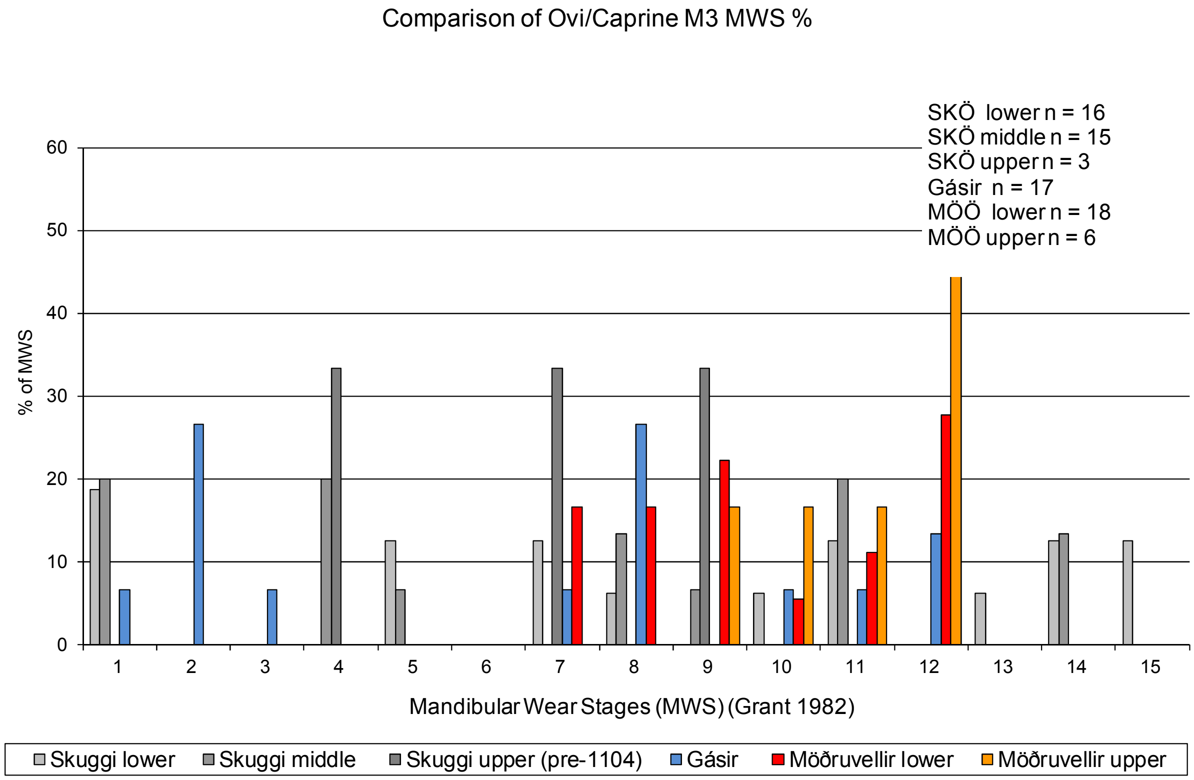

Figure 16. Ovi/Caprine M3 MWS (Mandibular Wear Stage, after Grant 1982). SKÖ = Skuggi (ca. AD 950 – 1100); Gásir archaeofauna contemporaneous with Möðruvellir (MÖÖ) lower midden deposits, 13th – early 15th c.

The Möðruvellir M3s available for tooth wear state grading were all graded on a range between b with a score equal to 1, and g with a score equal to 12 (Grant 1982 in Hillson 2005:319). This suggests the animals were mature, but not of old age. Skuggi ovi/caprines included some older animals, with M3 MWS (Mandible Wear Stage, Grant 1982) up to 15. None of these animals had scores between 15 and 20 (categories 0, 16, 17, 18, 19, 20 had no y-values and were eliminated for a less crowded presentation of the individual data columns), indicating a Möðruvellir presence of mature but not very old animals.
Compared to the other ovi/caprine M3 MWS, the one from Möðruvellir suggests a relatively narrow age range for these animals. Just as there seem to be no very young ovi/caprines culled at Möðruvellir, figure 16 indicates there were also no very old animals present. Therefore, a typical management of a dairy herd seems not reflected in the Möðruvellir ovi/caprine remains (see Harrison et al 2008, McGovern et al 2007).

Three sheep (*Ovis aries*) mandibles from context [041], upper midden phase, displayed P4 pathologies. These heavily impacted P4 patterns in sheep jaws are believed to be associated with indigestion of volcanic grit and the phenomenon is called “Broken Mouth disease” (i.e. McGovern et al. 2004, 2009). All three ovi tooth rows have their M3 in wear, with a TWS of g – score of 12 (according to Grant 1982), indicating mature animals (Harrison 2006, 2009).

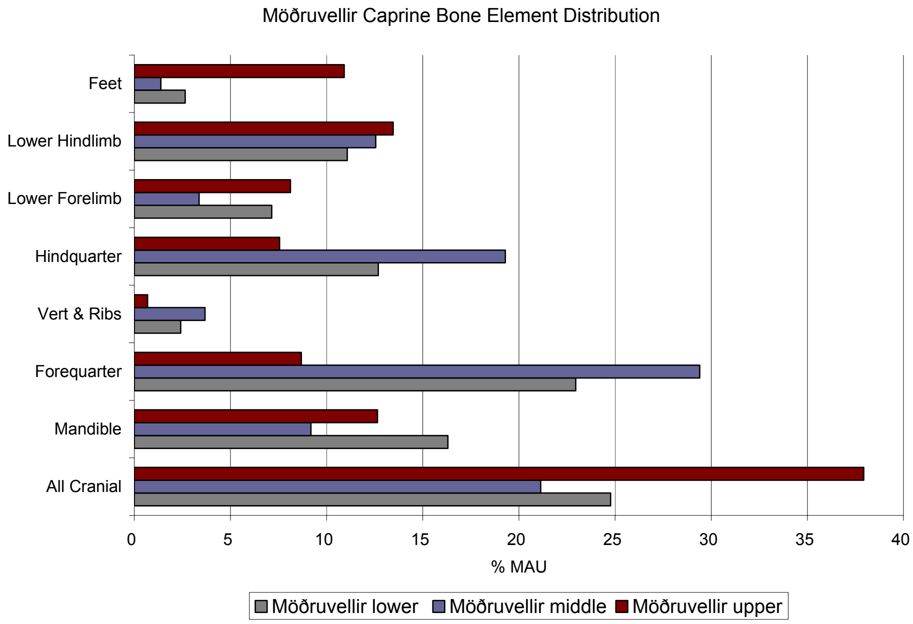

Figure 17. Caprine skeletal element distribution per phase.

All three temporally distinct archaeofaunal collections contained caprine elements from the entire skeleton, albeit at varying degrees. Since the upper midden layers exhibit the best organic preservation, the 19th/20th c. skeletal distribution can be viewed as the one the most representative of the actual faunal remains deposited during midden formation. The other two faunal collections exhibit presence of skeletal elements or portions of caprines that coincide with bone density factors, displayed more clearly in the graph below. The general absence of vertebral and rib elements again is due to the practice of placing sheep and goat sized animals into the MTM category to not mistakenly place other mammal species of similar size into the caprine category.

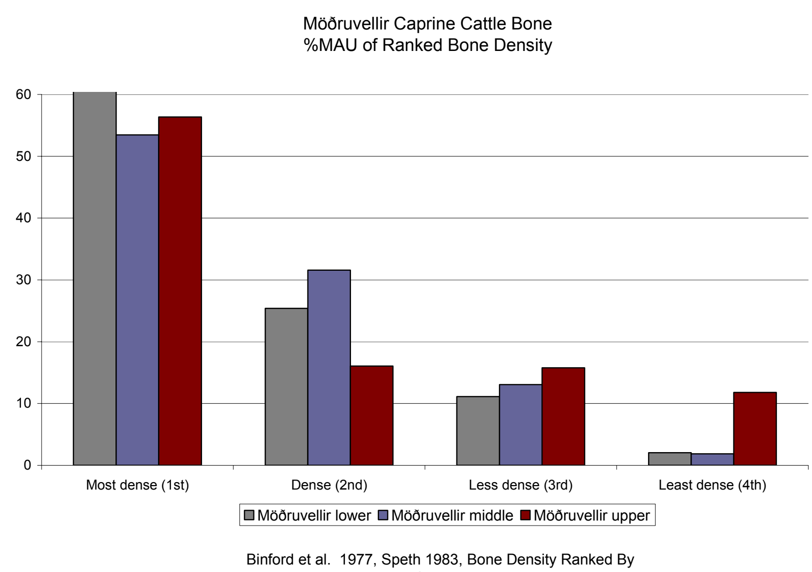

Figure 18. Möðruvellir – analysis of caprine bone density ranks.

The ovi/caprine density ranking comparisons indicate a sharp decrease in skeletal elements of lower ranks for the medieval caprine remains, with the post-medieval/Early Modern ones displaying a very similar pattern, indicative of poor faunal preservation. The well preserved 19th/20th c. caprine bones suggest a higher proportion of skeletal elements that are not the densest ones. Since this again is an indication for a relatively realistic sample of the actual collection preserved from the upper midden deposits, the results in the MGUI ranking below can be used to make a statement on how people in the c. managed their caprine resources.

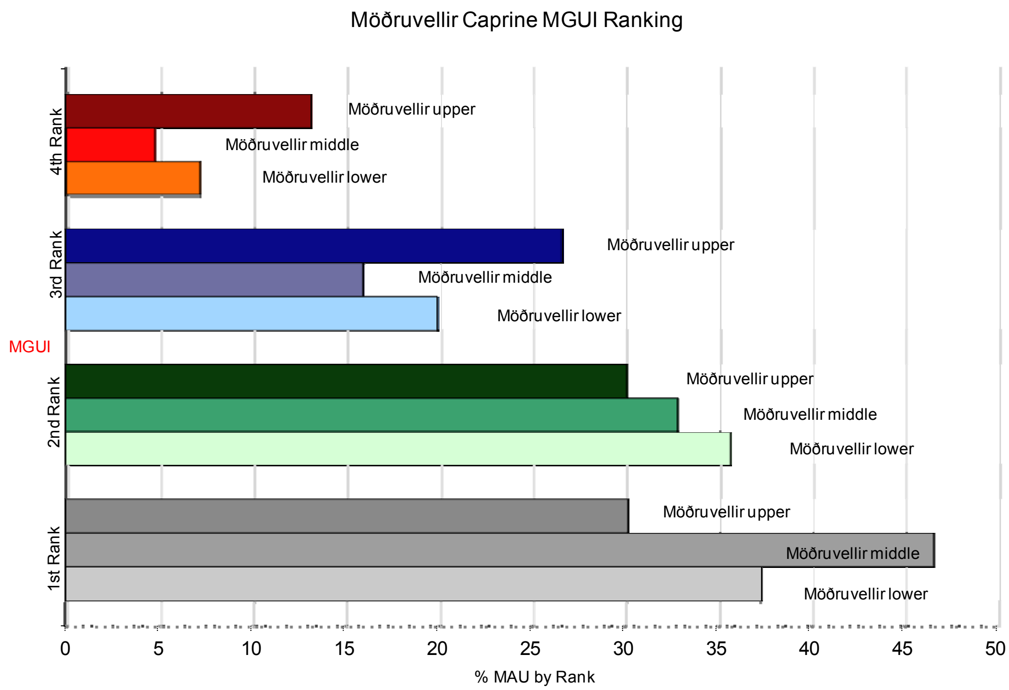

Figure 19. Möðruvellir – Caprine MGUI rankings.

The percentage for the medieval caprine skeletal elements with the highest food value is almost the same as that for the one ranked second. This pattern resembles the one from the 19th/20th c. archaeofauna to a degree, with differences observed for skeletal element proportions that have a food utility index rank of 3 and 4. There, the caprines from the most recent midden deposits may display more complete skeletons that have not been as much affected by taphonomic factors as those from the earliest phase. The MGUI ranking for the post-medieval/Early Modern sheep and goats suggests prevalence of skeletal elements of higher food value with a progressive decline in proportions of skeletal elements relative to their MGUI.

Horse

Phasing	Context	Species	Skeletal element	Count
Phase 4 upper midden	065	Equus caballus	Mandibular premolar	1
Phase 4 upper midden	602	Equus caballus	Patella	1
Phase 3 middle midden	073	Equus caballus	Tibia	1
Phase 3 middle midden	019	Equus caballus	Maxillary molar	1
Phase 2 lower midden	101	Equus caballus	Mandibular premolar	1
Phase 2 lower midden	087	Equus caballus	Mandibular molar	1
Phase 2 lower midden	120	Equus caballus	Mandible	1
Phase 2 lower midden	120	Equus caballus	Mandibular premolar	1

Table 5. Horse elements recovered from the Möðruvellir midden.

All three Möðruvellir midden phases produced a small number of horse elements. The lower phase contexts contained at least three, possibly 4 different individuals; not likely a considerable amount of animals slaughtered/consumed over the course of several centuries. The occasional horse meat may have still have been consumed on the farm, although those people following a strictly catholic diet there might have not been the ones enjoying the occasional horse meat.

Context [120] contained two equine mandibular elements that were possibly from the same mandibular fragment recovered from the same context.
Consumption of horse meat was at least not fashionable in the 18th c., except for lack of other resources (Sveinsson 1962) but the few elements recovered from the 19th/20th c. midden deposits are hardly extraordinary.

Dog

A single fragmentary tooth from the lower midden deposits at Möðruvellir was collected. It is not even clear if this tooth represents an animal that had died and was discarded, or if this is simply a lost tooth.
Evidence of dogs present at Möðruvellir can be observed from a number of elements marked by dog gnawing.

Context number	Phasing	Gnaw	Count
013	Phase 4- ca. 1870 early 20th c.	Dog gnawing	1
014	Phase 4- ca. 1870 early 20th c.	Dog gnawing	1
018	Phase 4 - ca. 1870 early 20th c.	Dog gnawing	1
039	Phase 4 - ca. 1870 early 20th c.	Dog gnawing	15
041	Phase 4 - ca. 1870 early 20th c.	Dog gnawing	3
500	Phase 4 - ca. 1870 early 20th c.	Dog gnawing	1
505	Phase 4 - ca. 1870 early 20th c.	Dog gnawing	2

601	Phase 4 - ca. 1870 early 20th c.	Dog gnawing	2
603	Phase 4 - ca. 1870 early 20th c.	Dog gnawing	3
			29
019	Phase 3 post-medieval/Early Modern	Dog gnawing	3
			3
082	Phase 2 - late 13TH - early 15TH c	Dog gnawing	1
086	Phase 2 - late 13TH - early 15TH c.	Dog gnawing	1
			2

Table 5.Dog gnawed elements recovered from the Möðruvellir midden.

Wild Mammals

As indicated by the NISP table, the number of wild mammals at Möðruvellir is very low. The few marine mammal bones recovered from the midden trenches were all non-diagnostic skeletal elements, and so could only be grouped into more general categories, i.e. large phocid vs. small phocid, large cetacean vs. small cetacean (of dolphin or porpoise size).
One terrestrial mammal bone displayed marks from what was likely rodent gnawing.

Seals

Phasing	Species	Bone	Count
Phase 4- ca. 1840-E20th c.	Phocid	2nd Phalanx	1
Phase 4 - ca. 1840-E20th c.	Phocid	Rib; five in total, but not recovered articulated	5
Phase 4 - ca. 1870-E20th c.	Phocid	Thoracic vert.	1
Phase 4 - ca. 1870-E20th c.	Phocid	Rib	1
			8
Phase 2 – early 14th -early 15TH c.	Phocid	Canine	1
Phase 2 - early 14th -early 15TH c.	Large phocid	Canine	1
Phase 2 - early 14th -early 15TH c.	Phocid	Rib	1
			3

Table 6.Seal elements recovered from the Möðruvellir midden.

Only the upper and lower midden deposits contained bones from seal, none were diagnostic enough to be speciated beyond general sizes, but the majority of the 10 elements were likely from Harbor seal (*Phoca vitulina*) and the large-phocid canine could be from a Gray seal (*Haliocherus grypus*). Both seal species give birth on the sandy Icelandic coastal strips. In the middle ages, there used to be several known seal hunting places in Eyjafjörður (Kristjánsson 1989 I:315), and while there are very few seal elements collected from the Möðruvellir lower

phase deposits, these animals could have originated in one of those areas. Maybe they were brought to the monastic estate by tenant farmers in a collective labor effort.
It is likely that the five phocid ribs from context [041] belonged to the same individual, but they were not recovered as an articulated unit.

Cetaceans

Of the four identified cetacean elements listed in the NISP table, three could be placed more securely into a porpoise/dolphin sized category; one vertebral element from context [039], one series of five articulating chopped lumbar vertebrae from context [041][3], and one tooth from context [103]. Porpoises (*Phocoena phocoena*) and at least the White-beak dolphins (*Lagenorhynchus albirostis (Gray)*) are relatively frequent in Icelandic coastal waters, especially during the summer months (Feilberg & Gensbøl 2003:133-35)

Figure 20. Möðruvellir – porpoise/dolphin chopped lumbar vertebral column sequence from the Möðruvellir upper midden phase ([041]).

Context	Phasing	Species	Bone	Count
039	Phase 4 - ca. 1840-E20th c.	Dolphin/Porpoise	Vertebra	1
041	Phase 4- ca. 1840-E20th c.	Dolphin/Porpoise	5 articulating lumbar vert. - articulated	1
				2
089	Phase 2 - early 14th -early 15TH c.	Cetacean	Rib	1
103	Phase 2 - early 14th -early 15TH c.	Dolphin/Porpoise	Tooth	1
				2

Table 7. Cetacean elements recovered from the Möðruvellir midden.

[3] Context [041] also contained a blue painted caprine mandible likely a toy (Guðrún Alda Gísladóttir, forthcoming).

Rodents

Only one long bone fragment of large terrestrial mammal (cattle or horse) from context [004] associated with layers deposited between ca. 1840 – early 20th c. revealed rodent tooth marks on it. No actual rat or mouse skeletal elements were identified.

Birds

Möðruvellir	Midden Phases					
Bird species count	Lower - Phase 1& 2		Middle - Phase 3		Upper - Phase 4	
Identified Bird Species	NISP	% NISP	NISP	% NISP	NISP	% NISP
Migratory Waterfowl						
Mallard Duck (*Anas platyrh.*)					1 (33)	9.09
Eider Duck (*Somateria mollissima*)			2	66.67		
Swan species (*Cygnus sp.*)			1	33.33		
Anser species (Goose family)	1	4.35				
Sea birds						
Murre species (Uria species)	15	65.22			2	18.18
Auk family (Alcid familie)	5	21.74			1	9.09
Non Migratory Terrestrials						
(Ptarmigan/grouse (*Lagopus muta*)	2	8.70			3	27.27
Domestic chicken (*Gallus gallus*)					4	36.36

Table 9. Count of analyzed birds species.

The total count of Möðruvellir bird bones is 127, or 1.60 % of the overall NISP.
This number can be broken down by phase: the lower midden deposits (Phase 1 & 2) had a total bird bone count of 44 (33.56 % of NISP); the middle phase had a total bird count of 27 (8.94 % of NISP); the upper midden deposits produced a total bird count of 56 (0.87 % of NISP).
Out of a total of 37 bird elements identified to species or family level, 17 were from either Guillemot (*Uria aalge*) or Common Murre (*Uria lomvia*), with another 6 bird bones placed in the more general auk family. Both uria species' skeletal elements are very similar to each other. These are sea birds found and can be found along the sandy beaches and coastal waters of Eyjafjörður (and all of Iceland) in the winter (Hilmarsson 2000:30-31).
While the middle midden layers contained 2 Eider duck elements and one from swan, this phase did not produce any of the bird species found in the layers above or below. Eider ducks are found in Eyjafjörður (Harrison 2006), and their down collected for its insulation properties.

The articulated Mallard skeleton recovered from the upper phase, context [006], was discussed in an earlier report (Harrison 2007).
Both the medieval and 19th/20th c. deposits produced a few Ptarmigan remains, and the most recent layers also contained several domestic chicken bones.
Generally, the low amount of bird elements that could be placed into family and species categories does not indicate a heavy reliance on avian species for subsistence purposes. An occasional exception could be the consumption of auk species, especially Guillemot or Common Murre.

Fish

As indicated by the NISP table, fish make up 20.13 % of the medieval archaeofauna, 21.20 % of the post-medieval/Early Modern archaeofauna, and 84 % of the 19th/20th c. archaeofauna. The only analyzed fresh water species element was from Brown Trout (*Salmo trutta)* and it is safe to suggest that at least the great majority of the unidentified Möðruvellir fish remains were marine species.

The low numbers of fish bones available for the lower midden deposits (NISP=249) and the middle midden deposits (NISP=64) are in strong contrast with those found in the upper midden deposits (NISP=5,427). Preservation is one factor, but it also seems the Möðruvellir residents' preference for certain animal foods changed over time. If the medieval phase once had a percentage of fish remains similar to that found in the 19th/20th c. deposits that NISP would have to be 2,809 instead of 121, following an upper phase ratio of domestic mammals compared to identified fish of 1 to 3.10. This would be similar to the 2,787 identified fish bones from that upper level. If one were to assume that same ratio for the middle phase that number of identified fish would have to be 589 instead of 34. These calculations would only be accurate if the proportion of fish vs. domestic mammals remained the same throughout time; however, since there is now way of testing for this, these numbers are only *hypothetical*.

The Möðruvellir fish bone numbers for the earlier two midden phases are very small; only very general information can be gained from them. The upper midden phase produced a large enough fish data set allowing for approximate fish live-size reconstructions and skeletal element pattern analysis.

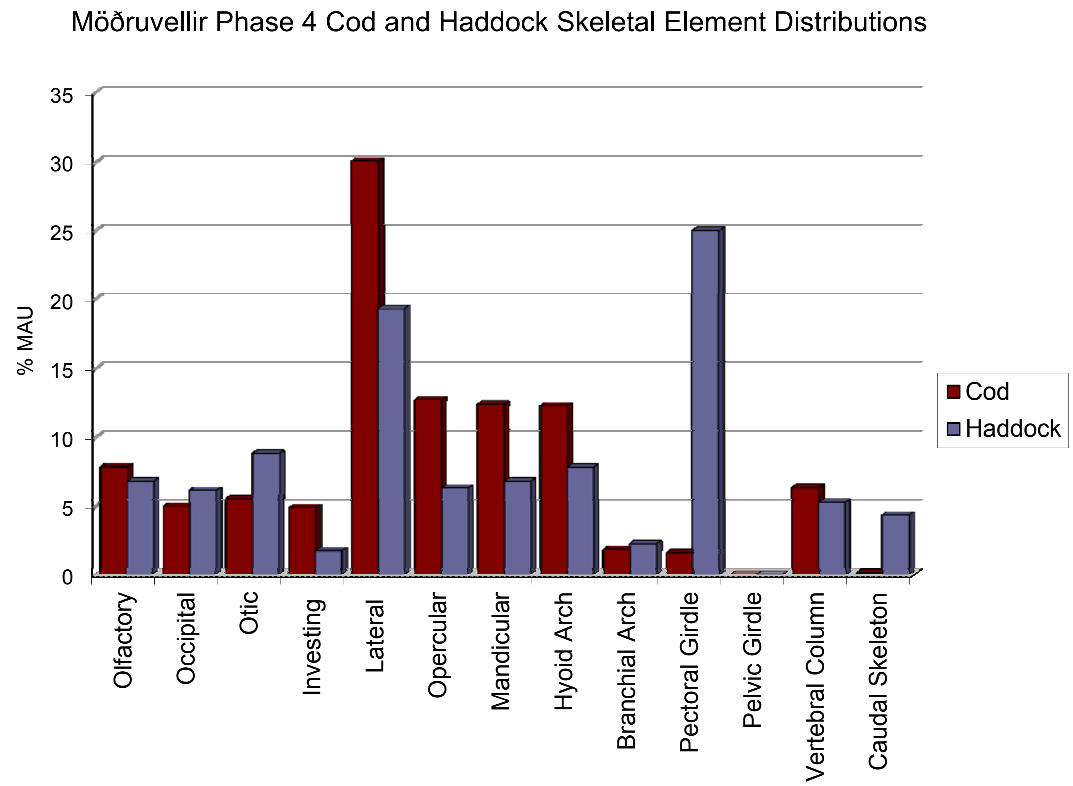

Figure 21. Möðruvellir, Phase 4 – Cod and Haddock skeletal element distributions comparison.

The cod and haddock skeletal element distributions from the upper midden layers are presented in figure 21. A predominance of cod remains from the head rather than the post cranial area, save the thoracic vertebrae (fig. 22) is indicated. This could indicate preparation of a cod fish filet in one area, with the fish filet consumed and the bones discarded elsewhere on site.

The haddock skeletal element distribution pattern on the other hand suggests a different processing and consumption pattern; potentially, a haddock product was consumed in the activity area associated with this household midden deposit. The high number of pectoral elements indicates the presence of a higher number of haddock cleithra than in cod category (for a discussion on cod/had elements representing certain parts of the fish, see Perdikaris and McGovern 2008, McGovern et al. 2009, also Harrison et al 2008).

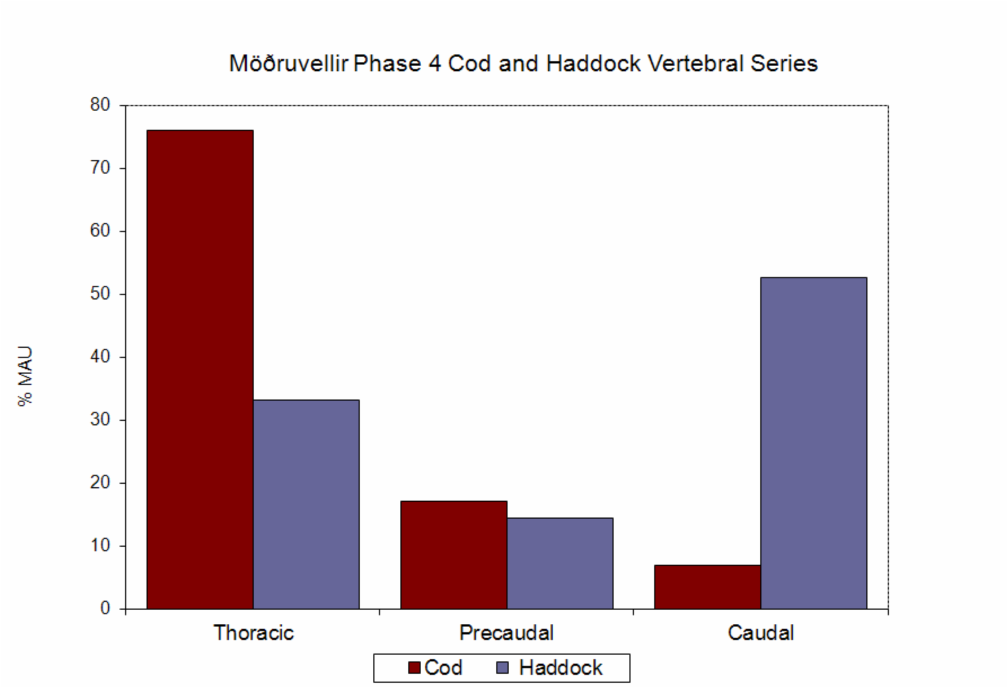

Figure 22. Möðruvellir – Cod and Haddock vertebral series comparison from upper midden phase.

The cod and haddock vertebral series comparison graph and cod and haddock premaxilla versus cleithrum element distribution graphs displayed here only present data from the Möðruvellir upper midden phase (Phase 4), as does the cod and haddock skeletal element distribution graph in figure 21 above (for information on all the Möðruvellir cod and haddock elements presented in this fashion, see Appendix II).

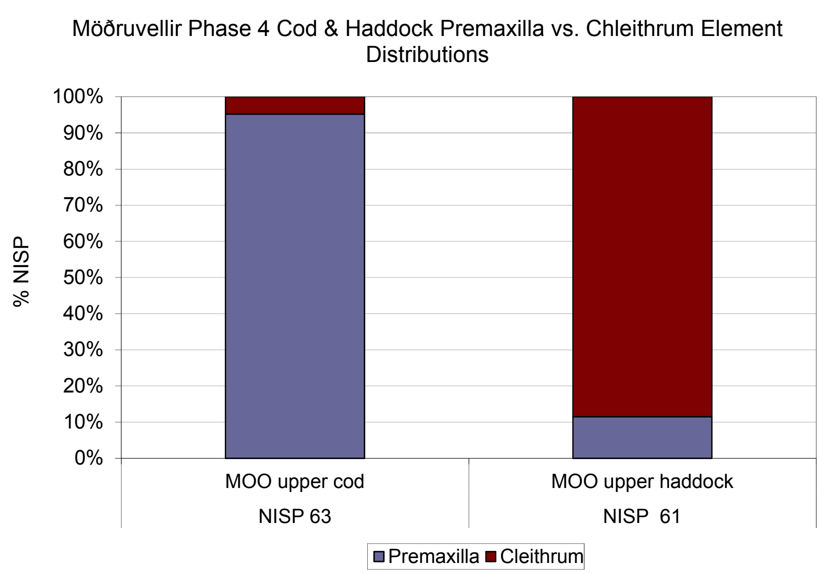

Figure 23. Möðruvellir – Cod & Haddock premaxilla vs. cleithrum element distributions.

Figure 23 displays the ratios of premaxilla (jaw bone) versus cleithrum (large bone from pectorial region) from the 19th/20th c Möðruvellir cod and haddock remains. The cleithrum is often used as indicator for a preserved fish filet and usually found on sites where consumption of preserved fish (of cod and haddock in this instance) took place. In addition to the cleithrum, a certain proportion of the spinal column is often indicative of a certain kind of preserved fish: for example dried in the round, with the thoracic vertebrae included in the element distribution. Another dried fish filet signature can be signaled by the presence of cleithra and predominantly precaudal and caudal vertebrae, but very few thoracic vertebrae. This would likely signify a smaller filet, dried in split form (Perdikars et al 2004, Perdikaris and McGovern 2007, 2008, McGovern et al. 2009, also Harrison et al 2008).
The premaxilla tends to be discarded in relatively high numbers at the point of fish cleaning and preparation for drying or consumption, and therefore is associated with fish-producing activities.

The Möðruvellir cod skeletal remains suggest on-site processing of fresh cod fish into either fresh or dried fish filets. A considerable number of people likely present on the Möðruvellir premises during the 19th/20th c. may have needed a secure food storage solution for the winter and therefore it is possible that round-dried cod filets were prepared on site for the occupants of the school or the governor's house. Alternatively, these fish products may have been served in fresh form, especially if they were aimed for the high official residing at Möðruvellir (Vésteinsson 2001).

Haddock remains also included vertebrae, mostly from the precaudal and caudal portion, generally suggesting consumption remains rather than processing remains. It is possible that the contexts containing most of these elements were associated with a kitchen/dining area from where almost all haddock elements were directly discarded onto the same midden area[4].

[4] Cod and haddock size-reconstructions are still ongoing and may indicate whether the Möðruvellir Phase 4 cod fish were actually made into round-dried filets, or whether they were simply processed fresh on site and the skeletal parts after consumption discarded somewhere else.

Mollusks

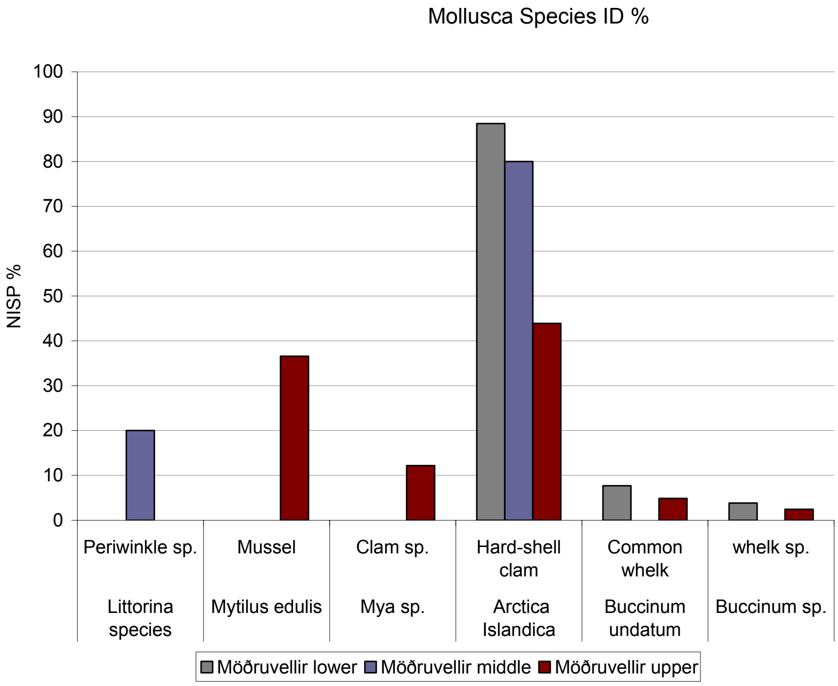

Figure 24. Mollusks identified to species level from all phases.

The total mollusk numbers (and NISP %), including unidentified mollusk species per phase are as following:
Phase 1& 2 – lower midden = 33 (2.67%); Phase 3– middle midden = 22 (7.28 %); Phase 4 – upper midden = 73 (1.13 %).
With the exception of faunal remains from the post-medieval/Early Modern phase, the mollusk proportions of the total NISPs are less than 5 %, and even that one is less than 8 %. It is likely that some of these mollusks were consumed by humans, as Möðruvellir is situated several hundred meters from the nearest beach and therefore discarded fishing bait remains would likely be found closer to the sea.

All the mollusks retrieved from the various midden deposits are found in North Atlantic waters, and none of these species are thus out of the ordinary (In Kristjánsson 1989 I:147-149).
Preservation of the Möðruvellir mollusks was relatively good, and therefore the clams could be put into soft-shell (Mya species, most likely *Mya truncata* (Kristjánsson 1989 I:143)) and hard-shell categories. Given the geographic location, it is reasonable to suggest these hard-shell clam remains to be *Arctica islandica*, an edible, long-living, intertidal clam fund that is still used commercially in Iceland and is caught also in Eyjafjörður (www.fisheries.is/ main-species/invertebrates/ocean-quahog/). Traditionally, *Arctica islandica* (Isl. *kúfskel/kúskel)* was one of the most prevalent shellfish species collected; others were Blue mussel (*Mytilus edulis*), and Horse mussel (*Modiolus modiolus*) (Kristjánsson 1989 I:144). *Arctica islandica* was also one of the shellfish species consumed by humans rather than primarily used for bait (Kristjánsson 1989 I: 151).

Taphonomy

Skeletal element distribution analyses for bovine and caprine elements above already point to a higher degree of bone degradation in the medieval and post-medieval/Early Modern faunal collections at Möðruvellir when compared to the 19th/20th c. archaeofauna.
The following analyses will highlight the degrees of burning, fragmentation, and butchery per phase and provide thus another indicator for overall bone preservation from midden trenches TR1 and TR2/2b.

Burning

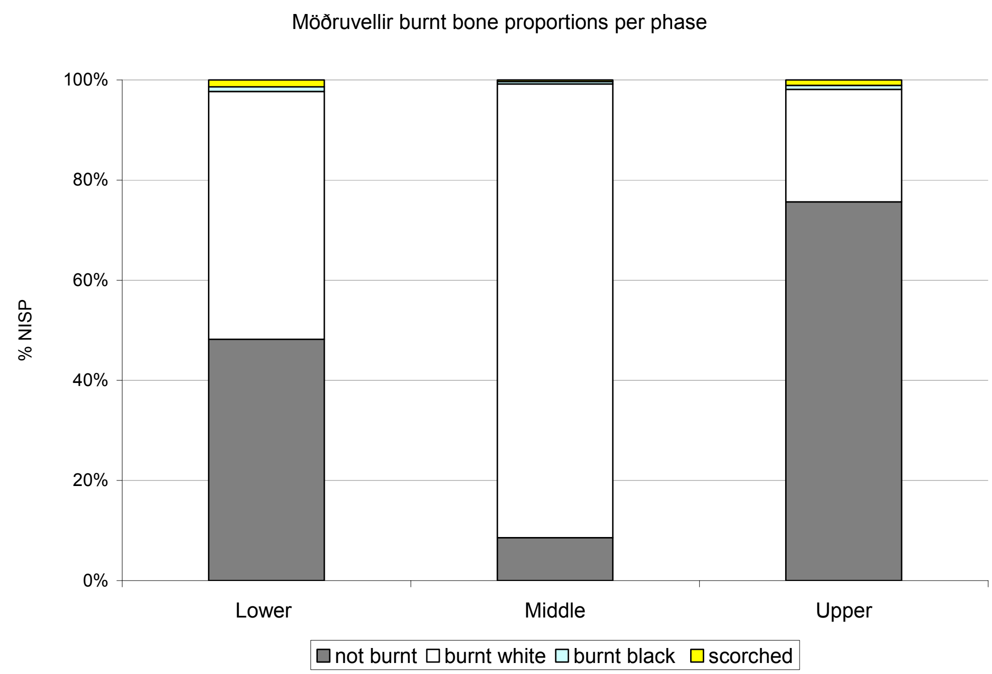

Figure 25. Möðruvellir burnt bone percentages per midden phase.

The percentage of white burnt bone presented in figure 25 partially explains the preservation conditions of the Möðruvellir archaeofauna. About half (52 %) of the bones from the medieval layers indicated exposure to fire/heat, almost all of these bones were burnt white, or calcined. When the bone is exposed to high heat for a prolonged period of time, all the organic materials break down and leave a calcined bone behind (i.e. Lyman 1994).
These elements shatter very easily and may explain why the numbers of unidentified mammal bones were so high for the medieval phases, and especially for the post-medieval/Early Modern phases.
As much as 90.60 % of the faunal remains from the middle midden deposits are burnt white, with only 9 % not burnt.
In contrast, almost 76 % of the 19th/20th c. faunal remains were not burnt, with 22.50 % burnt white.

This change in burning proportions throughout time is likely connected to fuel utilization practices at Möðruvellir. A more thorough analysis on this issue is planned (see further work section).

Fragmentation

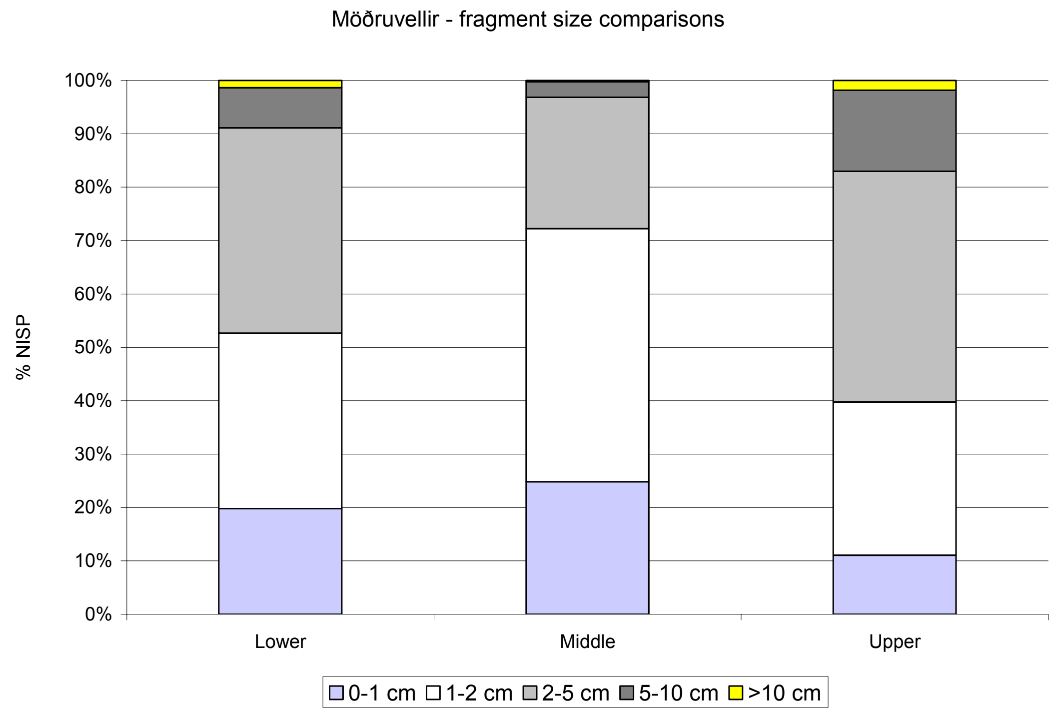

Figure 26. Möðruvellir fragment size comparisons.

Figure 26 presents the various fragment size proportions per phase; size categories 0-1 cm and 1-2 cm are indicators of heavily modified animal bones, either through butchery, burning, trampling, and other mechanical and chemical factors (Lyman 1994).
Although the medieval layers at Möðruvellir had the lowest ph level, their faunal remains do not seem to be the most damaged ones: 52.64 % of the lower phase bone fragments were smaller than 2 cm, with almost ¾ (72.23 %) of the middle phase falling into these size categories; 60 % of the bones from the upper phase were larger than 2 cm, and 17 % thereof larger than 5 cm.
Few fish and bird, and no small terrestrial mammal remains were recovered from the lower and middle midden phases, the bone fragments less than 2 cm large were mostly fragments of larger mammal bones.

Butchery

A relative count of elements with vs. without butchery indication, is a further way of assessing whether the heavy fragmentation rates for the Möðruvellir lower and middle midden phases were due to human decision making prior to consumption, or after. With poor bone preservation in the earlier midden layers, detecting butchery marks on bone elements is difficult as the bone surfaces are weathered. If there is a very fragmented but well persevered and not predominantly burnt archaeofauna with a high degree of bone modification due to butchery, the small sized faunal remains can potentially be linked to cooking/butchery activity rather than burning of the bones after consumption.

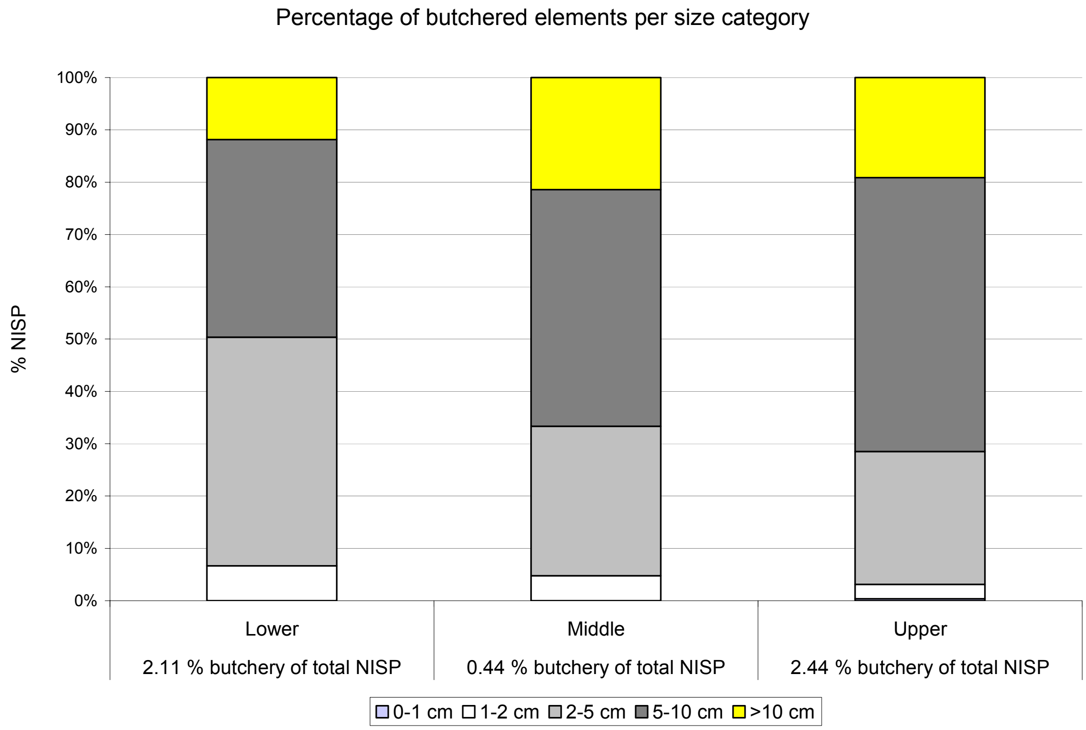

Figure 27. Möðruvellir; evidence for butchery found on faunal elements compared to fragment size groups.

Skeletal elements in the 2 cm size category and below that were found to indicate butchery amounted to less than 10 % (Upper = 3 %; Middle = 5 %; Lower = 7 %), with the fragments falling into the size categories of 5 cm and larger making up a larger proportion for both post-medieval phases than the medieval one.

From this graph, a direct relation between butchery and fragment size cannot be drawn; the fragments found in the below 2 cm size class may not be the ones found to have a large proportion of butchery evidence. The 2-5 cm sized elements make up 43.70 % versus 28.60 % in the middle phase and 25.39 % in the upper phase.

When summed up, the fragments sized 5 and below make up 50 % of the medieval butchered elements, vs. 33 % in the post-medieval/Early Modern ones, and 29 % of those from $19^{th}/20^{th}$ c.

A relatively larger amount of larger faunal elements (see figure 26) seems to be preserving in these lower layers and not in those of the following one.

Potentially, the difference in burning degrees, butchery and fragmentation numbers, and general NISP vs. TNF ratios between the Phase 1&2 medieval archaeofauna and the Phase 3 post-medieval/Early Modern one can indicate slightly varied taphonomic factors in place:

The medieval faunal sample may be the result of not only chemical processes, but also decision making by the food preparer before deposition of meat-less bone remains as rubbish, whereas the faunal remains retrieved from the midden layers above were more heavily destroyed after consumption.

Conclusion and further work

Work done on the faunal remains indicate that the people of Möðruvellir changed their habits of food preparation and consumption and therefore also deposition of rubbish from food preparation/consumption and other domestic activities over time. Only an entire excavation of the midden and the adjacent farm mound can give a thorough picture of the behavior patterns of some of the Möðruvellir residents through time. Since this undertaking would be very time consuming and require enormous financial means, the faunal sample presented here is likely the only way to learn about some of the Möðruvellir consumption habits and site economy at all.

Phase 4 could be an indication of what might be missing from earlier midden phases. With so few fish remains preserved from the earlier phases, one can imagine a relatively equal loss in what could have been originally thousands of domesticate remains typical for the household midden assemblages of such an institution.
From the analysis of certain taphonomic factors, however, it is possible that the medieval faunal distribution pattern is at least a sample collection, offering some information on the household midden deposition activities in that particular area more than five hundred years ago.

It is possible that the medieval faunal collection spanning activities from the 13th to early 15th c. reflect human activities associated with a specific area on the Möðruvellir estate, possibly the kitchen of the farm owners/managers and therefore people inhabiting higher ecclesiastic positions and social status. There could have been more fish remains found elsewhere as evidence of the fasting activities prescribed by the Catholic Church all over Northern Scandinavia once Christianity was accepted by the various countries, connected to not a small degree to the emergence and peak in medieval Icelandic export of stock fish (i.e. Karlsson 2000, Perdikaris and McGovern 2007, 2008).

Möðruvellir as a monastic site was clearly a high status estate, and this is reflected in the medieval remains of domestic mammals in the trenched midden area. A cattle percentage of nearly 20 % of the total NISP is clearly a demonstration of the wealth of this site at a time when the cattle numbers had declined and caprines – mainly sheep – were used for dairy and wool products (Harrison et al 2008, McGovern et al 2007, 2009). A complete absence of pig should be noted and further the low number in seal and cetacean bones observed in all midden phases. Potentially, these two marine mammal species indicated lower status food already in the late 13th c. (Harrison et al 2008) and the people responsible for the midden deposits from that period were not in need for such lowly food sources.

With a general overview of the Möðruvellir faunal samples now available, more analytical work is necessary, and below are a few issues to be addressed next:

- *Dairy strategies at medieval (and later) Möðruvellir* – from the age at death reconstructions for both, bovine and caprine remains, a distinct lack in very young animals usually present in faunal collections of sites of active dairying was observed in all the three midden phases. With the influence the manorial estate at Möðruvellir had over its surrounding region, it is possible that the majority of dairy products were supplied from smaller farm steads as taxes or tithe. Alternatively, dairy animals belonging to the Möðruvellir estate were kept in shieling sites or winter shelters belonging to Möðruvellir, but located further in the valley systems' interior areas. Two sites connected to Möðruvellir, Klausturhús and Möðruvallasel, were cored for midden remains in the summer of 2008 (2008 GHP report), but did not produce typical farm midden remains. As mentioned earlier, historic sources (i.e. Jarðabók), but also more recent Möðruvellir farm registers and church records) will be consulted to better understand the organization of farms and animal shelters in medieval and post-medieval Hörgárdalur and other Eyjafjörður valley system.

- *Comparisons w contemporaneous intra- and inter regional faunal collections* – a series of comparative data sets is now available for the three different Möðruvellir midden phases. A comparison to other Hörgárdalur sites and also the Gásir trading site archaeofauna (contemporaneous with the medieval Möðruvellir archaeofauna) to gain a better idea on Möðruvellir's place in the region's long-term human ecodynamics.

  Inter-regional comparisons with other contemporaneous faunal collections can help understand how either ordinary or special the sites in Hörgárdalur are compared to other regions in Iceland.

- *Cod size reconstructions and atlas incremental age reconstruction*. The cod size reconstruction based on selected elements will demonstrate whether the cod fish prepared on site were of the right size for a large, dried in the round fish fillet (see Perdikaris & McGovern 2007, 2008, Perdikaris et al 2004, Krivogorskaya et al 2005, Amundsen 2004). The cod atlas based incremental size reconstruction will indicate the age at death of some of the fish skeletons from the 19th/20th c. midden deposits.

- *Specifics of the c. cod and haddock fish preparation* – who were the people eating the fish prepared and consumed at Möðruvellir? Were the meals prepared for students of the practical secondary school there in the late 19th c? Was it the governor residing at Möðruvellir? Or was the priest's family responsible for these midden deposits? A more thorough analysis of the fish remains based on specific context numbers and in combination with the artifact report (Gísladóttir, FSI, forthcoming) may be helpful forming hypotheses on these issues.

- *Origins of medieval midden contents* - In context w. textile and artifact information, maybe a hypothetical analysis of some discrete midden layers is possible. The relatively numerous textile remains collected from the medieval midden deposits were analyzed by Michele Hayeur-Smith from Haffenreffer Museum of Anthropology, Brown Universityin Rhode Island (Hayeur-Smith, forthcoming). These textile remains may even offer a clue into the regional textile production and its organization by large land holders, i.e. the Möðruvellir manor.

- *Fuel utilization analysis* - the burnt bone, dried and burnt animal dung, peat ash, and wood ash samples (all soil micromorphology samples to be under future analysis directed by Dr. Ian Simpson, U Stirling, with paleobotanical materials retrieved from bulk-samples to be processed and analyzed under direction of Dr. Mike Church, U Durham) will be used to gain a better understanding of the Möðruvellir fuel utilization practices over time. The majority of the midden deposits was composed of multiple series of peat ash and wood ash dumps, mixed with dried animal dung, and of course the faunal remains discussed in this report. Clearly, the burnt animal bones recovered from these midden layers were at least partially remains of usage of animal bone for fire materials.

Acknowledgments

This report was enabled by generous funding provided by grants from the US National Science Foundation (Grants OPP ARC 0732327 and OPP ARC 0809033), and from Fornleifasjóður, Iceland (2008 excavation), and the CUNY Northern Science & Education Center.

The author would like to thank the 2006-2008 field teams, and all the specialists contributing to this project. The author is indebted to Howell M. Roberts for his support over the years as well as sharing his ideas and data. Further thanks go to Guðrún Alda Gísladóttir, Elín Ósk Hreiðarsdóttir, Mjöll Snæsdóttir, Þóra Pétursdóttir, and all other helpful people at FSÍ. Thanks to Michele Hayeur-Smith for all her work on and help with Möðruvellir the textile collection. The author would like to especially thank Dr. Thomas H. McGovern and Dr. Sophia Perdikaris for their continuous professional support and advice, for offering access to and generous use of their laboratories, and for their tremendous help discussing and disseminating the data.

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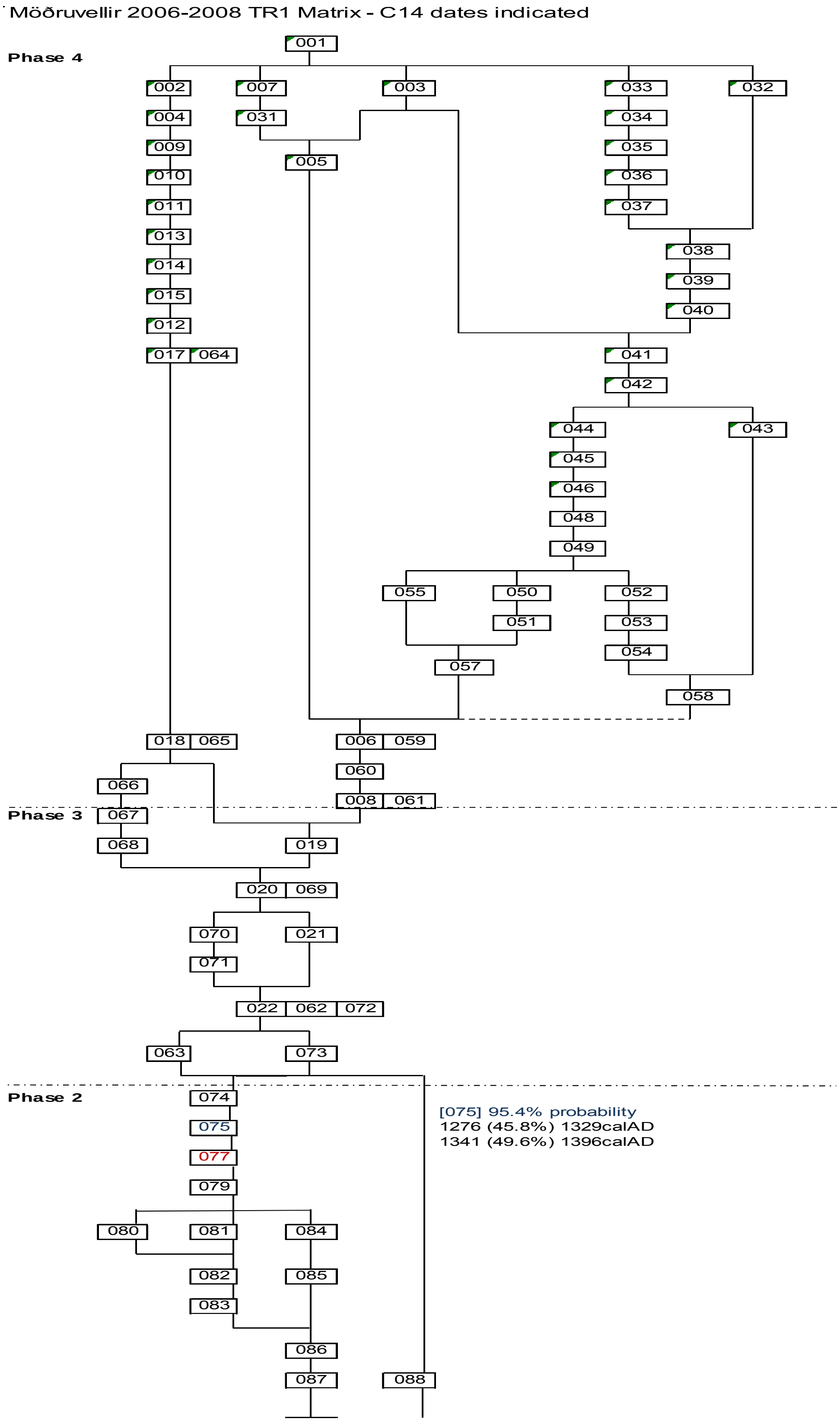
Appendix I – Matrices



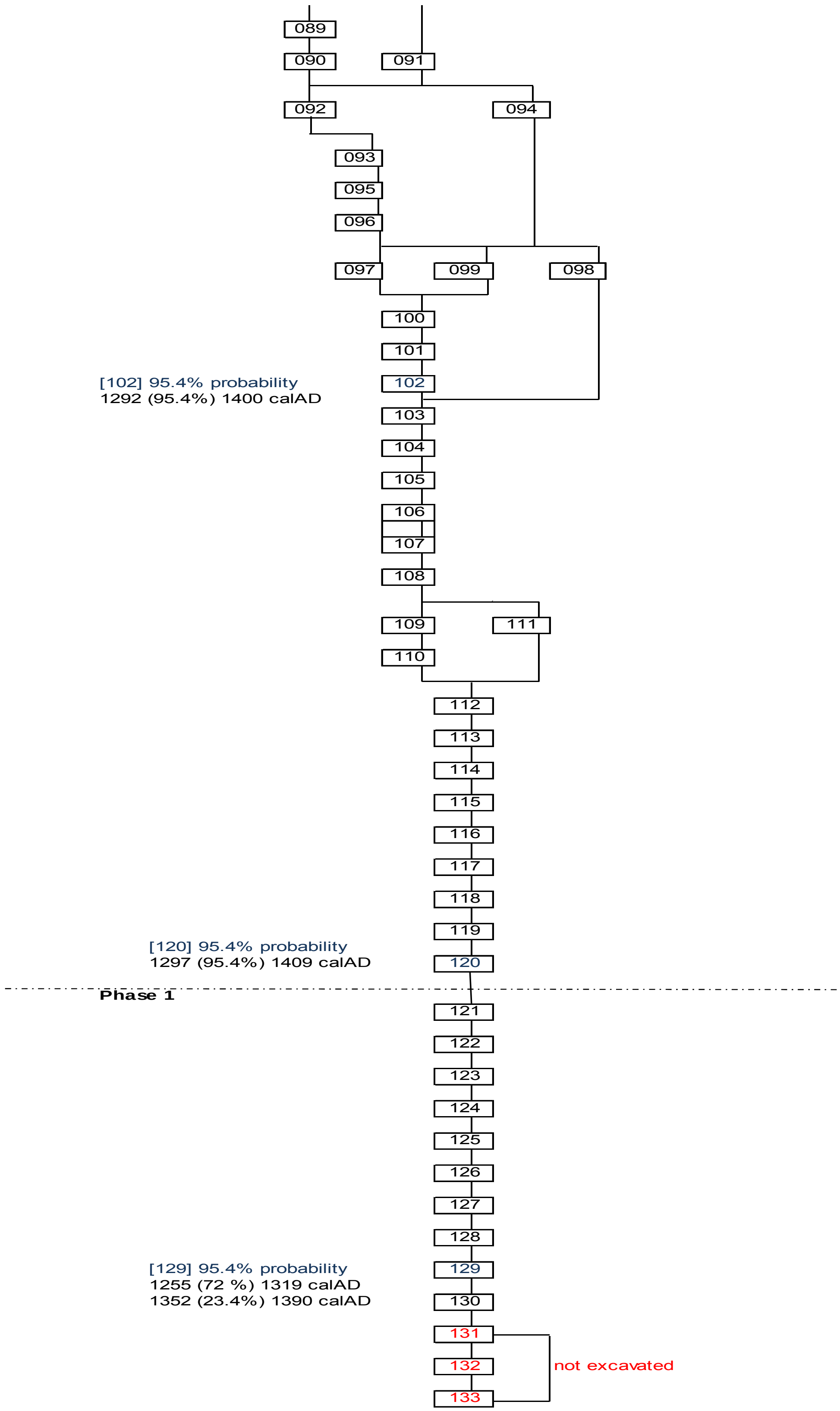


Figure I. Möðruvellir TR1, Harris Matrix

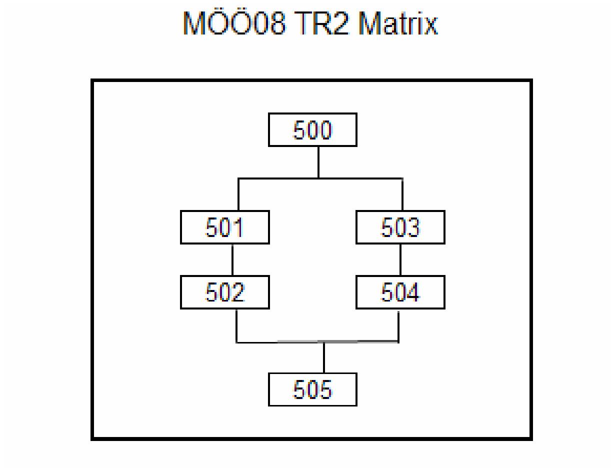


Figure II. Möðruvellir TR2, Harris Matrix

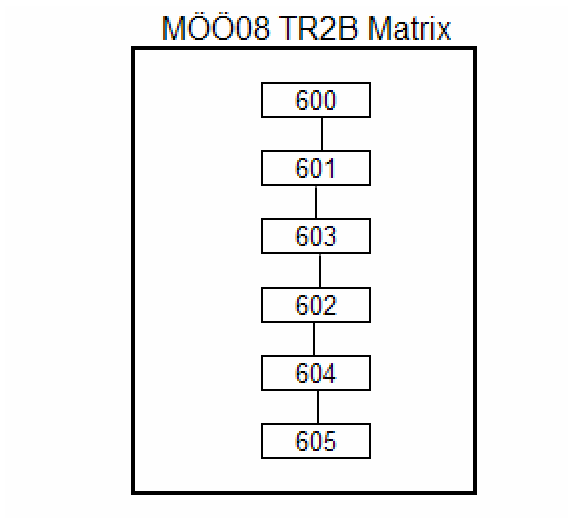


Figure III. Möðruvellir TR2b, Harris Matrix

Appendix 2 – Cod & haddock graphs including data not discussed in main text

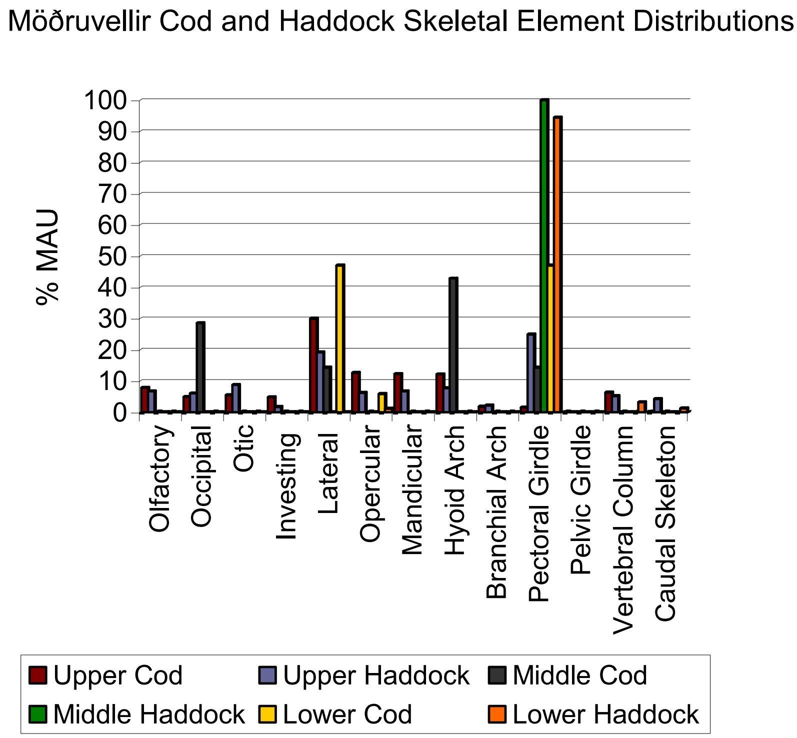


Figure I. Cod and Haddock skeletal element distributions; all Möðruvellir midden phases compared.

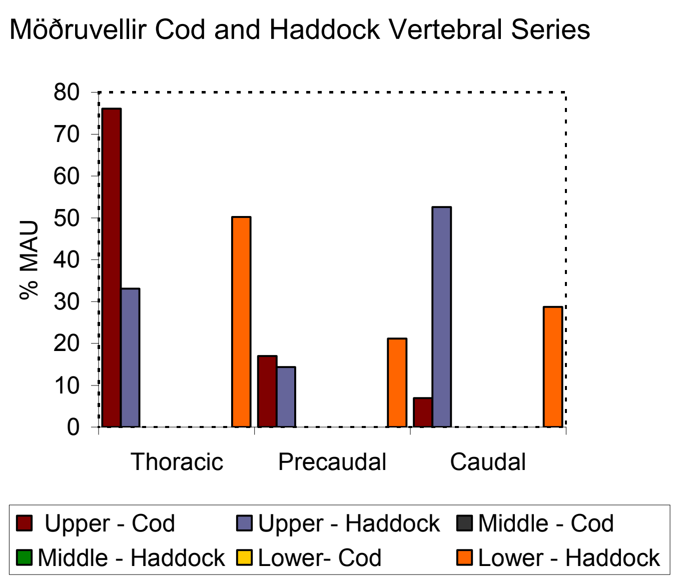


Figure II. Cod and Haddock vertebral series; all Möðruvellir midden phases compared.

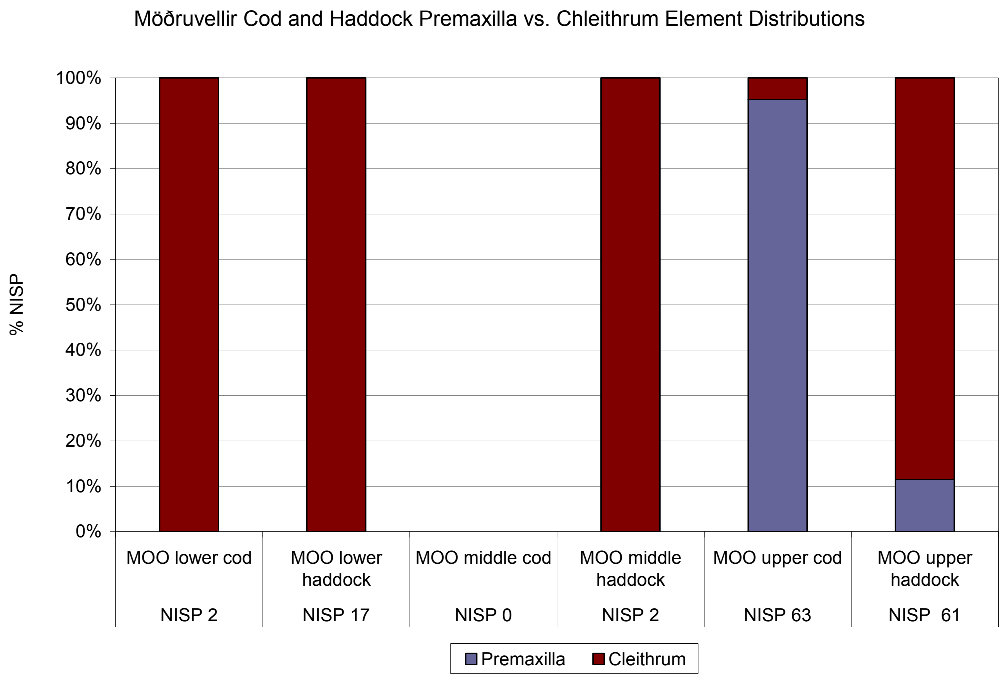


Figure III. Cod and Haddock premaxilla vs. cleithrum distributions; all Möðruvellir midden phases compared.