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Hrísheimar: Fish Consumption Patterns

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By

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I. INTRODUCTION

A. Introduction

In the 9th Century, Norse settlers expanding throughout the North Atlantic colonized Iceland, a volcanic island near the Arctic Circle. The Norse transported a standard set of domesticated animals including cattle, pigs, horses, goats, and sheep with them to these new settlements (Amorosi et al. 1997; Dugmore et al. 2005). They also brought the cultural processes they had utilized in other settlements and their Scandinavian homelands. Initially, the settlement of Iceland was thought to have begun along the coasts and only moved inward as the population increased. Often this model emphasizes that early settlers focused on farming and the future use of their introduced domesticated animals for subsistence. Thus, early settlers sought out areas with vegetation most beneficial for these domesticated animals. In this model, fishing and other wild resources were considered supplemental until domesticated animal stocks were large enough to sustain the population (Sigurdsson, 2008). However, recent archaeological evidence from inland sites in Iceland has provided new insight into this model and the Icelandic *Landnám* (McGovern et al., 2007).

Recent zooarchaeological evidence shows that inland settlements throughout Iceland were settled early and prior to the population growth necessary to fill coastal regions (Vésteinsson & McGovern, 2012; Perdikaris & McGovern, 2007; McGovern et al., 2006; Lawson et al., 2005b). Furthermore, this evidence provides numerous examples of early settlers utilizing a subsistence pattern that consisted of multiple wild faunal resources including sea mammals, sea bird colonies, and a variety of bird and fish species (McGovern et al., 2007). This faunal evidence remains vital to reexamining and altering the traditional model of settlement of Iceland. This paper will continue the discussion of new zooarchaeological evidence with a focus on the fish remains from the early inland site of Hrísheimar in the Mývatnssveit Region, showing that inland sites were not only settled early, but utilized both marine and freshwater fish resources throughout the span of the settlement. It will also examine whether iron production at Hrísheimar caused any unique patterns of fish usage in relation to other less specialized sites in the Mývatnssveit Region.

B. Broader Implications

As one of several early inland sites in the Mývatnssveit Region, the Hrísheimar site provides more evidence for the argument that the traditional model of settlement needs to the reexamined. The zooarchaeological evidence from the early phases of many sites in the Mývatnssveit Region show that from the time of settlement, natural fauna played a key role in the subsistence strategy of settlers. Due to the lack of land-based mammals, with the exception for the arctic fox, early settlers of Iceland exploited marine mammals, birds, and fish (Church et al., 2005). Thus, wild fauna resources also might have played a significant role in the decision of early settlers to choose certain areas over others. Additionally, even after domesticated animal stocks were large enough to sustain a farm, wild resources in the Mývatnssveit Region continued to be utilized, often at a similar rate. The site of Hrísheimar shows continuous usage of several wild resources including freshwater and marine fish.

At Hrísheimar, well-preserved middens have provided a large assemblage of fish bones. These fish bones include thousands from local freshwater fish that settlers had easy access to in the region. However, this site also includes early evidence of the marine fish species gadidae. Several well-dated sites have also provided remains of the marine fish species gadidae in the inland Lake Mývatn region prior to A.D. 940 (Smiarowski et al., 2017). The remains of these marine fish on early inland sites such as Hrísheimar provides further evidence of sustained contact between inland and coastal farms in early Iceland and even the use of commercial products from the settlement period. Hrísheimar and other inland sites from the Mývatnssveit region provide evidence of a pattern of consumption of commercial marine fish product in the 9th Century, prior to the "fish event horizon" that occurred in Europe and without the delay seen between rural and urban areas in other areas of Europe (Barrett et al., 2004b). However, the Norse settlers did show the usage of dried fish products in the 9th-10th Century (McGovern et al., 2006). The early settlers of Iceland likely brought the customs and processes of creating dried fish products from Norway; however, the climate of Iceland wasn't as fit as their homeland for creating dried fish products (Perdikaris, 1999). An analysis of the fish remains at Hrísheimar and other early settlement sites might provide further evidence in understanding the significance of dried commercial marine products to early Icelandic settlers.

The fish assemblage from Hrísheimar also shows a unique amount of Atlantic salmon (*Salmo salar L*.) remains. The location of the Hrísheimar site resides upstream about 20 km further from the end of the current migration patterns of Atlantic salmon. Is it possible that as a specialized, albeit short lived, production site that Hrísheimar held a special status or prestige compare to other sites in the region? Is it possible that Hrísheimar might have had trade connections with another nearby region or that trade networks were more extensive than previously considered in early Iceland? The presence of Atlantic Salmon may create more questions than can be currently addressed, but the implications are worth the discussion.

Since Hrísheimar is a specialized site that focused on the production of iron products, I hypothesize that the site would utilize fish resources more than other sites in the Mývatn region. The iron production at the site also might be associated with elite trade allowing for them to gain access to Atlantic Salmon from the lower reaches of the Laxá River. Furthermore, I hypothesize that the fish remains at Hrísheimar provide archaeologists with further evidence that inland sites such as those in the Mývatnssveit Region utilized both local freshwater and marine fish from the coastal regions as a part of their subsistence pattern.

C. Layout

The introduction of the first section has served to give an overview of what will be discussed throughout the paper and the implications for such analysis. The second section addresses the dating techniques utilized in the Mývatnssveit region. Due to the volcanic activity of Iceland, this includes a discussion of tephrochronology and recent research with ^{14}C radiocarbon dating that has provided more validity to the dates associated with tephra layers.

The third section focuses on the environmental and archaeological context of the site Hrísheimar by first examining the historical ecology of Iceland, reviewing changes that occurred during Icelandic *Landnám*, and then focusing on the environment and some of the archaeological sites in Mývatnssveit Region where Hrísheimar resides.

The fourth section takes an in-depth look into the site of Hrísheimar by first reviewing the location of the site and surrounding environment. Following this environmental context will be an examination of the history of the site and its archaeological excavation including a description of the site, methods utilized during excavation, and a brief review of any other relevant archaeological context.

The fifth section describes the methods utilized during the fish analysis including the sample size of the fish assemblage, the identification techniques utilized for the fish bones, how the fish bones were measured, and the equations and statistical methods utilized throughout the analysis.

The sixth section examines the results from analyzing the fish data of the site. This will include the proportions of fish species found at the site and two other sites in the Mývatnssveit region. In addition, it will examine the implications of Atlantic Salmon at the site. It will also discuss the remains of the marine gadidae species and what this data shows about the site and its connections with coastal regions.

The final section provides a look at future research questions that could address the unanswered questions about Hrísheimar and the Mývatnssveit region.

II. DATING

A. Tephrochronology

The archaeological record of Icelandic settlement sites has been based on several techniques including tephrochronology, radiocarbon dating, historical documentation, and artifact dating (Schmid et al., 2017). One of the most important methods for the dating of Icelandic settlement sites is tephrochronology. The volcanic nature of Iceland that has caused various eruptions in the country throughout time has provided archaeologists with volcanic ash layers known as tephra that can be utilized to date archaeological sites. Tephra can be utilized so easily in Iceland because these layers are often widespread across large areas of the country, have unique characteristics that allow them to be identified, and are associated with other independent dating techniques (Schmid et al., 2017). Once deposits are found and the isochrons for that eruption defined, a calendar or sidereal date for the tephra must be established (Schmid et al., 2017). Sigurður þórarinsson developed tephrochronology as a dating technique in Iceland in the 1940s (Schmid et al., 2016). The technique has continued to develop, utilizing chemistry compositions and fine-grained deposits, some invisible to the naked eye, to enhance stratigraphic resolution (Schmid et al., 2017; Dugmore et al., 1992).

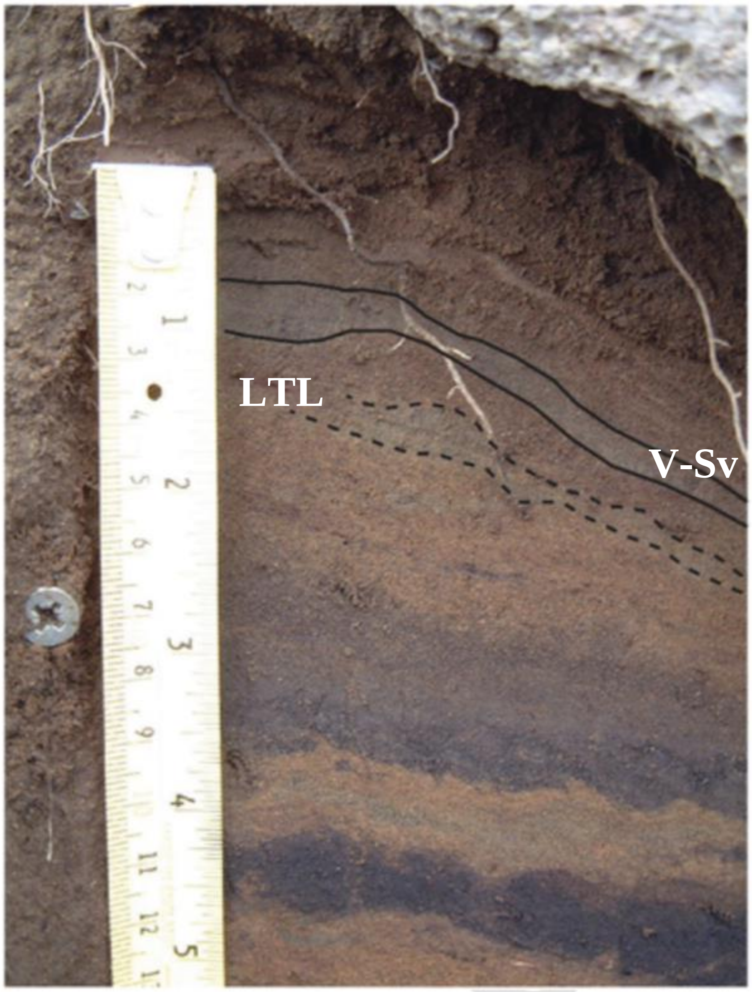


FIGURE 1. “The preservation of the LTL and V-Sv tephras *in situ* below a structure at Sveigakot (Anthony Newton)” from Schmid et al., 2016.

The above photo shows an example of the tephras found for dating sites throughout Iceland.

To date the Icelandic tephra layers, researchers utilized corresponding ice-core stratigraphies in Greenland. The Landnám Tephra Layer (LTL) created by the Veiðivötn volcanic system was originally dated with this method and placed Icelandic settlement at A.D. 871 ± 2 (Schmid et al., 2017). The LTL tephra layer has a unique chemistry from other Veiðivötn tephras due to the interaction between the Veiðivötn and Torfajökull eruptions creating unique crystals (Schmid et al., 2017). This date corresponded well to the Landnám dates derived from written records which placed settlement at c. A.D. 870 (Schmid et al., 2017). Since then, higher resolution ice-core aerosol analyses have achieved a more accurate dating by utilizing the volcanic fallout of Vesuvius in A.D. 79 as a fixed reference point. These dates move the LTL tephra layer and correspondingly Landnám dates to A.D. 877 ± 1.

Tephra dates have also been dated utilizing the sediment rates from nine lacustrine sediment cores extracted from Lake Mývatn (Schmid et al., 2017). Figure 1 shows the LTL and

V-Sv tephras at a site from the Mývatnssveit region. This method allowed for the more accurate calculation of the V-Sv tephra also from the Veiðivötn volcanic systems utilizing the dates of the LTL tephra and Hekla H-1158 tephra (Schmid et al., 2017). The revision of the LTL tephra revises the date of the V-Sv tephra to 938 ± 6 (Schmid et al., 2017). These dates are vital to our

FIGURE 2. "^{14}C Ages and Delta ^{13}C values for animal bones from domestic middens and pre-Christian burials from Mývatnssveit" from McGovern et al., 2007. The below chart contains the dates from several sites and contexts in the Mývatn area and the confidence range for the corresponding dates.

and Lab Reference #	Context & Species	Context description	Delta ^{13}C (‰)	Delta ^{15}N (‰)	C/N Ratio	Radiocarbon age (years BP)	95.4% confidence range (AD)
		DOMESTIC MIDDEN SAMPLES					
Hofstaðir							
Beta 149404	HST G 008 cow	pit house floor	−21.5			1130 ± 40	780–1000
SUERC-3429	HST 7a cow	lower pit house fill	−21. 0			1160 ± 35	770–980
SUERC-3430	HST 7a pig	lower pit house fill	−21.0			1170 ± 40	770–980
Beta 124004	HST G 6n cow	lower pit house fill	−21.4			1170 ± 40	770–980
SUERC-3431	HST 6d cow	upper pit house fill	−20.3			1045 ± 35	890–1040
SUERC-3432	HST 6d pig	upper pit house fill	−21.5			1040 ± 40	890–1160
SUERC-3433	HST 6g cow	upper pit house fill	−20.9			1030 ± 35	890–1160
Beta 149403	HST G 004 cow	upper pit house fill	−21.7			1120 ± 40	780–1020
Beta 149405	HST E 1144 cow	outside hall	−21.6			1060 ± 50	880–1160
Sveigakot							
Beta 134146	SVK M 011 cow	Lower midden M	−21.0			1110 ± 40	780–1020
Beta 134144	SVK M 002 cow	Upper midden M	−21.0			1120 ± 40	780–1020
Beta 134145	SVK M 012 sheep	Upper midden M	−19.3			1090 ± 40	880–1030
Beta 146583	SVK T 055 cow	upper fill of pit house T	−22.7			1040 ± 40	890–1160
Beta 146584	SVK T 055 cow	upper fill of pit house T	−21.5			1010 ± 40	900–1160
Hrísheimar							
AA-49627	HRH 003 cow H	Midden fill of pit house	−20.7			1150 ± 35	780–980
AA-49628	HRH 003 cow H	Midden fill of pit house	−21.0			1135 ± 45	770–1000
AA-49629	HRH 003 cow H	Midden fill of pit house	−20.2			1135 ± 45	770–1000
SUERC-3439	HRH 003 cow H	Midden fill of pit house	−20.9			1085 ± 35	890–1020
SUERC-3440	HRH 003 pig H	Midden fill of pit house	−21.3			1150 ± 40	770–990
SUERC-3441	HRH 003 cow H	Midden fill of pit house	−22.0			1095 ± 35	880–1020
SUERC-3445	HRH 060 cow L	Lower midden L	−20.9			1090 ± 35	890–1020
SUERC-3442	HRH 002 pig H	Deflated upper deposit	−20.1			1120 ± 35	810–1000
SUERC-3446	HRH 002 cow N	Deflated upper deposit	−21.4			1080 ± 35	890–1020
Selhagi							
AA-49630	SLH1 01 004 cow	Upper midden	−21.1			960 ± 45 BP	990–1190
AA-49631	SHL2 01 004 cow	Upper midden	−20.8			995 ± 45 BP	970–1170
Steinbogi							
AA-52498	SBO 002 Cow	Main surviving midden deposit	−21.4			875 ± 40 BP	1030–1260
AA-52499	SBO 002 Cow	Main surviving midden deposit	−20.5			870 ± 40 BP	1150–1230
		PRE-CHRISTIAN BURIALS					
Gautlönd, Skútustaðahr							
SUERC-2026	Human GLÞ-A-1		−19.5	8.4	3.0	1200 ± 35	
SUERC-2663	Human GLÞ-A-1		−19.7	7.7	3.0	1175 ± 35	
SUERC-2664	Dog		−20.5	8.3	2.9	1175 ± 35	
Grímsstaöir, Skútustaðahr							
SUERC-2018	Human GRS-A-1		−19.3	10.0	3.1	1225 ± 35	
SUERC-2019	Horse 1967-213		−21.0	1.7	3.1	1145 ± 35	*880–990
SUERC-2662	Horse 1967-213		−20.7	1.2	3.0	1105 ± 35	
Ytri-Neslönd, Skútustaðahr							
SUERC-2016	Human YNM-A-1		−18.9	9.7	3.1	1395 ± 35	
SUERC-2660	Human YNM-A-1		−19.3	8.3	3.1	1405 ± 35	
SUERC-2017	Horse 1960-46		−21.8	2.7	3.2	1175 ± 35	**770–900
SUERC-2661	Horse 1960-46		−21.7	2.0	3.1	1200 ± 35	
Þverá, Reykdælahr							
SUERC-2039	Human 2000-3-1		−19.7	8.7	3.1	1235 ± 35	

Note. All calibrations were undertaken using the OxCal Program, which uses the INTCAL98 data (M. Stuiver et al. 1998). All AMS ^{14}C were made on extracted bone collagen.
*calibrated range (95.4% confidence) derived from the weighted mean age of SUERC-2019 and SUERC-2662 (1125 ± 25 yr BP).
**calibrated range (91.4% confidence) derived from the weighted mean age of SUERC-2017 and SUERC-2661 (1188 ± 25 yr BP).

understanding of the Mývatnssveit region. The accumulation of aeolian sediments utilized with known tephra layers and written sources have also allowed for the dating of later tephras (Schmid et al., 2017).

Throughout Iceland, these well dated tephras can be found in almost 84% of known archaeological sites (Schmid et al., 2017). In addition, these tephras allow for a more accurate grouping of archaeological sites into time frames around Iceland including in Northern Iceland in the Mývatnssveit region. For example, tephra layers have allowed archaeologists to recognize that the anthropogenic layers occur below the V-Sv layers in two out of three of the current open area excavation sites around Lake Mývatn (Schmid et al., 2017). The LTL and V-Sv tephra layers and their associated dates are thus vital for our understanding of when and how wild resources were utilized at Hrísheimar.

B. Calibrated Radiocarbon Dates

Radiocarbon dates have also been completed for several sites around Iceland, including sites in the Mývatnssveit region. The radiocarbon dates at Sveigakot, Hrísheimar, Hofstaðir, Steinbogi, and Selhagi have provided dates consistent with those provided by the dated tephra layers and the Viking Age (McGovern et al., 2006). The radiocarbon samples came from the midden deposits of each site and consisted of mammal bone collagen from those with fully terrestrial delta ^{13}C ratios as to provide the most accurate dating (McGovern et al., 2006). Figure 2 shows these radiocarbon dates from several sites in the Mývatnssveit region and their corresponding confidence ranges. These dates have added further confidence in the established dates from tephra layers found in many sites throughout the Mývatnssveit region.

III. ENVIRONMENTAL AND ARCHAEOLOGICAL CONTEXT

A. Icelandic Historical Ecology

The location of Iceland to the northwest of the Faroes and to the east of Greenland causes it to have an overall low arctic climate (Olafsdóttir et al., 2001). Iceland's location at the intersection of polar air and warmer Atlantic air, as well as that of the warmer Irminger and colder East Iceland currents causes the country to have a variable climate with the North being much colder than the South (Sigurðardóttir et al., 2016). Overall, the warmer Irminger and North Atlantic cause Iceland to have a mild climate (Sigurðardóttir et al., 2016). However, the closeness of Arctic ice drifts and the Iceland Low also effect the climate, especially in the Northern region by impacting storm systems (Sigurðardóttir et al., 2016).

The landscape of Iceland at the time of settlement included familiar features to the Viking settlers such as the glaciers of the interior highlands (McGovern et al., 2007) and features that would have been alien to them such as lava fields, geysers, and sulfur pools (Hall, 2007). The vegetation of Iceland prior to settlement included grasses and heaths with the addition of mosses and lichens, which dominated the interior (Olafsdóttir et al., 2001). Iceland also benefited from extensive forests with large populations of birch and willow trees (Hall, 2007). Prior to settlement in Iceland, vegetation covered 60% of the land with as much as 15-40% covered by forest (Olafsdóttir et al., 2001). However, the late Holocene affected the climate in Iceland causing slight decline in some plant species, even before the arrival of Norse settlers (Olafsdóttir et al., 2001).

Importantly for the Norse settlers, areas existed on Iceland that could sustain the grazing of pasture animals (Hall, 2007) and limited agriculture (McGovern et al., 2007). However, as mentioned previously the polar climate and location of Iceland causes a delicate ecology, more vulnerable to changes by climate and human interaction. For example, modeling shows that a one-degree decrease in temperature could reduce usable rangelands by 10-20% (Olafsdóttir et al., 2001). A variety of wild faunal resources such as birds, fish, and marine animals including walruses and seals also attracted settlers to Iceland (McGovern et al., 2007). The only land mammal present prior to settlement was the arctic fox (Smith, 1995).

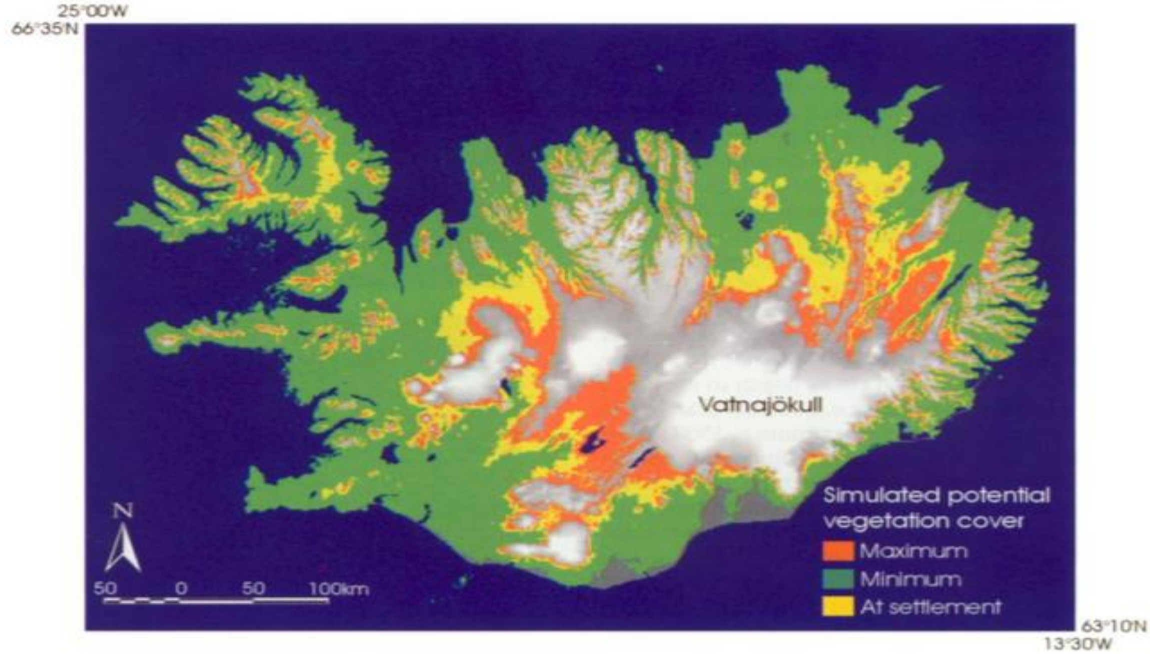


FIGURE 3. "Simulated changes in spatial and temporal vegetation cover throughout the Holocene" from Olafsðottir et al., 2001.

The figure above shows the vegetation cover of Iceland as simulated by a model utilizing estimates throughout different time periods including Landnám.

B. Icelandic Landnám

About a century prior to the settlement of Iceland, Norse settlers had expanded into other areas of the North Atlantic including the British Isles, the Orkneys, and the Faroes. Thus, it is not surprising that the settlers of Iceland originated from Norway and the British Isles (Hall, 2007).

These settlers might have emigrated from Norway to the British Isles before later settling in Iceland. Evidence of this origin for the settlers can be seen in the Icelandic Sagas, such as Landnámabok, place names, and genetic research. Some names with Gaelic origins can be found listed in Landnámabok and used as place names throughout Iceland (Sigurdsson, 2008). Some place names even correspond with place names used in the Hebrides, providing further evidence of a mixture of settlers from Norway and the British Isles (Sigurdsson, 2008). Recent genetic research utilizing Y-chromosome variation and mtDNA support the mixed origins of early Icelandic settlers with genetic evidence. This genetic evidence revealed that most female settlers in Iceland were from the British Isles, while most of the male settlers were of Scandinavian background (Helgason et al., 2001).

Originally, it was thought that many of these settlers chose sites in Iceland positioned near the coast. In this model, it was the rapid expansion of settlements on the coast of Iceland and subsequent population growth that pushed settlers to find new places of settlement along major river valleys and inland. However, the inland sites of the Mývatnssveit region show that this model may not be accurate. The dates for several sites within the region show they appeared shortly after the LTL tephra (McGovern et al., 2007). These sites were created before the coastal settlements and population gains could have caused enough pressure to push settlers inland.

Social and political aspects also played a role in the settlement of Iceland. Early Icelandic settlers were most likely wealthy farmers or chieftains who could afford to transport people and livestock over such distances (Sigurdsson, 2008). Historical documents also show that many of these Norse settlers brought slaves from the British Isles with them (Sigurdsson, 2008). Thus, these first settlers claimed large amounts of land and then divided this land into smaller areas for their followers and slaves (McGovern et al., 2007). This type of strategy allowed for some of the more wealthy and initial settlers to hold more power than the settlers that followed. These single farms dominated the settlement of Iceland, where no villages or towns developed. However, these initial settlers were engaging in distribution networks as marine mammals and fish have been found in multiple inland sites around Iceland, including the sites focused on in this paper in the Mývatnssveit Region (McGovern et al., 2007).

In the creation of farms, Icelanders utilized a variety of different resource zones often dispersed over large areas (McGovern et al., 2007). In preparing these landscapes for settlement, Icelanders aided in the decline of woodlands and vegetation in Iceland. There’s evidence of the burning of woodlands to clear areas for farmsteads and sometimes hayfields (Smith, 1996). The early settlers also utilized wood in the construction and maintenance of their settlements. In addition, at specialized sites such as Hrísheimar, early settlers used wood resources in the creation of iron. Evidence from Hrísheimar shows that settlers exploited birch wood as a major fuel resource in creating charcoal for iron smelting and smithing (McGovern et al., 2007). The clearing and use of woodlands also led to the decline of vegetation and negatively impacted soil accumulation causing an increase in the rate of soil erosion in Iceland (Smith, 1995).

The vulnerability of Iceland’s environment caused climate fluctuations to compound the negative impact of humans on the environment at many settlement sites. Prior to settlement, decrease of vegetation and soil erosion in Iceland was already occurring due to climatic factors (Simpson et al., 2004). The light volcanic soils in Iceland, andisols, are low in organic content and particularly vulnerable to erosion (Olafsdóttir, 2001). Some areas in Iceland due to regional patterns, slope, proximity to lava fields, and even height above sea level were also more susceptible to the pressures caused by the settlers (Simpson et al., 2004). Thus, the use of vegetation and the pressure of grazing livestock in Iceland accelerated the already occurring erosion and further reduced the natural flora, already near its biological and threshold limits which can be seen in Figure 4 (Olafsdóttir, 2001). At some of the sites, the biomass could support the numbers of livestock indicated in historic documentation (Simpson et al., 2004). However, the unpredictability of the climate and the effects it could cause on the growing period might have reduced the ability of the early Icelanders to accurately adjust land management and grazing practices at some settlement sites (McGovern et al., 2007). If sheep flocks were left too long past the growing season in pastures, it would cause pasture degradation, the breaching of soil cover, and further erosion (McGovern et al., 2007). Thus, the mismanagement of winter grazing of domesticated animals could cause severe declines in soil accumulation and erosion (Simpson et al., 2004). Current research shows that 73 percent of Iceland is affected by soil erosion (Arnalds et al., 1997). The

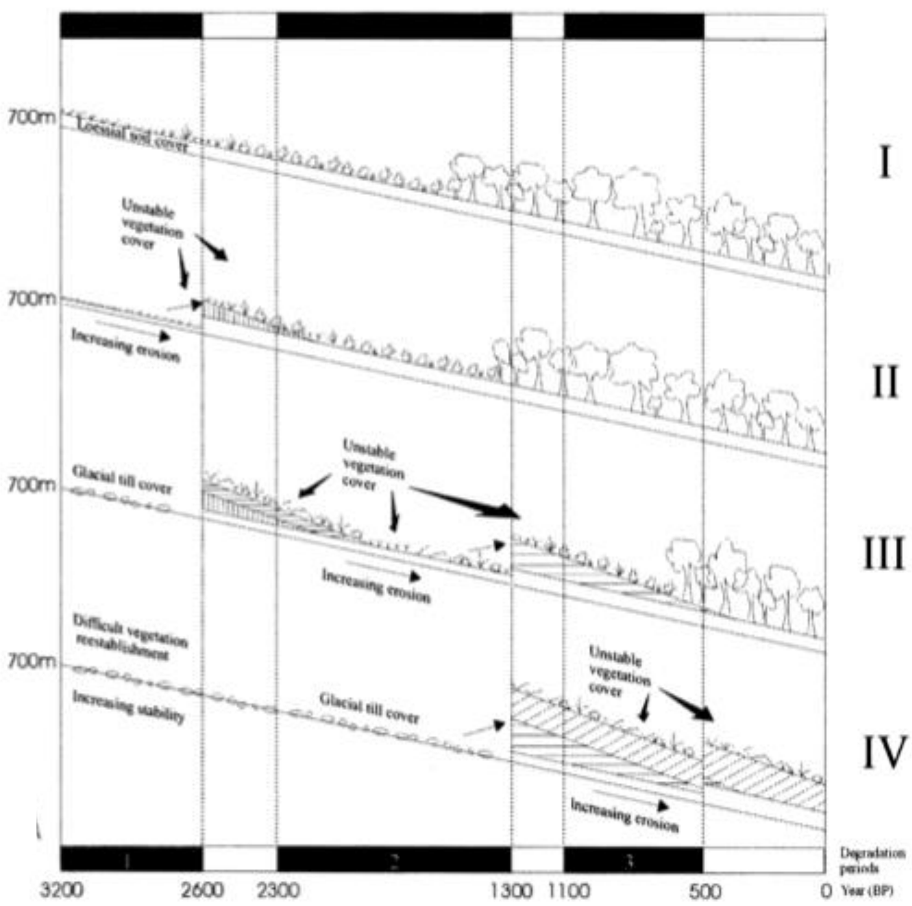


FIGURE 4. "A conceptual model of land degradation history during the last 3000 years based on modeling results and geomorphic data…" from Olafsdóttir et al. 2001.

The figure above shows a model of the compounding effects of erosion.

site of Sveigakot and Hrísheimar shows an example of how vulnerable areas rapidly underwent erosion and soil cover loss after settlement leading to irreversible land degradation (Simpson et al., 2004).

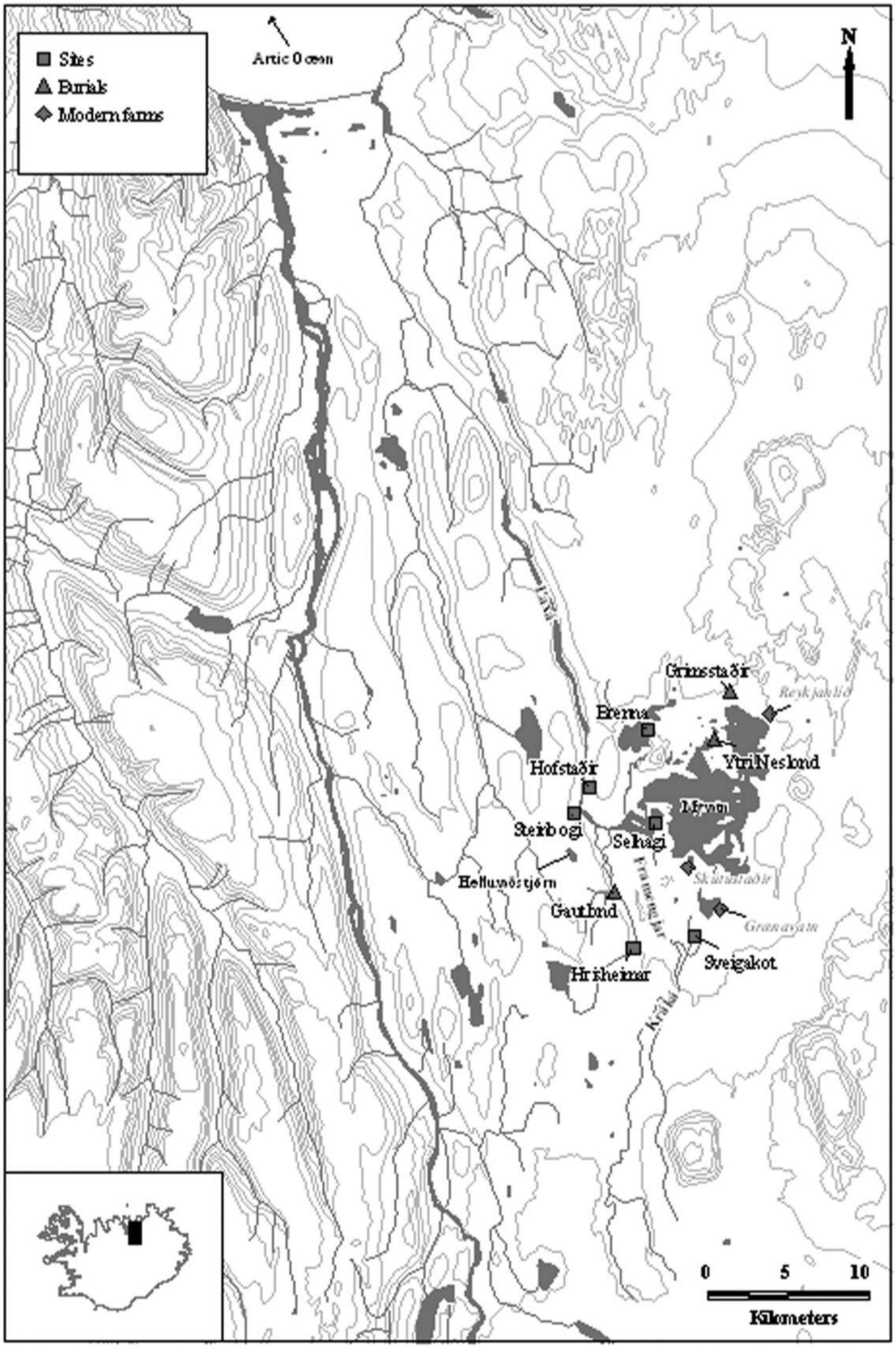
C. Mývatnssveit Region

1. Environment

The archaeological sites from the inland Mývatnssveit region centered around Lake Mývatn in Northern Iceland provide evidence of the early and common use of wild resources, including marine resources. The region is classified as a sub-arctic and alpine landscape and is the highest community above sea level in Iceland (Sigurðardóttir et al., 2016). The location of the region near the center of the mid-Atlantic ridge causes it to be impacted by volcanic eruptions and earthquakes (Sigurðardóttir et al., 2016). The climate of the Mývatn region is drier compared to other parts of Iceland, with relatively warmer summers than coastal areas in the North (Sigurðardóttir et al., 2016). This region might have attracted settlers due to the rich ecological system created by Lake Mývatn providing a variety of natural resources (McGovern et al., 2007).

Lake Mývatn is one of the largest lakes in Iceland. Abundant springs feed $35m^3/s$ of water to the lake which resides in the lake for only 27 days (Sigurðardóttir et al., 2016). Its dominance of the ecology of the region and its size provide the region with its name. The lake receives more solar radiation due to a rain shadow created by the Vatnajökull glacier, which allows this shallow lake to warm considerably (Sigurðardóttir et al., 2016). The chemistry and temperature of the underwater springs, the shallowness and warmth of the lake all allow nutrients to enter the lake which creates the rich biological and ecological system of the Mývatn region (Sigurðardóttir et al, 2016). The numerous species of flies or midges (around 50) that breed near

FIGURE 5. "General location map, Lake Mývatn basin area (Oscar Aldred)" from McGovern et al., 2007. The below map shows an overview of the Lake Mývatn area.



and around the lake provide the lake with its name, which translates to "Midge Lake" (Sigurðardóttir et al., 2016). These midges and nutrients allow for freshwater fish species, such as the Arctic Charr to prosper. The Jarðabók 1712 Land Register shows that traditionally fishing was done in the river and lake by gill netting and beach seining (McGovern et al., 2006). Then in the winter, it is recorded that Icelanders utilized gill netting in areas that were ice free and by hook and line in areas with ice (McGovern et al., 2006). Although the lake is well known for its large populations of birds and fish, the lakeshore also supports rich hay fields for domesticated animals (McGovern et al., 2007).

The nearby rivers also play a vital role in creating these rich resources. The Laxá River flows from Lake Mývatn and joins the Kráká River before heading to the Skjálfandi Bay on the coast. The Laxá is famous for its brown trout, but Atlantic salmon do visit its lower reaches (McGovern et al., 2007). The Kráká River has created a rich wetland system of several small ponds and streams near the southern edge of the lake known as the Framengjar (Sigurðardottir et al., 2017). The Framengjar contains rich grasslands that provides natural fodder for domesticated animals and would've been extremely attractive to early settlers. Two nearby lakes, the Sandvatn ytra and Grænavatn, also provide freshwater fish and bird resources (Sigurðardottir et al., 2016). Although no water sources remain near the site of Hrísheimar today, it is possible that the Framengjar wetland extended further west than it does today. The soil erosion in the region may also have caused changes in the landscape which can be seen with the infilling of the site. Soil erosion also caused the drying out of nearby wetlands, streams, and ponds in the late 15th Century and early 18th Century (Lawson et al., 2005b).

Prior to settlement, the vegetation of the region would have consisted of a mixture of birch woods, heath, grasslands, and wetlands at low elevations with dwarf-shrub heath lands and arctic-alpine herbaceous vegetation at high elevations (McGovern et al., 2007). At the Sveigakot and Hrísheimar sites, root casts show that the woods might have been dense prior to the mid-tenth century when the trees were cleared (McGovern et al., 2007). Although woodlands no longer exist in the region, a pollen core from five kilometers southwest of Lake Mývatn provides evidence that the area's birch woods were not immediately cleared by early settlers to the region (McGovern et al., 2007). Soil cores also show that the highlands around the area have undergone several phases of vegetation and soil loss since deglaciation (Olafsdóttir & Gudmundsson, 2002). Therefore, although soil might have been impacted by the rates of tephra production and climatic processes, the soil in the Mývatnssveit region was entering a period of stabilization prior to settlement (McGovern et al., 2007).

2. Archaeological Sites

Despite the area sitting about 250-300 m above sea level and 60 km from the Arctic Ocean, archaeological sites show that many areas of this region have been inhabited from Landnám to the present. During a survey of the Mývatnssveit region, over 1,200 sites and structures were documented including the pre-Christian "temple" site of Hofstaðir (McGovern et al., 2007). Several sites in the Mývatn area also included pre-Christian burial sites (McGovern et al., 2007). Many of the sites surveyed contained excellent organic preservation, thus several sites in the region have had major excavations including Sveigakot, Selhagi, and the site focused on in this paper, Hrísheimar (McGovern et al., 2007). Several of the sites mentioned in the Mývatnssveit region can be seen on the map in Figure 5.

The sites utilized for comparison of the regional patterns in fish element distributions and ratios include the sites of Sveigakot (SVK) and Hofstaðir (HST). Sveigakot was a more traditional farming site that was also settled shortly after Landnám (McGovern et al., 2007). The site was abandoned in the late 11th Century and then resettled, only to be abandoned again by the early 13th Century (Vesteinsson & McGovern, 2012). The initial settlement at Sveigakot appears to be mostly pit houses, potentially only slaves or lower status occupants. Whereas the Phase III deposits show a small long hall building, thus potentially a free tenant farmer occupied the site at this time. Throughout both periods though, Sveigakot remained smaller and less prosperous than Hrísheimar and Hofstaðir. The site of Hofstaðir appears to have been a working farm, with a connection to ritual feasting (McGovern et al., 2007). The zooarchaeological evidence including weathered skulls and young adult animals of the site shows strong evidence that the site was a specialized, pre-Christian temple site that produced animals for ritual feasting (McGovern et al, 2007). Thus, there may be similarities between Hofstaðir and Hrísheimar in terms of diet, since

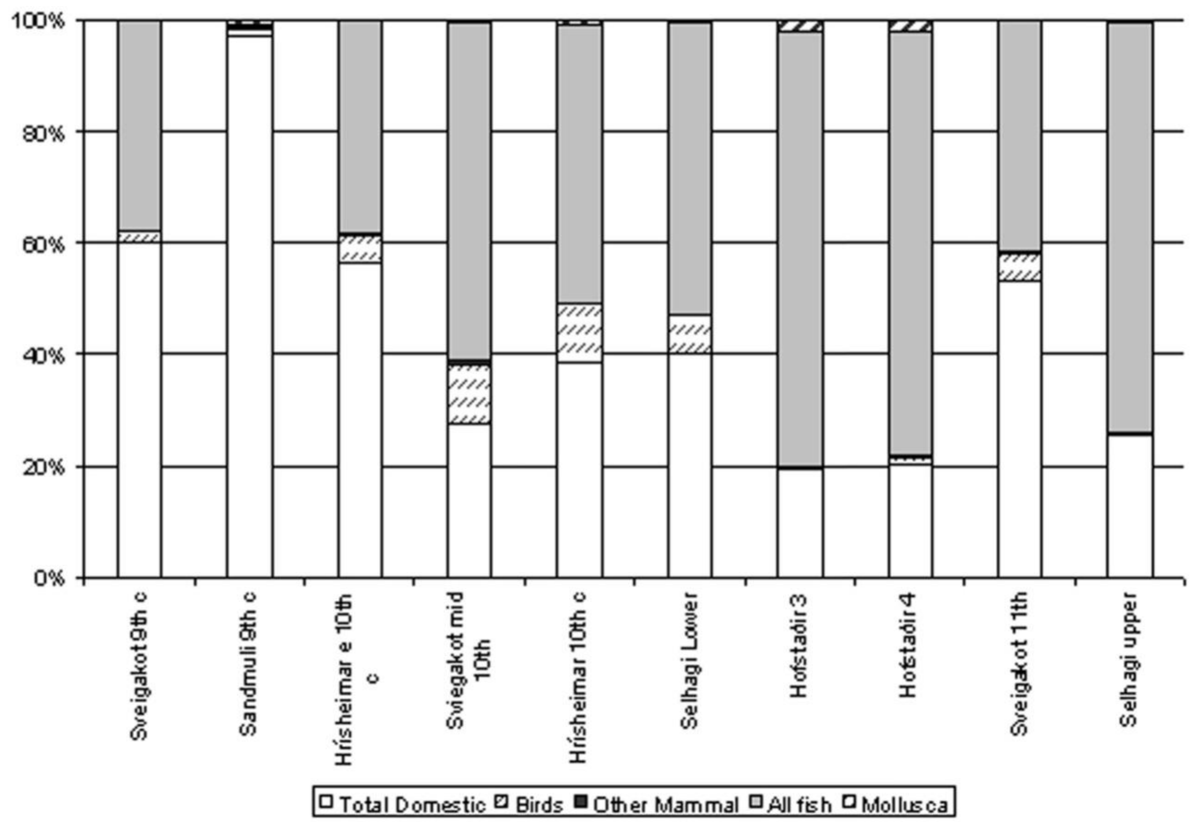


FIGURE 6. "Wild and domestic species use in ninth-to-12th century Mývatn and Krókdalur" from McGovern et al., 2007. The above figure shows the ratio of wild resources and domesticated animals found in several Mývatn sites. The fish numbers utilized for this chart were preliminary to the fish analysis completed for this paper.

both were potentially high status, specialized sites. However, Hofstaðir was settled around the mid to late tenth century, thus settled later than both Sveigakot and Hrísheimar. All three sites utilized show varying rates of erosion, however Hofstaðir's erosion rate was reduced below the regional average, while the sites of Sveigakot and Hrísheimar show a worsening of erosion until the sites were abandoned (McGovern et al., 2007).

As mentioned previously, the ecology of the area supports a variety of wild resources including multiple local bird and fish species. Figure 6 shows preliminary data from 2007 comparing several sites in the Mývatn region. This chart was created before the analysis of fish for Hrísheimar completed for this paper. Some of the most frequently found fish species in the region include the Arctic Charr (*Salvelinus alpinus L.*) and Brown Trout (*Salmo trutta L*.), which can be found in Lake Mývatn (McGovern et al., 2007). Zooarchaeological data from these sites including Hofstaðir, Sveigakot, Hrísheimar, and others provide evidence of marine mammals, fish, birds, and molluscan remains throughout multiple phases showing recurrent contact with coastal regions (McGovern et al., 2007). Marine fish species from the gadidae or cod family including Cod (*Gadus morhua L*.), Haddock (*Melanogrammus aeglefinus L*.), and Saithe (*Pollachius virens L*.) also appear in many of the Mývatn sites (McGovern et al., 2007). In the Mývatnssveit Region, 12-30% of fish from fully analyzed collections come from the cod family (McGovern et al., 2007). This pattern of remains from the cod family provides evidence of commercial use long before the "fish event horizon" occurred in the rest of Europe. The assemblage of fish from the site of Hrísheimar show this pattern and the usage of Atlantic Salmon.

IV. SITE BACKGROUND

A. Location and Environment

Hrísheimar is an abandoned farm and iron production site located in the Kráká river drainage to the south of the lake (McGovern et al., 2007). It lies around 300 m above sea level and on a heavily eroded ridge overlooking a small bog on the west side of the Kráká River (McGovern et al., 2006). Potentially the bog that now appears to the south and southwest of the site was larger during the site's occupation (Edvardsson & McGovern, 2007). Hrísheimar's location would have provided access to a variety of resources with freshwater streams, lakes, wet meadows, and pastures (McGovern & Woollett, 2003). The area at the time of the settlement would have been much wetter and allowed for the regular production of the iron pan, providing the site with ore (Edvardsson & McGovern, 2007). The ruins of a nearby shieling exist along the southeastern slope of the ridge, which dates much later than the site of Hrísheimar's occupation (Edvardsson & McGovern, 2007). The heavy erosion of the site allowed for Viking age artifacts and bone fragments to appear on the surface of the site for years prior to its excavation (McGovern & Woollett, 2003).

B. Archaeological Excavation

Excavation of the Hrísheimar site began in 2001 as a part of the Landscapes of Settlement project (McGovern & Woollett, 2003). The excavation began with a 2 x 2 m unit on a visible farm mound with well-preserved concentrations of animal bones (McGovern & Woollett, 2003). The deposits were dated utilizing AMS radiocarbon dates to the 9th and 10th Centuries which can be seen in figure 7 (McGovern & Woollett, 2003). Tephra in several of these areas allowed for further dating of the middens and the materials found within them. All deposits occurred prior to the fall of the H 1104 tephra (Edvardsson & McGovern, 2007). The excavation approach at the site focused on stratigraphic excavation, single context excavation and recording, 100% dry sieving, and whole soil sample collection for flotation (Edvardsson et al., 2005). Excavations were carried out by a combination of graduate students, undergraduate students, and led by Ragnar Edvardsson, Thomas McGovern, Sophia Perdikaris, and Mike Church (Edvardsson et al., 2005).

Lab Reference #	Context	Material	comment	delta C13	radiocarbon age BP
SUERC-3441	[002]	cattle bone	deflated midden	-21.5	1095+/-35
SUERC-3442	[002]	pig bone	deflated midden	-20.2	1120+/-35
SUERC-3446	[002]	cattle bone	deflated midden	-21.5	1080 +/-35
AA49627(GU9729)	[003]	cattle bone	Area H upper	-20.7	1150+/- 35
AA49628(GU9730)	[003]	cattle bone	Area H upper	-21.0	1135+/- 45
AA49629(GU9731	[003]	cattle bone	Area H upper	-20.2	1135+/- 45
SUERC-3439	[003]	cattle bone	Area H upper	-21.1	1085+/-35
SUERC-3440	[003]	pig bone	Area H upper	-21.4	1150+/-40
SUERC-6433	[045]	cattle bone	Area L upper	-21.7	1120+/-35
SUERC-6437	[045]	cattle bone	Area L upper	-20.7	1120+/-35
SUERC-3445	[060]	cattle bone	Area L upper	-20.9	1090+/-35
SUERC-6431	[293]	cattle bone	Area L lower	-21.5	1220+/-35
SUERC-6432	[293]	cattle bone	Area L lower	-21.4	1200+/-35

Table 2 Laboratory data

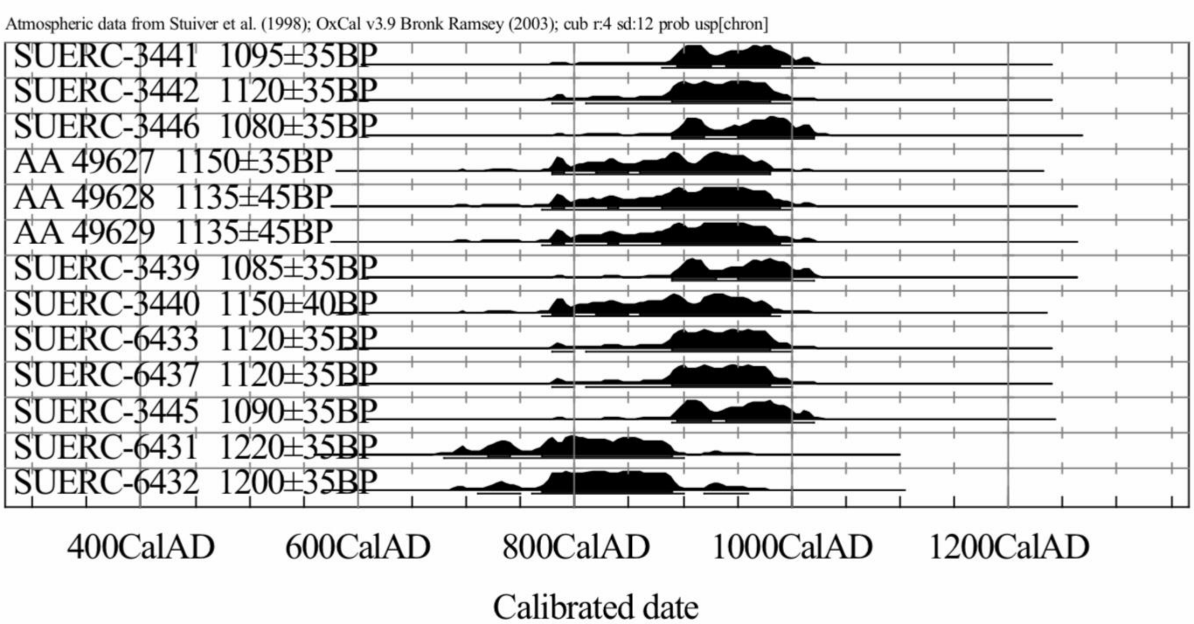


FIGURE 7. "Calibrated date" from Edvardsson & McGovern, 2006. The above figure shows the calibrated dates from several contexts at Hrísheimar.

Excavations continued for the next few years, expanding the original area to a 5 x 6 m and revealing a pit house in 2003 (McGovern & Woollett, 2003). Several other areas were also opened in 2003, including several test trenches and a 3 x 5 m unit revealing intact turf walled structures and rich midden deposits (McGovern & Woollett, 2003). Expansions to these areas occurred during the 2004 excavation (Edvardsson et al., 2005). In 2005, a much larger area to the north of the previous units was excavated revealing that different parts of the site had been utilized and then filled in prior to the entire site's abandonment (Edvardsson et al., 2005). The occupation of the site can then be placed into three major phases; Phase I from settlement ca. A.D. 877 to 938 and Phase II and III from ca. A.D. 938 to 1050 (Edvardsson & McGovern, 2007). The V-Sv tephra separates Phase I from the later Phase II and III. Thus, Phase II and III both occurred after ca. A.D. 938, with Phase II producing few materials. In the year of 2006, a pit house, latrine, and another shallow depression were fully excavated (Edvardsson &

FIGURE 8. Top left image from McGovern & Woollett, 2003.

FIGURE 9. Left image "Figure 11" from Edvardsson & McGovern, 2007.

The two finds from different contexts and excavation years show evidence of the Viking Age cultural items from the Hrísheimar site.

McGovern, 2007). The calibrated dates from Figure 7, show that there was a large gap between the end of anthropogenic deposited material and the 1104 tephra. Thus, site abandonment may have occurred between A.D. 1000 and A.D. 1050 (Edvardsson & McGovern, 2007).

Over the course of the excavations, many items of interest were found at the site. During the 2003 excavation, iron ore processing and iron-producing sites were identified including 19 small and 2 large furnaces (Edvardsson & McGovern, 2006). Despite the erosion, the site produced large amounts of cultural remains dated to the Viking Age (figures 8 and 9) in addition to faunal remains (Edvardsson & McGovern, 2006). The site has good preservation and deeply stratified midden deposits (Edvardsson & McGovern, 2006). In 2004, the expanded excavations provided further evidence of Viking Age objects such as Scandinavian whetstones, steatite vessel sherds, and comb fragments (Edvardsson & McGovern, 2006). The following year another 201 additional finds and large amounts of animal bone remains were excavated (Edvardsson & McGovern, 2006). A substantial amount of the animal bone remains were fish bones (Edvardsson et al., 2005). In 2006, sixty more cultural founds were excavated including several steatite spindle whorls and all were dated to the Viking Age (Edvardsson & McGovern, 2007).

C. History of the Site

The archaeological evidence from Hrísheimar shows that it was established during Landnám (McGovern et al., 2006). Hrísheimar excavations also revealed smelters, smithy structures, slag, and debris showing evidence of large-scale iron smelting (Edvardsson et al., 2005). The site also shows that the charcoal for this process was locally produced from the birch woodlands in the area (McGovern et al., 2007). Hrísheimar also contains a pre-Christian burial from the 9th Century with a single domesticated dog bone (McGovern et al., 2006). Therefore, the site appears to have been a substantial medium to high status farm and iron production site

(McGovern et al., 2006). Potentially this site is an example of what written documents referred to later as an "iron farm" (McGovern et al., 2006). The site has closely spaced pit houses potentially for housing many workers or slaves . There's also evidence of weaving taking place at the site with the discovery of might be loom weights in one structure (Edvardsson & McGovern, 2006).

Between the two phases at Hrísheimar, the site was reorganized with some areas of the site being filled in and production areas moved. The formerly utilized production areas were changed into fields with midden material utilized to level out areas. The reasons for this rearrangement of the site is still unknown. The AMS radiocarbon dates show that Hrísheimar was abandoned around A.D. 1020. The reasons for abandonment are also still unknown,

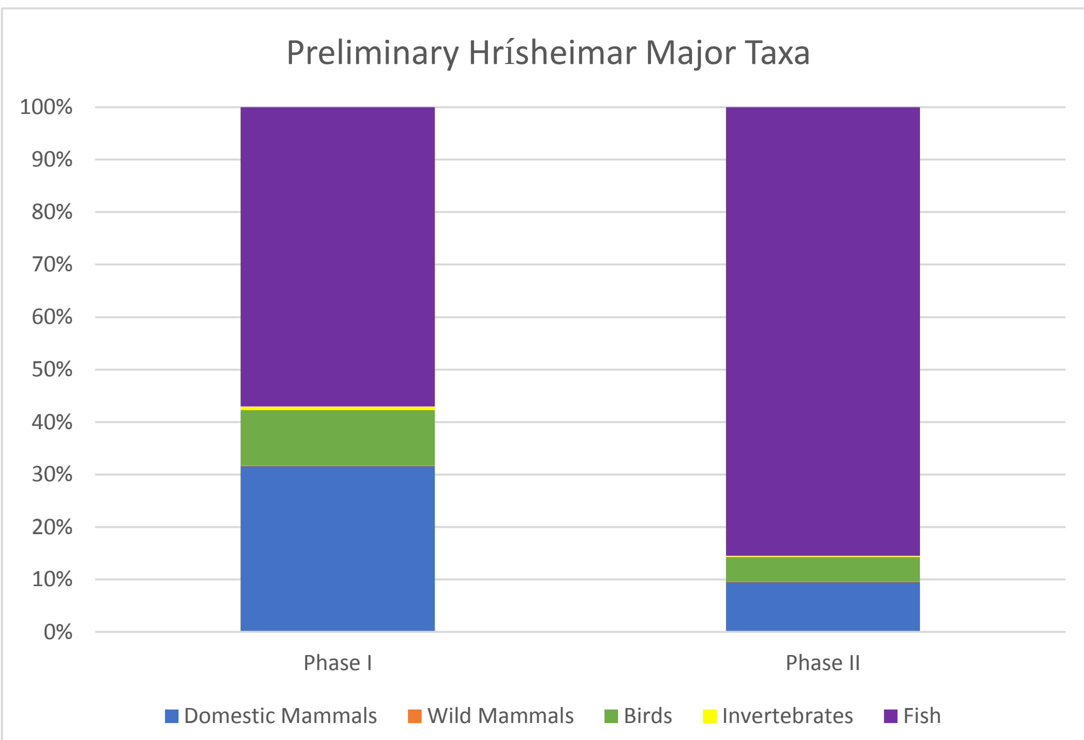


FIGURE 10. Preliminary Species Taxa Comparison at Hrísheimar. The above figure shows the current species proportions for both phases at Hrísheimar.

although several hypotheses exist. Changes in drainage patterns may have led nearby small streams to dry up, which could have impacted the formation of iron pan deposits that the site relied on for ore (Edvardsson & McGovern, 2007). However, it's also possible that political changes or even the choice to relocate could be the reason for the site's abandonment (Edvardsson & McGovern, 2007). Further field research would be needed to understand the site's full extent and size, production changes, and abandonment.

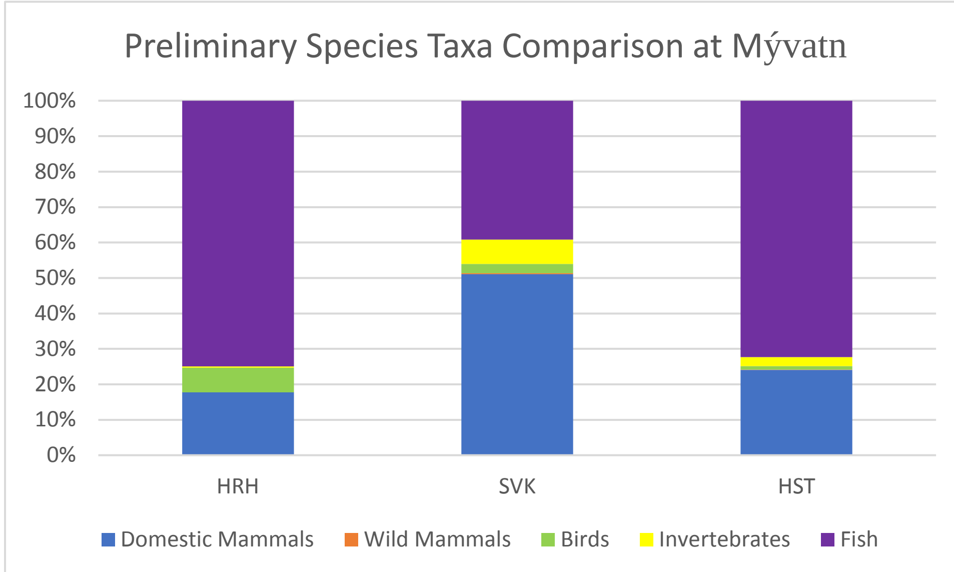


FIGURE 11. Preliminary Species Taxa Comparison at Mývatn. The above figure shows the current species proportions for Hrísheimar (HRH), Sveigakot (SVK), and Hofstaðir (HST).

V. METHODS

A. Sample Size

The excavations at Hrísheimar provided large amounts of archaeofauna remains. The site's zooarchaeological remains continue to be examined, but the current preliminary proportions for Phase I and Phase II with the fish assemblage can be seen in figure 10. As mentioned previously, there are two comparison sites being utilized in understanding the regional patterns of the Mývatnssveit region, Sveigakot (SVK) and Hofstaðir (HST). The full taxa comparison with the other two sites show a difference in proportion as seen in figure 11. Hrísheimar has a higher percentage of fish than that which was identified at Sveigakot and

Hofstaðir. However, since the analysis of other taxa continues for the Hrísheimar assemblage, the proportions may not accurately reflect any differences between major taxa at the Hrísheimar site.

The currently recorded fish bone totals from the Hrísheimar site reaches a total NISP of 41,068 and of those fish bones, 27,196 can be identified to a species. Figure 12 shows the ratio of identified to unidentified fish bones in Phase I and Phase II at Hrísheimar. The percentage of identified fish in Phase I was 41% and the percentage of identified fish in Phase II was 39%. The relatively same ratio of identified fish in both phases at Hrísheimar provide a good sample for comparison, despite Phase II having a larger overall sample size. Overall, the percentage of identifiable fish to species at Hrísheimar thus far is 66%.

The site was excavated with 100% dry sieving, which allowed for a higher rate of fish bone collection than purely relying on hand-collected materials or samples (Wheeler & Jones, 1989). The sieving allowed for more size classes and species to be represented in the assemblage (Wheeler & Jones, 1989). Additional organic material was also obtained from the floatation carried out on samples. The fish bones from the site come from a variety of contexts, a total

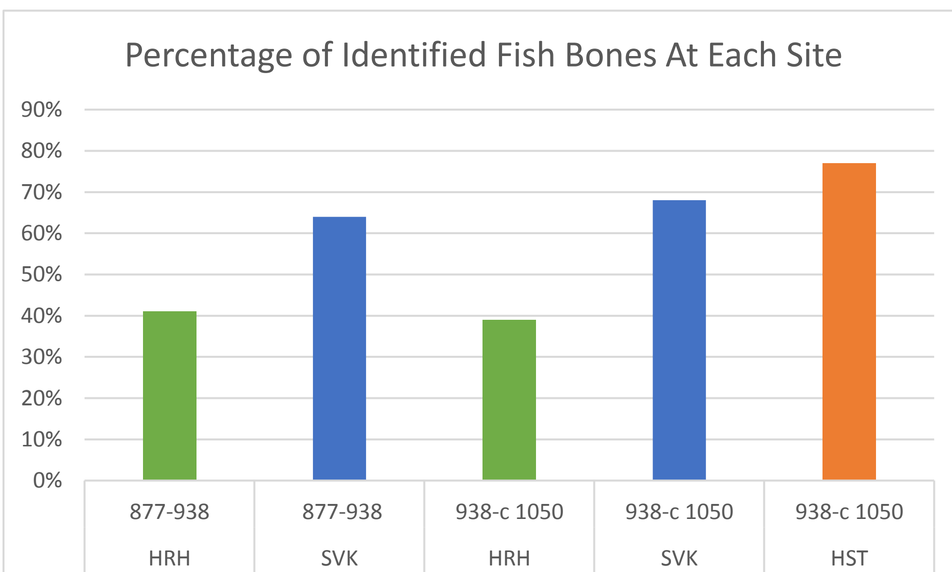


FIGURE 13. Percentage of Identified Fish Bones at Each Site. The above figure shows the percentage of identified fish bones at each site for each phase.

of 102 different contexts from 002 to 502. The largest collection of fish bones originated from Context 45 and Area L, with 9,128 bones (22%) coming from that context. This context is above the V-Sv tephra and a part of Phase II at Hrísheimar. Area L was a rich midden with many faunal remains and turf wall lines (Edvardsson et al., 2005).

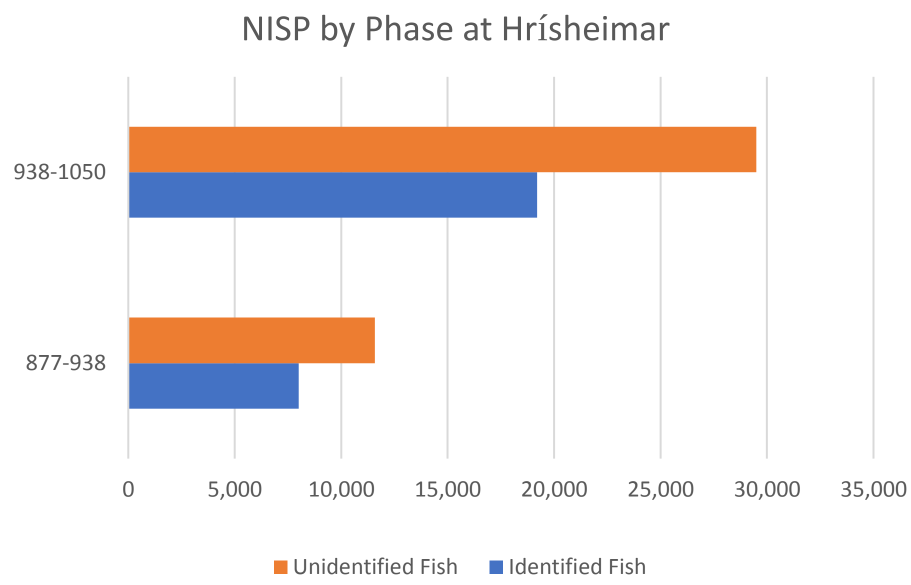


FIGURE 12. Rate of Identified Fish by Phase. The above table shows the rate of identified fish in the early phase of ca. 877-938, and the second phase of ca. 877-938.

In comparing Hrísheimar with Sveigakot and Hofstaðir, the totals and rates of identified fish species differ. Phase I of Sveigakot has a total of 368 fish bones with 235 identified fish to species, a total rate of 64% identified. Phase II of Sveigakot has a total of 4,770 fish bones with 3,220 identified fish bones to species, a total rate of 68% identified. The total amount of fish at Sveigakot is also much lower in both phases (a total of 36,063 less bones were recovered), than the total

FIGURE 14. Tray of Fish Bones for Sorting

fish bones from the Hrísheimar assemblage. However, the total overall percentage of identified fish for both phases at Sveigakot was 67%, similarly to the total identified rate for both phases at Hrísheimar of 66%. The settlement of Hofstaðir occurred later, thus only has a Phase II for comparison which has a total of 26,809 fish bones of which 20,541 were identified to species. The site of Hofstaðir has a large collection with a high rate of identification of 77%. Figure 13 shows the breakdown of identified fish percentages at each site for each phase. These rates should be considered when comparing slight differences between the sites, as the rate of identification could cause the proportions of some species to differ. In addition, an estimate of minimum number of individuals was not attempted for these fish assemblages, due to the nature of limited remains accurately showing an individual, thus limiting its usefulness (Wheeler & Jones, 1989) and that species proportions provide more valid information for the hypothesis being addressed.

B. Identification

Although different strategies are often utilized for fish identification, the large assemblage from Hrísheimar was examined in entirety by context and separated on trays at the North Atlantic Biocultural Organization (NABO) Zooarchaeology Lab at Hunter College, City University of New York, Hunter College in New York City (see figure 14). Each bone was examined to identify the bone, genera, and species when possible and then correspondingly recorded utilizing the NABONE Zooarchaeological

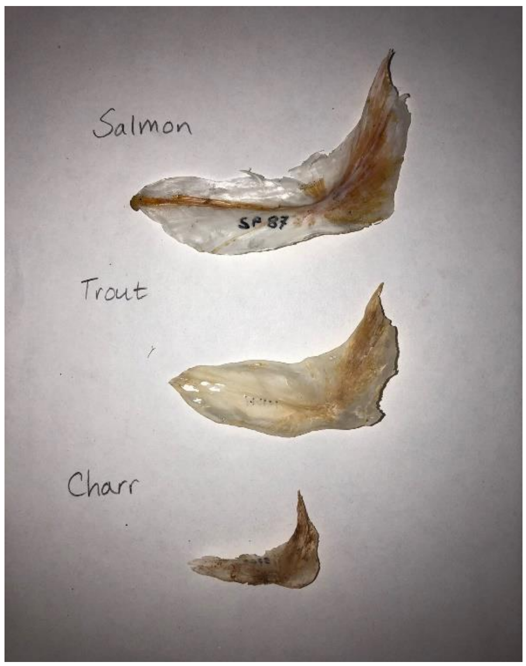


FIGURE 15. Photograph of the Comparative of Cleithrum at the NABO Lab

Database 9th Edition Recording System Codes (2010). The bones were identified utilizing a variety of resources including a full comparative available at the NABO lab (see figure 15). Also utilized for identification was the Marine Fish Osteology, A Manuel for Archaeologists by Debbi Yee Cannon, 1987 and Fishes by Alwyne Wheeler and Andrew K.G. Jones, 1989. Table 1 shows the results of this identification with the amount of each bone found at the site by family or species if known listed. The bones that could not be identified to species or family are listed under "Fish". The following other labels are utilized: "SMD" - Salmonidae family, "SAL" – Atlantic Salmon (*Salmo salar L.*), "CHR" – Arctic Charr (*Salvelinus alpinus L)*, "TRT" – Brown Trout (*Salmo trutta L)*, "GAD" – Gadidae family, "COD" – Cod (*Gadus morhua L)*, "POL" – Saithe (*Pollachius virens L.*), "HAD" – Haddock (*Melanogrammus aeglefinus L.*), "BRO" – Cusk (*Brosme brosme L.)*.

Table 1: Fish Bone Count Per Species/Family

Bone	SMD	SAL	CHR	TRT	GAD	COD	POL	HAD	BRO	FISH
Alisphenoid	11									
Angular	200	73	321	272						2
Atlas	3		4	6		5				
Basibranchial	15									
Basipterygium	243				2					
Basioccipital	59									1
Branchiostegal ray	97				18					
Caudal Vertebra	101	289	6255	3684	84	1161	110	83	4	2
Ceratobranchial	220									
Ceratohyal	419	45	351	215	2					
Cleithrum	138		20	2	318	33		52		1
Coracoid	162		8	2	5					
Dentary	198	43	248	296						1
Ectopterygoid	5									1
Expanded haemal spine										2
Expanded neural spine	152									17

Epibranchial	65									
Epihyal	408	7	6	14						2
Epiotic	26		3	1						
Epural	197									
Exoccipital	84									1
Frontal	30									
Hypural	119				3					
Hypohyal	2				1					
Hyomandibular	259	99	224	310	1					2
Hypobranchial	59			1						
Interopercle	133		3							
Interhaemal spine	1									9
Lachrymal	2									
Lingual Plate	1			2						
Maxilla	186	1	7	7	1					3
Mesocoracoid	1									
Metapterygoid	188		13	3						
Mesopterygoid	140		10	3						
Nasal	3									
Opercle	74	37	104	104	2					
Opisthotic	2									
Palatine	123									
Parietal	31									
Parasphenoid	402	1	6	13						
Postcleithrum	7				82	17		2		
Penultimate Vertebra	4	36	3	98						1
Pharyngobranchial	9									
Premaxilla	61		3	1						
Postemporal	113				1	1				
Pharyngeal plate	40									1
Prefrontal	3									
Preopercle	164	3	2	3						1
Prootic	41	1		3						
Pterrotic	112									
Precaudal vertebra	62	178	1071	584		3		1		
Quadrate	31	57	188	168						2
Radials	1									1
Subopercle	125									2

Scapula	27				129			
Supracleithrum	55				1			
Sphenotic	16							
Spines	1							2332
Suborbital	9							
Supramaxilla	1							
Supraopercle	11							
Supraoccipital	18							
Symplectic	4							
Thoracic vertebra	35	193	1389	1616	1	12	8	2
Unidentified bone element	33				30			11060
Urohyal	186				3			
Ultimate vertebra	36		1	3	1	1		4
Vertebral fragment	403		4	12	79	23	1	421
Vomer	25							

C. Measurements

All fish bone measurements were recorded for each fragment's maximum dimension to the nearest centimeter distinction as follows: 1 for below 1 cm, 2 from 1-2 cm, 5 from 2-5 cm, 10 from 5-10 cm, and 11 for items larger than 10 cm maximum dimension. As can be expected with fish bones, 53.4% of the fish bones are categorized as a 1, for below 1 cm. The arctic charr was the most represented species in the 1 cm category. Figure 16 shows the remaining ratios of the fish bone sizes. The gadidae species make up a majority, 51%, of all the bones in the 10 cm and 11 cm categories. Unidentified fish fragments make up 18% of the 1 cm category, 56% of the 2 cm category, 47% of the 5 cm, and 32% of the 10 cm category.

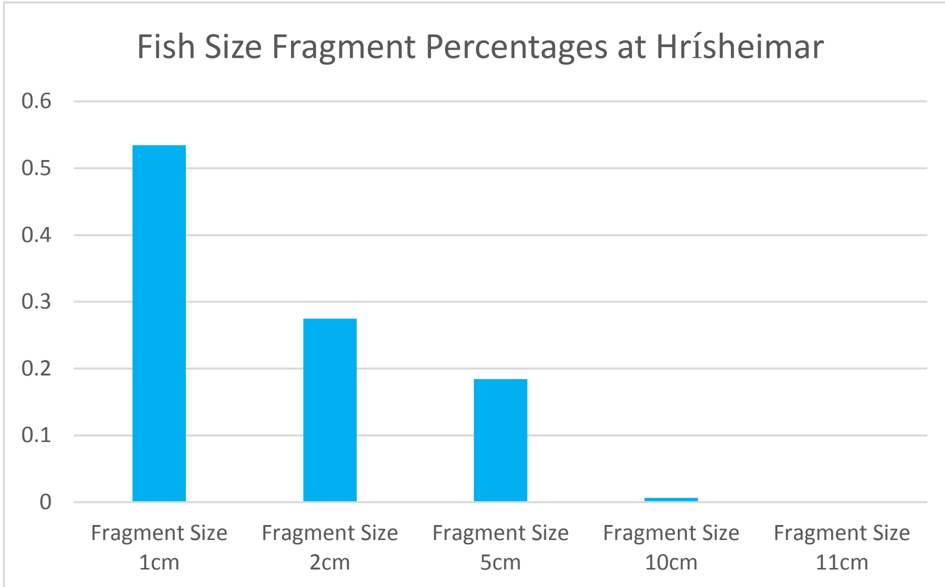


FIGURE 16. Fish Size Fragment Percentages of Hrísheimar. The above table shows the percentages for each size represented in the fish assemblage from Hrísheimar.

Measurements were also taken from a variety of species at the site utilizing the vomer, premaxilla, cleithrum, parasphenoid and dentary following the guidelines of Wheeler and Jones, 1989 and Morales and Rosenlund, 1979. These bones were selected due to their ability to provide a more accurate comparison. The bones chosen for these calculations were identified to species and completed on bones without damage to prevent sizing errors. Overall, there were 33 fish bones measured all from the salmonidae family, a total of .08% of the entire assemblage. Measuring digital calipers were utilized for these measurements. Measurements were taken twice, and an average taken for a more accurate reading. Each measured element was provided a special code for recorded and labeled. Of the elements, dentaries were the most sized at 61% and parasphenoids due to the fragility the least measurable at 3%. Size reconstruction from these measurements has not taken place at the time of this research, but the data can be analyzed and utilized for future research.

D. Statistical Analysis

To provide a better representation of the site, a standard error range with a confidence interval of 90% and 95% was calculated for the population ratios of fish species at Hrísheimar. These calculations were performed to better understand the error range and confidence of such ratios from the excavated portions of the site in representing the entire site for each phase. For the calculations of the standard deviation of the proportion the following equation was utilized: s = $\sqrt{pq}$ with s representing the standard deviation, *p* representing the proportion expressed as a decimal fraction, and *q* representing 1 – *p* (Drennan, 2004). The results from these computations were then utilized to calculate the Standard Error with the following equation: SE = $\frac{\sigma}{\sqrt{n}}$ where σ represented the results from the above calculation and n due to the use of proportions was 100. A standard t chart was utilized for intervals of 1.658 for a 90% and 1.98 for a 95% confidence interval the further calculation of the standard error percentage (Drennan, 2004).

In completing a comparison of HRH, SVK, and the HST proportions of Salmonidae and gadidae species ratios, a chi-square (χ^2) test was completed utilizing the statistical software program R. This test was utilized to analyze the proportions of the variables due to the large sample sizes from the sites. The equation for this chi-square was $\chi^2=\Sigma\ (0_i-E_i)^2/E_i$. The 0_i represents the observed number of the total species bones at the site and E_i represents the expected number if the proportions of species were the same at each site. The χ^2 test was utilized to examine the null hypothesis, in this case to verify whether the groups are significantly different from one another or if the differences are nothing more than sampling vagaries. The null hypothesis would stipulate in this case the groups are not different. In order to test the strength of this test, a Cramer's V was also calculated in R with the following equation V =

$\sqrt{\frac{\chi^2}{n\,(S-1)}}$ where n is the total number in the sample and S is the number of columns or rows whichever is smaller (Drennan, 2004).

VI. ANALYSIS

1. Species Proportions

Although many fish bones could be identified to family, not all fish bones could be identified to the species level. The bones most prevalently utilized for species identification in both the salmonidae and gadidae families were vertebrae which totaled 17,935 bones and made up 44% of all identified bones at the site, 29% of these were caudal vertebrae. Other bones utilized for species identification of species within the salmonidae family include the angular, ceratohyal, cleithrum, coracoid, dentary, epihyal, hyomandibular, maxilla, opercle, parasphenoid, premaxilla, preopercle, and quadrate. Other bones utilized for species identification within the

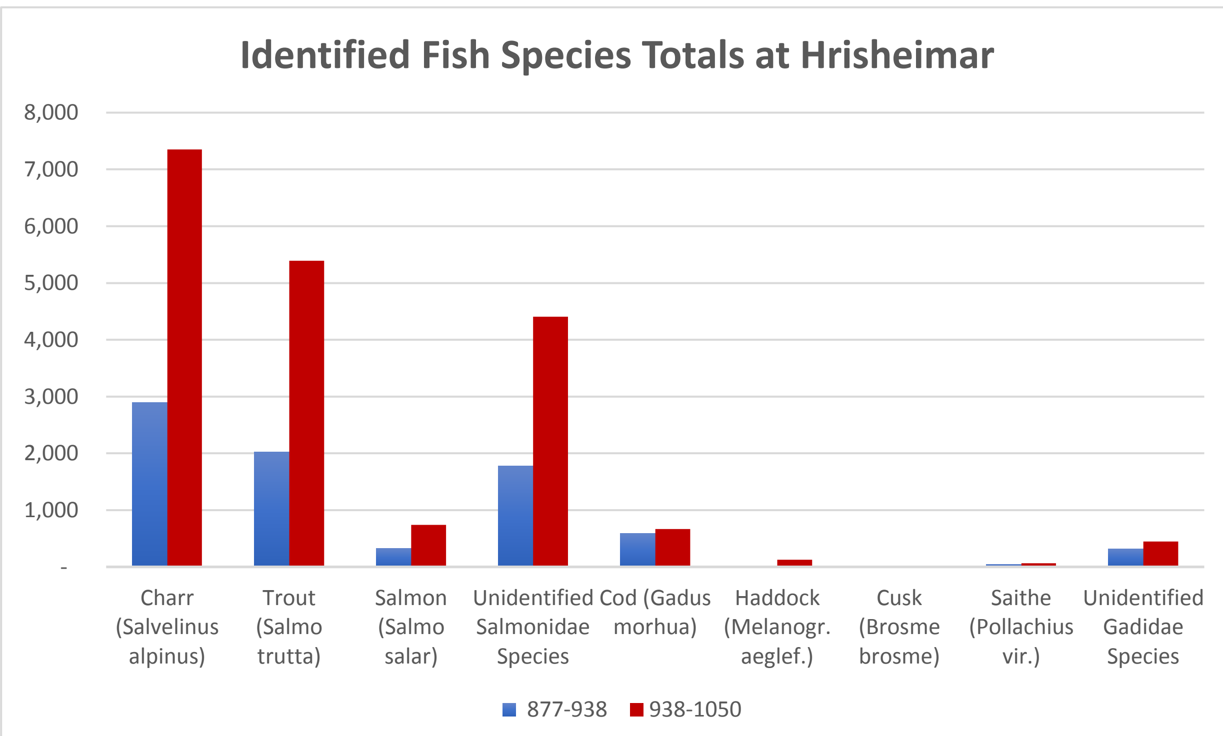


FIGURE 17. Identified Fish Species Totals at Hrísheimar. The above figure shows the totals of different fish species and the bones identifiable only to family for each phase at Hrísheimar.

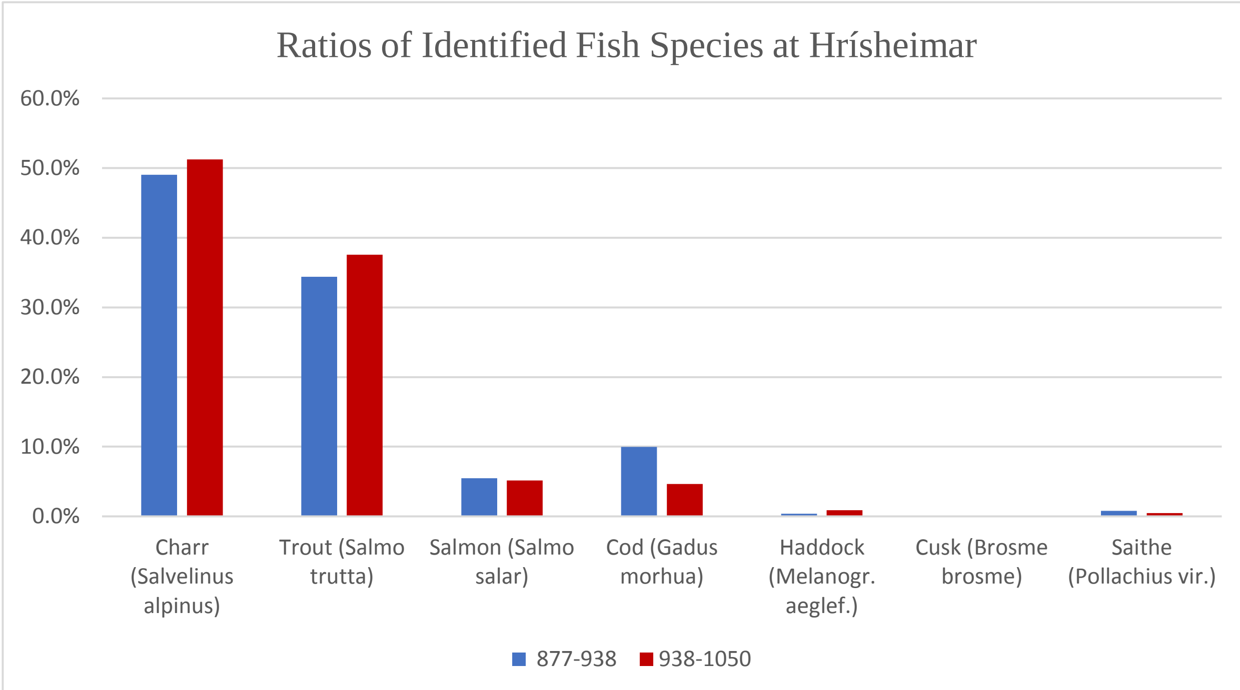


FIGURE 18. Ratios of Identified Fish Species at Hrísheimar. The above figure shows the ratios utilizing percentages for the fish species from each phase at Hrísheimar.

gadidae family include the cleithrum and postcleithrum. Although other bones can be utilized in distinguishing gadidae species, the site of Hrísheimar included limited gadidae elements. Figure 17 shows the total number of species found per phase at Hrísheimar. The totals are much larger from Phase II. Figure 18 shows the ratios of identified fish species at Hrísheimar in percentages at each phase. These ratios show a very close similarity between Phase I and Phase II at the site in terms of species. This figure does not include the unidentified salmonidae or gadidae remains. Figure 19 shows the ratio of the entire salmonidae and gadidae families including those identified and unidentified to species.

The results of the fish species analysis show that at Hrísheimar, Charr was the most prevalent fish excavated in both Phase I and Phase II and II with a total of 10,243 bones found and totaling 50.60% of all fish identified to species. When factoring in salmonidae and gadidae fish remains only identified to family, Charr makes up 38% of the total identified fish to family

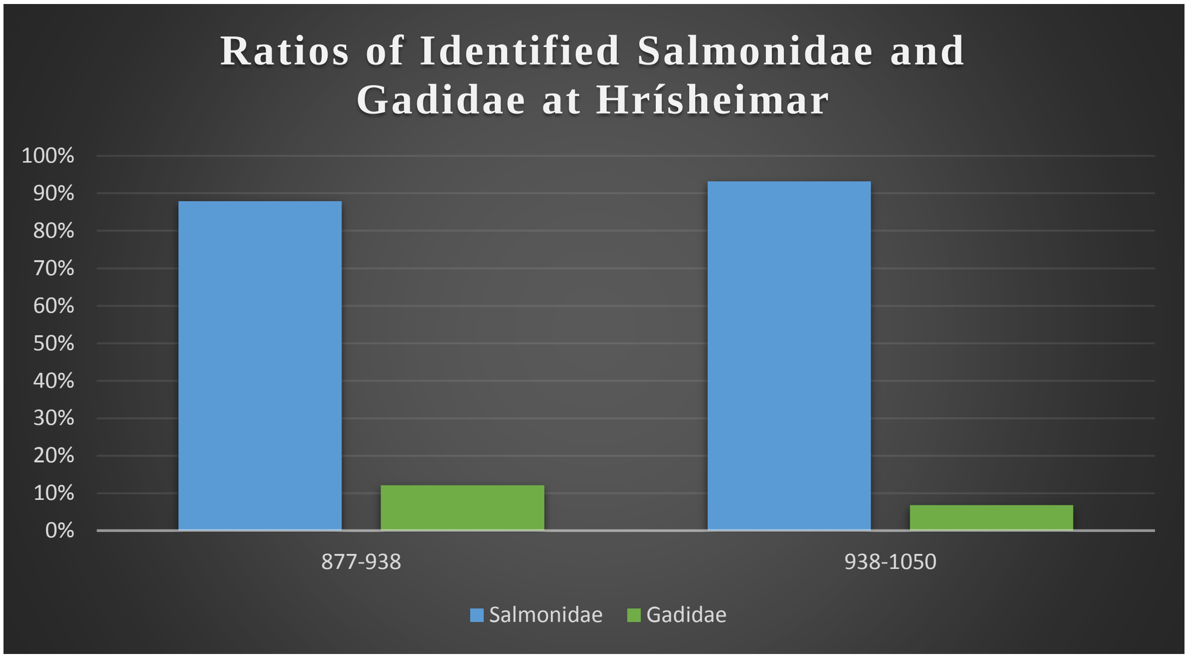


FIGURE 19. Ratios of Identified Salmonidae and Gadidae at Hrísheimar. The above figure shows the proportions of all identified Salmonidae and Gadidae remains in both Phase I and Phase II and III.

at the site. The amount of charr at the site numbers even more than the bones that could only be identified to the salmonidae family. Trout also made up a significant amount of the fish species discovered at the site with 7,419 total bones found and making up 36.65% of all fish identified to species and 27% of the total fish identified to family recovered. The number of Atlantic Salmon bones at the site remains small with a total of 1,062 and totaling 5.25% of all fish identified to species and 3.9% of all fish identified to family at the site. However, even the appearance of Atlantic Salmon shows some significance which will be discussed further in the next section.

To address whether the proportions of the excavated portions of the site might be accurate representations of the proportions of the entire site, a standard error calculation was completed at the 90% and 95% levels. The results of these calculations can be seen in tables 2 and 3. These calculations included those remains only identified to family. The calculations show that at the highest confidence level, certain species proportions would potentially change for the entire site. For example, the 95% confidence level standard error shows the higher charr and trout proportions could change causing trout to have the highest proportion of fish bones at the site.

Table 2: Total Fish at HRH at 90% Confidence Level

	877-938	c. 938-1050
Charr (*Salvelinus alpinus*)	36% ± 8%	38% ± 8%
Trout (*Salmo trutta*)	25% ± 7%	28% ± 7%
Salmon (*Salmo salar*)	4% ± 3%	4% ± 3%
Salmonidae Species	22% ± 7%	23% ± 7%
Cod (*Gadus morhua*)	7% ± 4%	3% ± 3%
Haddock (*Melanogr. aeglef*.)	0.3% ± 1%	.7% ± 1%
Cusk (Brosme brosme)		0.02% ± .2%
Saithe (*Pollachius vir*.)	0.6% ± 1%	0.3% ± 1%
Gadidae Species	4% ± 3%	2% ± 3%

Table 3: Total Fish at HRH at 95% Confidence Level

	877-938	c. 938-1050
Charr (*Salvelinus alpinus*)	36% ± 10%	38% ± 10%
Trout (*Salmo trutta*)	25% ± 9%	28% ± 9%
Salmon (*Salmo salar*)	4% ± 4%	4% ± 4%
Salmonidae Species	22% ± 8%	23% ± 8%
Cod (*Gadus morhua*)	7% ± 5%	3% ± 4%
Haddock (*Melanogr. aeglef*.)	0.3% ± 1%	.7% ± 2%
Cusk (Brosme brosme)		0.02% ± .3%
Saithee (*Pollachius vir*.)	0.6% ± 2%	0.3% ± 1%
Gadidae Species	4% ± 4%	2% ± 3%

Shuffling could also be seen for other species with small and close proportions such as salmon, cod, saithe, cusk, and haddock. Thus, if the entire site were excavated, a small amount of shuffling might be seen for some species that are close proportionally. However, even at the confidence level of 95% the standard error calculations show that the more distant proportions would not be capable of switching places. For example, even if the proportions of charr fell by 10% to be 28% of the site and the proportions of cod rose 4% to be 7%, the smallest proportion of charr bones would still be far above that highest proportion of cod. So, although some fish proportions could increase or decrease, large ratio movements still show as improbable for the entire site. Even more so at the species level, where the total proportion of salmonidae species would still be far above the proportion of gadidae species. Thus, the excavated sample would best represent the proportions that are further away in distance numerically from one another.

Many salmonidae species bones that could not be identified past the family were also excavated at the site. The total number of Salmonidae bones that could not be identified further to species totals 6,190 bones and making up 23% of the site. The total amount of all salmonidae family bones including those not identified to species numbers 24,314, with a high percentage of 92% of the entire site. Thus, of the two families of species at the site, the freshwater salmonidae species including charr, trout, and Atlantic Salmon were the most prevalent. The proportion of salmonidae species to gadidae species for each phase can be seen in Figure 19. For each phase, the proportions are similar, despite the larger total number of fish remains from Phase II and III.

To better compare Hrísheimar with the sites of Sveigakot and Hofstaðir, a chi-square and Cramer's V was completed. The numbers utilized for the chi-square and Cramer's V were the total salmonidae and gadidae numbers from each site. The results of these calculations can be seen in figure 20. The null hypothesis that stipulates the results are from sampling vagaries and that the groups are not different or there is not correlation between the variables is rejected in this case, as the p-value of 2.2e-16 was far below alpha. Since the p-value is less than alpha, these results can be considered significant. The high χ^2 value of 1894.7 results could be a result from the large sample size of fish from both sites and the great differences in the proportions between the salmonidae and gadidae species at each site. A Cramer's V test was also completed with a result of .604844. This test supports the differences between the two variables of salmonidae and gadidae species at the sites. Therefore, these results show that there were similarities in how these sites utilized freshwater and marine resources. The usage of the gadidae family at the site will be examined in further detail in the third part of this section.

```
Data:  Mývatn
χ² = 1894.7, df = 2, p-value < 2.2e-16

> chisq.test(Mývatn)$expected
       site
species       HRH       SVK       HST
  salmon 23183.336 2945.2282 17503.436
  gadid   4012.664  509.7718  3029.564
> chisq.test(Mývatn)$observed
       site
species   HRH   SVK   HST
  salmon 24914  2795 15923
  gadid   2282   660  4610

Cramer V = 0.604844
```

FIGURE 20. Chi-Square and Cramer's V

The figure shows the results of the Chi-Square and Cramer's V test between the proportions of Salmonidae and Gadidae at Hrísheimar, Sveigakot, and Hofstaðir.

Other sites in the Mývatn region show a similar pattern of focusing on freshwater fish, with a large ratio of freshwater fish found at each site. Figure 21 shows the percentages of identified fish bones to species for Hrísheimar, Sveigakot, and Hofstaðir. These ratios show that at Hrísheimar and Sveigakot, charr was the most utilized freshwater species. In contrast, Hofstaðir shows more of a focus on trout than charr. This could be due to the location of Hofstaðir or the fact that the fish assemblage from Hofstaðir only appears from Phase II and III. However, as noted with the percentages of error chart in tables 2 and 3, these comparisons are based off the currently excavated portions of the site and all recovered and identified fish bones.

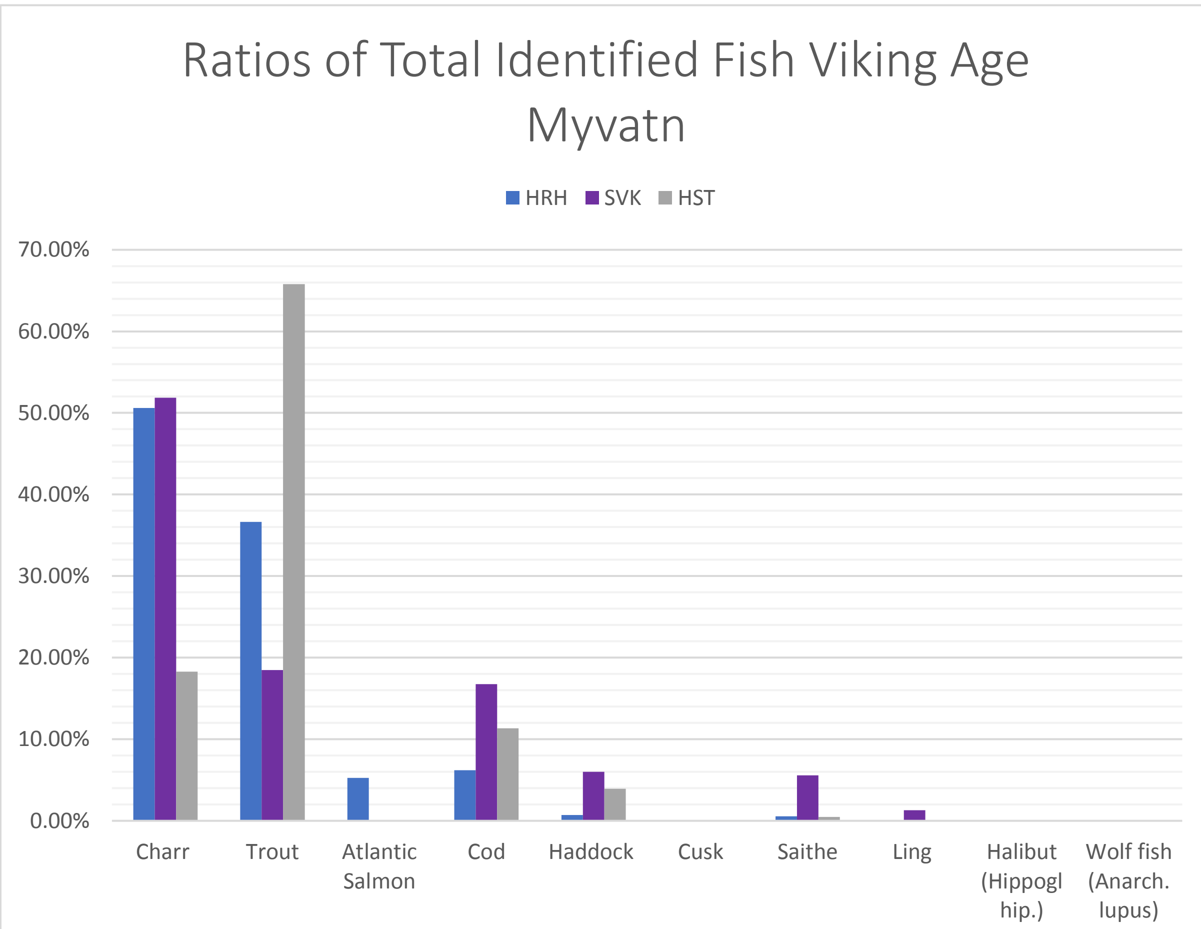


FIGURE 21. Ratios of Total Identified Fish Viking Age Mývatn. The above table shows the total site ratios utilizing percentages for the represented species for only the fish remains identified to species for each site.

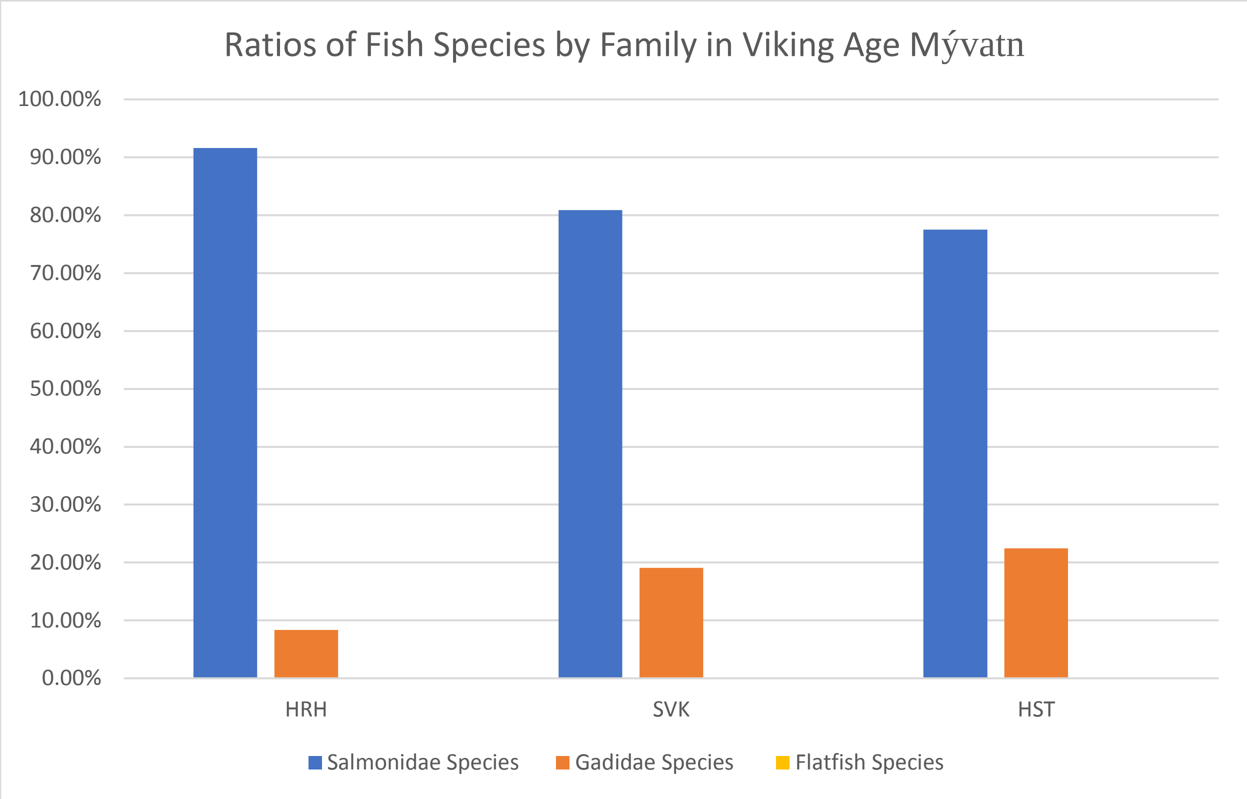


FIGURE 22. Ratios of Fish Species by Family in Viking Age Mývatn. The above table shows the ratios at each of the three sites utilizing percentages for all of the species families found at each site.

The charr and trout proportions at Hrísheimar could potentially be higher or lower for the entire site, causing the most utilized species to differ from the results currently being compared. Of the three sites, Hrísheimar contains the highest proportion of Atlantic Salmon, with very little representation at Hofstaðir and a complete absence of representation at Sveigakot. Sveigakot has a high number of bones not speciated, but within the Salmonidae family, while Figure 22 shows that Hofstaðir is the only site where a slim evidence of flat fish appears. In addition, Figure 22 shows several similarities between the sites proportionally, especially when examining species by family. When analyzing the gadidae species, the numbers remain small for the three sites in comparison to the use of freshwater fish.

The fish bones possess evidence of processing with some showing knife marks, chopping, and different levels of burning. Only .04% of the fish bones showed clear evidence of knife marks and chopping. Of the 18 samples of fish with evidence of knife marks and chopping, there were 17 vertebrae and one scapula. The cut and chop marks on the vertebrae most likely came from when the knife worked along the vertebrae to remove the filet, whereas that on the scapula could have occurred during the processing of the fish for drying (Wheeler & Jones, 1989). Most of the bones with these processing marks were from the Salmonidae family with a total of 15 bones and making a majority of 83% of all knifed and chopped fish bones. In the assemblage, there were also 27 vertebrae from the Salmonidae family that were fused, .07% of the total fish bones found at the site. A larger amount, 636 fish bones and a total of 16% of the entire fish bone collection showed evidence of contact with fire at some point, either being burned later after being consumed or during the processing of the fish creating some to be blackened, whitened, or scorched. The highest numbers of burn marks, 75% of all marks occurred on fish bones from the Salmonidae family and 84% occurred on vertebral elements.

2. Atlantic Salmon

The zooarchaeological evidence of a site can show the specific diet of the people who utilized the site and provide information about their social status (Wheeler & Jones, 1989). Although thousands of Atlantic Salmon migrate up the Laxá river during the spring, they do not reach the Mývatnssveit region due to waterfalls that occur midway between the sea and Lake Mývatn (McGovern et al., 2006), about 20 km from the estuaries of Lake Mývatn (Ólafsson, 1981). The total proportion of Atlantic Salmon in both phases at Hrísheimar remains small, 4.1% in Phase I and 3.8% in Phase II and III. These proportions are similar despite most of the Atlantic Salmon bones coming from Phase II and III. When calculating in the standard error for a 95%

confidence level, these proportions could be smaller with an error of about ± 4% for each phase. Sveigakot shows no evidence of Atlantic Salmon at the site, while the site of Hofstaðir only had 5 bones identified as Atlantic Salmon, about .02% of the entire Hofstaðir fish assemblage. However, the mere presence of Atlantic Salmon at the specialized site of Hrísheimar, potentially provides further information about the status of the site and its role in trade networks.

The excavations at Hrísheimar revealed a large amount of iron and metal working debris, but also included at least one pre-Christian elite burial and some other elite items such as amber beads and a sword chape (McGovern et al., 2006). Hypothetically, the privileged status of those who settled at Hrísheimar or the status those at the site gained through trade might have led to the ability of those at the site to obtain Atlantic Salmon. The site might have employed a similar strategy to that of Iron Age Norway where the ability to control or obtain certain resources was viewed as an important way for chieftains to maintain their status (Perdikaris, 1999). The use of Atlantic Salmon at Hrísheimar could also be a part of a settlement strategy of early Icelanders. In this strategy, a large area of land would be settled by workers sent into different resource zones to increase surpluses and access to varied resources for the owner (McGovern et al., 2007). The early appearance of Atlantic Salmon potentially shows that the settlement of Hrísheimar might have had a similar provisioning strategy.

Even if this was not the case, the stable transfer of marine fish inland indicates the importance of trade and exchange networks to and potentially within the Mývatn area. The high status of Hrísheimar due to its iron production might indicate that the presence of Atlantic Salmon at the site occurred due to its connections to a more extensive trade network including regions further down the Laxá River than the other sites in the Mývatn region. Thus, Hrísheimar the iron production allowed for access to elite or more rare trade items. Thus, the connections between the production of iron, its trade, and the overall wealth of the site might have played a role in the appearance of Atlantic Salmon at the site. However, status and wealth alone does not explain the Atlantic Salmon remains at the site, because the high-status site of Hofstaðir does not show this same pattern. Currently, many questions about the presence of Atlantic Salmon at the site need further investigation.

3. Marine Fish

1. Commercial Fish

Despite its distance from the coast, the Mývatn region includes bones of the marine gadidae species. Of the current quantifiable collections, 12-30 percent of identifiable fish in the Mývatn region are of the cod family (Lawson et al., 2005). Hrísheimar shows slightly less than this pattern of bones from the cod family. The amount of gadidae species bones was 2,282, with a percentage of 8% of the entire site. Figure 23 shows the gadid fish ratio to those of other identifiable fish at the Hrísheimar throughout the occupation of the site. The varying ratios of

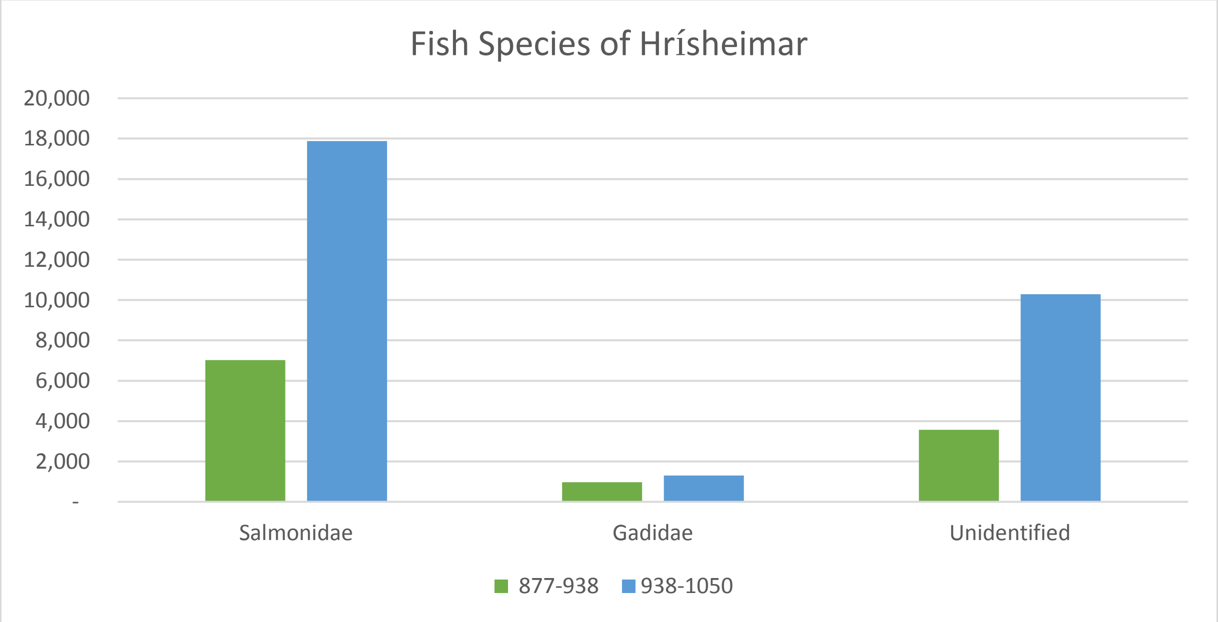


FIGURE 23. Fish Species of Hrísheimar. The above table shows the total number of Salmonidae, Gadidae, and Unidentified bone totals for the phases at Hrísheimar.

gadidae species in the different phases of Hrísheimar, Sveigakot, and Hofstaðir can be seen in Figure 23. The most common gadid at Hrísheimar was cod with 4.62% of the total identified fish bone and 55% of the gadid fish bone at the site being cod. The least common gadidae species recovered at Hrísheimar was the cusk with only .01% of the total identified fish bones and .02% of the total gadid fish bones. All three of the sites show an increase in the haddock bones between Phase I and Phase II and III.

The gadidae presence at Hrísheimar and other Mývatn sites show that from Icelandic Landnám settlers were interacting with the coast for dried fish product. These interactions and the transporting of marine resources happened in the 9th Century in Iceland and prior to the "fish event horizon" in Europe. Barrett et al. focusing on sites within Great Britain argued that it was rare for marine fish to be transported inland until the intensification of marine fishing occurred within a few decades of ca. 1000AD and then such increased thereafter (2004a). Even after the "fish event horizon", rural interior sites in England show very few fish bones for another 400 years (Barrett et al., 2004b). The pattern in Belgium seems similar in that urban settlements also show evidence of marine consumption much earlier than rural sites (Van Neer & Ervynck, 2003). In contrast, the early Icelandic sites show evidence of marine fish consumption in interior rural areas such as Mývatn.

In addition, the pattern of gadid remains found at Hrísheimar show a similarity to the fish remains found later throughout Iceland when fishing was commercialized in the 11th and 19th centuries (McGovern et al., 2007). One of the major differences is that at Hrísheimar and other early Mývatn sites, the fish remains appear to be of several different cod family species instead of focusing on one species like later fisheries (figure 24). However, these sites show similar element distribution providing evidence of consumption of dried fish products. Dried fish products were created during the winter from spawning fish of the gadidae or cod family (Perdikaris, 1999). During the production of dried fish products, the head of the cod fish was removed and the body air dried without the use of salt (Perdikaris, 1999). The size of the fish matters in this process, as too large of a fish would rot before the drying process had successfully completed (Perdikaris, 1999). Due to a gradual drying process requiring temperature fluctuations that often occur between day and night in Norway, this process also requires special environmental conditions (Perdikaris, 1999). These temperature fluctuations allow the fish to freeze and thaw slightly without rotting (Perdikaris, 1999). In Norway, the dried fish product known as stockfish is created by hanging the cod to dry on racks from January to March or April (Perdikaris, 1999).

In Iron Age Norwegian fisheries, some dating back to the fifth century, they also utilized several species from the cod family in a similar pattern of species diversity to that seen at the Mývatn sites (Perdikaris, 1999). In these Norwegian fisheries, elites managed the production and local exchange of dried fish product starting in the fifth century (Perdikaris, 1999). Additionally, starting in the Iron Age and continuing into the Viking Age, one of the keys to chieftainships in Norway was access to stockfish (Perdikaris, 1999). The access to stockfish provided the elites in Norway with power over subsistence by allowing them to maintain surpluses and resources (Perdikaris, 1999). Stockfish can last two years without refrigeration and provide a stable resource when other items might not be available (Perdikaris, 1999). Thus, the use of stockfish would have been able to counter problems that could occur with other wild and domestic resources.

The zooarchaeological evidence of stockfish use in Norway was also able to show consistency in the number of bones and pattern of elemental distribution ratios between Iron Age sites and later medieval sites (Perdikaris, 1999). This consistency shows the importance of stock fish from the Iron Age through the Viking Age and into the medieval period for elites and societies in Norway (Perdikaris, 1999). It is possible that the dried fish product was brought to Iceland by early settlers, like the importation of other subsistence strategies for more cultural than natural reasons (McGovern et al., 2006). The process of creating dried fish products could have held an unknown significance for these early settlers, because they deliberately continued to

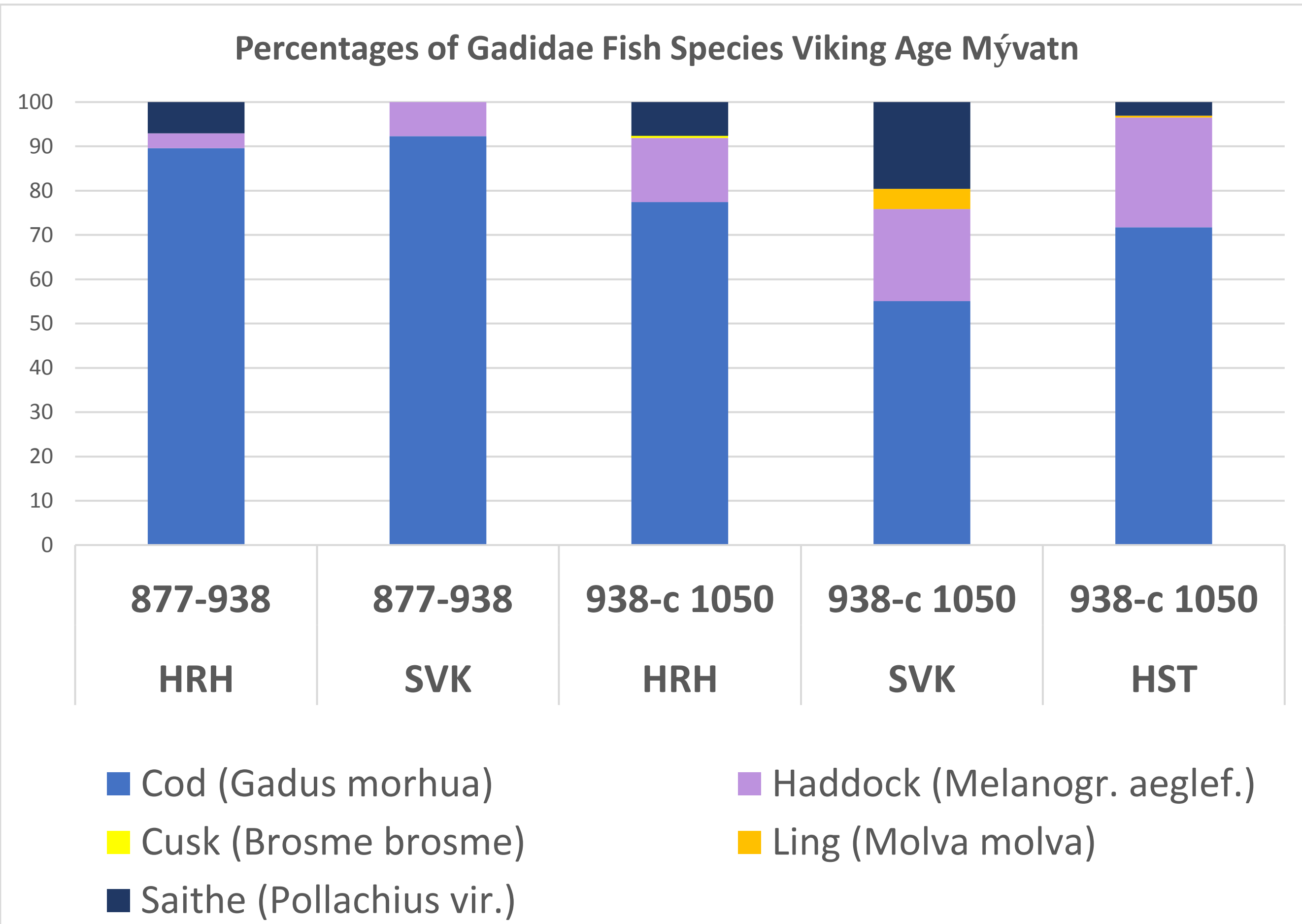


FIGURE 24. Percentages of Gadid Family Fish Species Viking Age Mývatn. The above figure shows the different proportions of Gadidae species during the Viking Age time periods at all three sites.

create and consume dried fish products, even though Iceland was not climatically prime for this process. Hypothetically, those elites who were settling at many of these sites in Iceland associated the dried fish product with maintaining their status due to its ties with elitism in Norway, but more research is needed on this topic. The type of gadid species bone elements that appear in early Icelandic sites such as Hrísheimar also show the consumption, but not the production of a dried commercial marine fish product.

2. Production vs. Consumption Site

The bone distribution patterns of the gadidae remains at Hrísheimar provide further information about the site. The remains of the freshwater fish at Hrísheimar and the other Lake Mývatn sites show evidence of whole-body consumption on site. Thus, the sites contain bones from the cranial and post cranial skeletons of the different salmonid species. In contrast, the remains of the gadidae species at these sites show a concentration of post cranial skeletal elements including the cleithrum from the pectoral area and vertebral elements with an absence of a significant number of cranial parts. Figure 25 shows a skeleton of a cod with the cranial

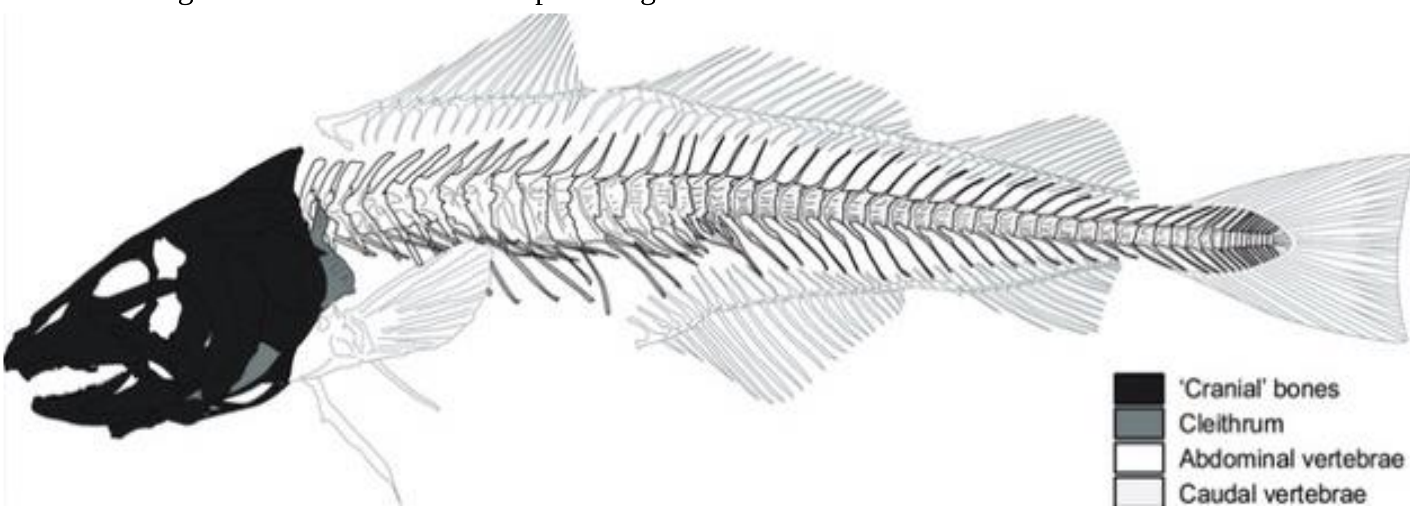


FIGURE 25. "Cod skeleton indicating anatomical categories used here (base image c ArcheoZoo.org)." from Orton et al., 2014. The above image highlights the different parts of a cod skeleton which can be utilized in differentiating consumption and production sites for marine dried fish product.

bones, cleithrum, and vertebrae highlighted. All the bones shaded black are mostly absent at the site of Hrísheimar. The distribution of bone elements of the gadid species at Hrísheimar can be seen in Figure 26. Vertebral elements were the most common of the gadid bones followed by pectoral elements with few to no cranial elements. This distribution is not based on taphonomy or bone survival, because many of the cranial parts of gadidae species are larger and more robust than the vertebral elements that do appear in great numbers at Hrísheimar. These specific elements provide evidence of a commercially dried gadidae product being transported to the site for consumption. When gadidae are processed for the creation of preserved fish products such as round-dried product or flat-dried products, the heads and many of the upper pectoral and

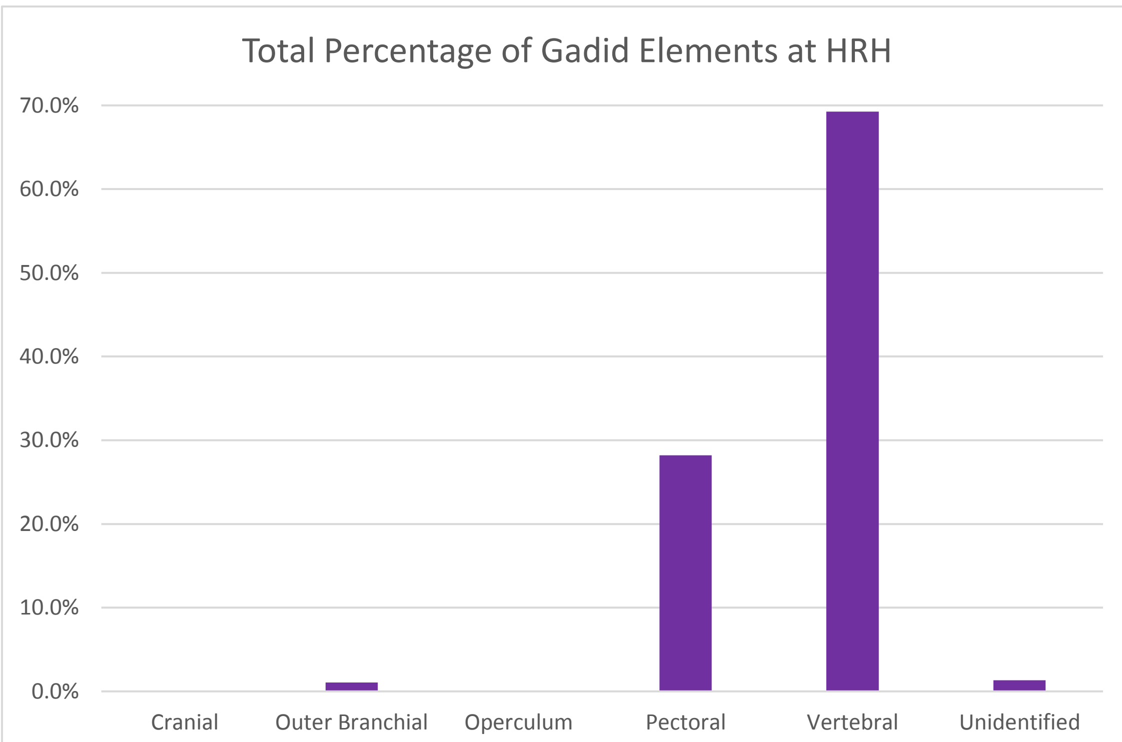


FIGURE 26. Total Percentage of Gadid Elements at Hrísheimar. The above table shows the percentage of different gadid elements recovered at Hrísheimar. Most of the bones are from the pectoral and vertebral areas of the fish.

FIGURE 27. A haddock cleithrum from the Hrísheimar Assemblage.

vertebral elements are removed at the production sites. The cleithrum (figure 27) and some other bones around the gill opening are intentionally left to hold the rest of the fish together throughout the process and transportation of the fish (Lawson et al., 2005). Therefore, at a production site, the archaeological deposits would consist of mostly cranial parts and early vertebral elements. The pectoral elements such as the cleithrum and the vertebral column of the fish would then be found in the archaeological deposits at the consumption site. Figure 26 confirms the imbalance between pectoral and vertebral elements and the rest of the identified gadidae bones at Hrísheimar proving that the site was a consumption site. The presence of certain types of vertebrae also reveals the type of dried fish product being consumed.

3. Flat and Round Dried Fish Stock

The vertebrae found at Hrísheimar demonstrates a changing pattern over time in the type of dried fish product being consumed. Figure 29 shows that 98.3% of the vertebrae at the Hrísheimar site were caudal. The presence of caudal vertebrae shows the consumption of a flat dried fish product, whereas the presence of precaudal and thoracic

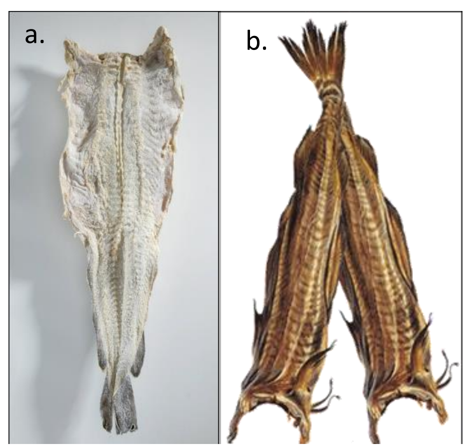


FIGURE 28. Dried Fish Products: a. Flat dried fish product

b. Round dried fish product

vertebrae shows the consumption of a round dried fish product (see figure 28). When breaking down the vertebrae distribution by phase, another pattern like that found at other Mývatn sites appears (see figure 30).

During Phase I (A.D. 877-938), most of the vertebrae for all the gadidae species represented (cod, haddock, and saithe) are caudal. In contrast, all the precaudal vertebrae and most of the thoracic vertebrae appear in Phase II and III (ca. A.D. 938-1050) for all the gadidae represented (cod, haddock, saithe, and cusk). A similar pattern tends to appear at the other Mývatn sites of Sveigakot and Hofstaðir. The differences in vertebral distribution for

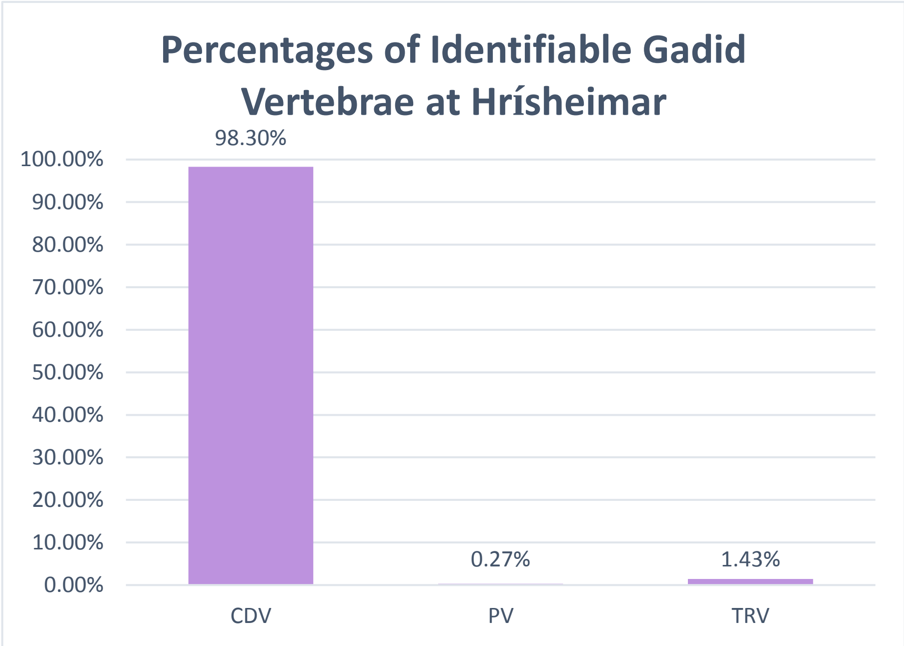


FIGURE 29. Percentages of Identifiable Gadid Vertebrae at Hrísheimar. The above figure shows that 98.30% of the vertebra at the site were Caudal, with very low percentages of Precaudal and Thoracic Vertebrae.

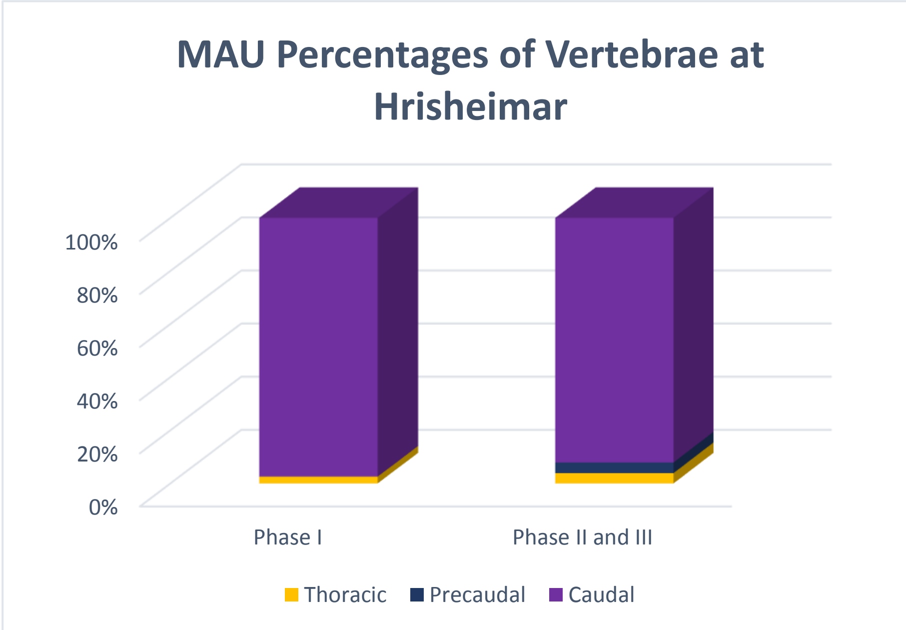


FIGURE 30. Percentages of Vertebra at Hrísheimar. The above figure shows the MAU percentages of different types of vertebra at Hrísheimar between the two phases.

cod at all three sites throughout the two phases can be seen in figure 31. The cod sample size is much larger for all three sites and demonstrates the clearest sign of a pattern with very few to no thoracic vertebrae appearing in Phase I and a larger amount of thoracic and precaudal vertebrae appearing in Phase II and III. Sveigakot also shows a larger proportion of precaudal vertebrae, but overall a smaller sample of cod vertebrae could account for this distribution. The haddock vertebral distribution in figure 32 also shows this pattern; however, most of the bones are only available for Phase II and III.

These results confirm that during Phase I the flat-dried fish products were utilized the most at both Hrísheimar and Sveigakot. In Phase II and III, it appears that round dried fish products were introduced due to the large increase in thoracic and precaudal vertebrae that begin

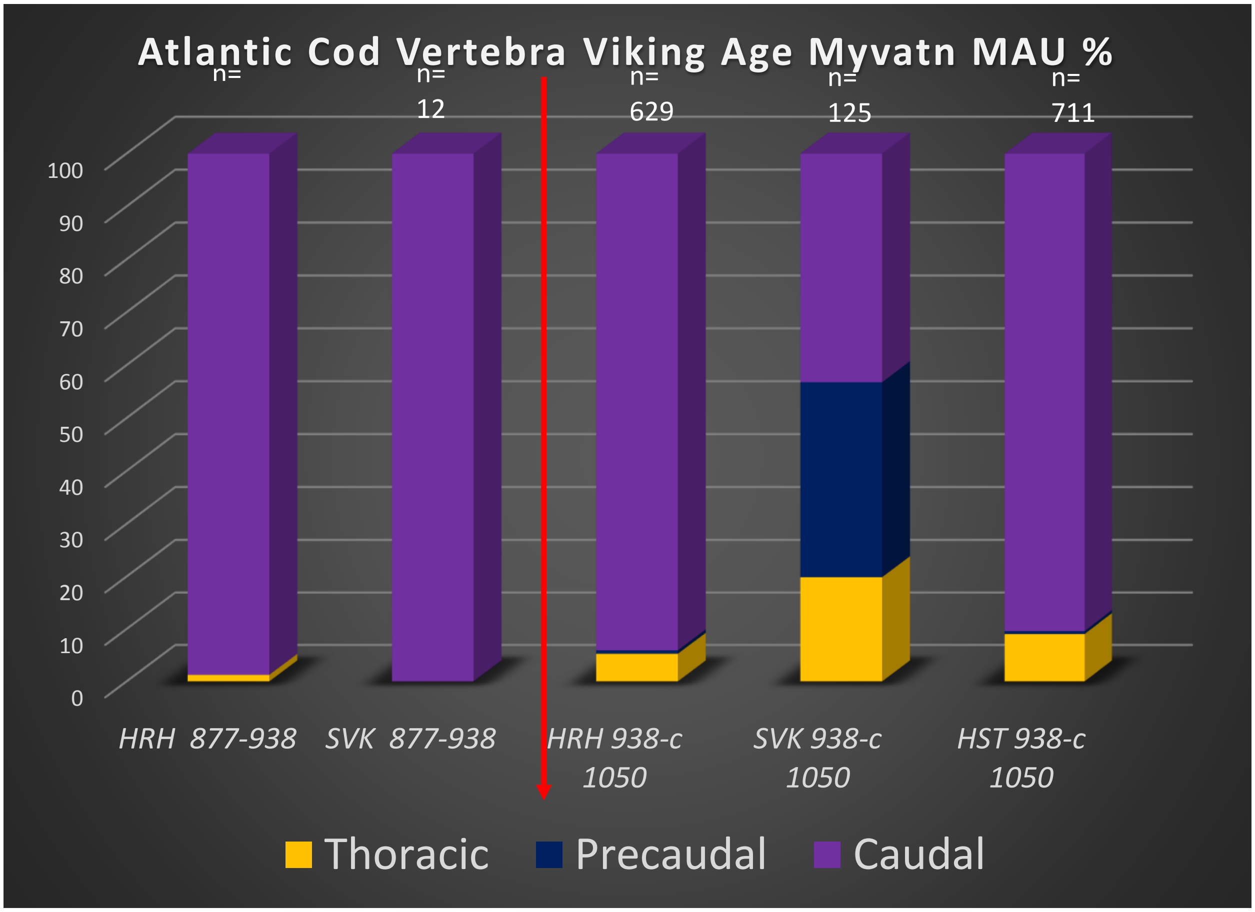


FIGURE 31. Atlantic Cod Vertebra Viking Age Mývatn MAU%. The above figure shows the proportions of Cod vertebra at three different sites in the Mývatn region for Phase I and Phase II.

to appear at Hrísheimar and Sveigakot and the mixture of vertebrae that also appears at Hofstaðir. This distribution pattern contrasts that from Norway, where the modern flat dried fish product, klipfisk was not produced until the 18th Century (Holt-Jensen, 1985). However, in Norway the round-dried stockfish was utilized in fully commercial fisheries from the 11th-19th centuries (McGovern et al., 2007). The reasons for early Icelandic settlers to begin with mostly flat dried fish products and then introduce round dried fish products needs further investigation at other sites within Iceland. Potentially the differences between Norway and Iceland may be a result of climate. In Iceland, the drying racks utilized for round dried fish products were often recovered far from the most convenient ship landing points, whereas flat dried fish products can

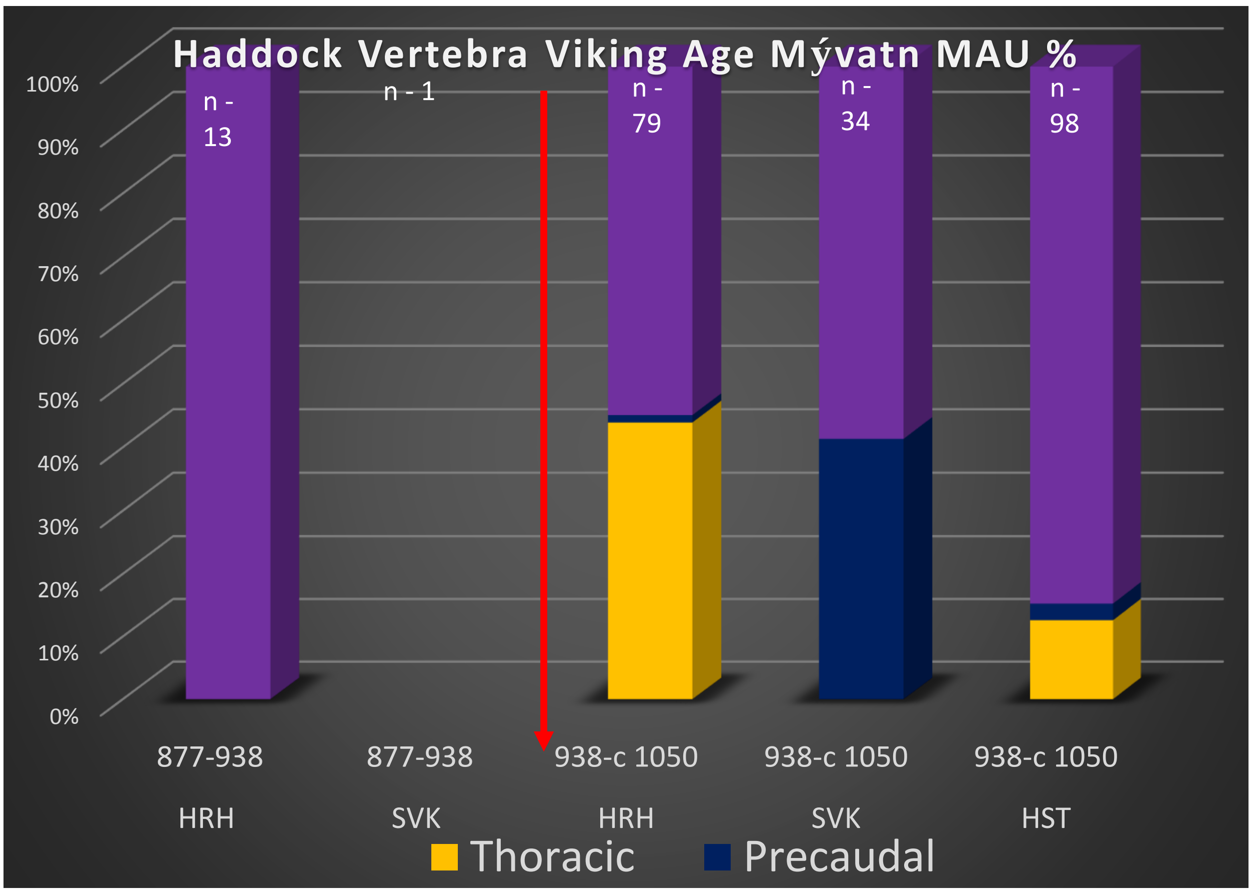


FIGURE 32. Haddock Vertebra Viking Age Mývatn MAU %. The above chart shows the proportions of Haddock vertebra at three different sites in the Mývatn region for Phase I and Phase II.

be done more easily by laying out the fish on a beach and occasionally turning them. However, the results from Hrísheimar and the other Mývatn sites confirm the consumption of marine flat dried and round dried fish products in early Icelandic sites.

VII. DISCUSSION

A. Fish Usage at Hrísheimar

Originally, I hypothesized that Hrísheimar as an iron production site provisioning a potentially large workforce might utilize fish to a larger extreme than the other sites in the Mývatn area. However, as the analysis above shows, it seems that Hrísheimar had a very similar fish usage pattern to both Sveigakot and Hofstaðir in most accounts. The proportions of fish usage in relation to the rest of the fauna resources seems larger than both Sveigakot and Hofstaðir. However, the analysis of zooarchaeological remains at Hrísheimar is still in progress and once completed, the outcome could be more alike to the other sites. In terms of fish species, the gadidae and salmonidae proportions are also similar across all three sites. Hrísheimar's use of fish resources also appears to occur throughout both Phase I from A.D. 877 ± 1 to 938 ± 6 and Phase II and III from about 938 ± 6 to the end of the site c. AD 1020. The early zooarchaeological dates at these Mývatn sites has already demonstrated that the traditional model of settlement in which sites in rural interior areas were settled only after the filling of other suitable sites as incomplete (McGovern et al., 2007). In addition, the consistent use of these wild resources at even the iron-farm of Hrísheimar in the Mývatn region are contrary to the traditional colonial model, where wild resources were utilized temporarily until domesticated animals reached stable numbers.

Hrísheimar appears to also provide further evidence that marine gadidae species in the form of dried fish products were consumed in the inland Mývatnssveit region from the early settlement period. This early usage of marine fish occurred prior to the "fish event horizon" noted in the British Isles and many areas of Europe. The reasons behind this early use of marine fish remains one of inquiry that could be related to the social status or subsistence strategies of early Icelanders. The gadid bone element distribution also shows evidence of both dried flat fish and dried round fish product utilization at all three sites. Thus, instead of showing a unique pattern of fish usage, Hrísheimar provides additional evidence that the Mývatnssveit region was consuming marine fish products from the coast.

The most unusual aspects of the fish pattern at Hrísheimar is the presence of Atlantic Salmon, which differs greatly from the other sites within the region for this time. Statistically, the proportions of Atlantic Salmon are not high in comparison to the other freshwater species present at the site. The reasons for this difference are hard to ascertain as more information would be needed to understand the exact reasons for this pattern. The presence of the Atlantic Salmon could be tied to iron production at the site, elite privileges, or even access to a larger, more diverse trading network. There are several hypotheses that could be equally valid, but all would require further research and investigation into other similar early inland production or trade sites.

VIII. CONCLUSION

A. Future Research Questions

Although Hrísheimar may be more similar than different to the other Mývatn sites in terms of fish usage patterns, many questions remain that would require further research. Hrísheimar and the other sites of the Mývatn region show early and continuous usage of wild resources from settlement and afterwards, contrary to the traditional ideas of settlement and subsistence patterns in early Iceland. These inland sites also show the continuous usage of marine fish and the usage of two types of dried marine fish products. Further research and comparison with other early inland settlement sites in various regions of Iceland would provide the answer to whether the Mývatn region was unique in this aspect and further information for revising the settlement model. If this comparison shows a similar pattern, it would provide further understanding of the motivations for settling an area and early trade networks within Iceland. If not, it would also provide further research questions for the Mývatn area and the emerging patterns of subsistence usage that is appearing there.

The reasons for the usage of dried flat fish and then the introduction of dried round fish products is also not completely understood in the Mývatnssveit Region. Did early settlers introduce different types of dried fish products due to the quality of the fish, the climate, changing tastes, or even the spread of ideas from other Viking settlements? Further research on fish assemblages containing marine gadidae dried fish products at other early production site or consumption sites where this introduction could be seen in Iceland would further our understanding of the reasons for the use of different types of dried fish products.

One of the major questions about the site of Hrísheimar remains the presence of Atlantic Salmon at the site throughout both Phase I and Phase II and III. Further research at other production sites within the Mývatn area or other inland sites would provide more information about the potential reasons for the presence of Atlantic Salmon. This information could be utilized to confirm hypotheses on the social status or strategies of early settlement chieftains. It could also provide answers about the networking accessibility of certain production sites. Overall, additional research in the Mývatn area and at inland interior sites would provide further comparison data and a more complete understanding of early settlements within Iceland.

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