Vestfirðir, and the Emergence of Fishing Communities in Pre-Modern Iceland

by

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UNIVERSITY OF STIRLING

Statement of Originality

I hereby declare that this research was carried out by the undersigned alone, has been solely submitted for this degree only, and that all research material contained within has been duly acknowledged and cited.

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Matriculation Number

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Abstract

Despite being a country synonymous with fishing and having very strong maritime traditions, the clear origins and development of specialist fishing communities prior to the mechanisation era in Iceland, particularly the Vestfirðir region, remain unclear. Further to this, the details of their chronological development are often erratic if not unknown. Historical records often recollect periods of success or failure, largely driven by economic narrative, however, the context, factors and responses to these changes have never been fully explored. Compounding this absence of information is the tendency for narratives to be accounting for Iceland as a whole, without giving allowance to any regional differences.

By adopting an interdisciplinary methodology, underpinned by the application of geoarchaeology (the interpretation of the cultural record contained within soils and sediments), the chronological developments and historical narrative can begin to be established. The result of this research is a clearer understanding of the environmental history of fishing communities in the Vestfirðir region spanning over eight centuries, displaying evidence of a resilient and responsive society. As a result of this research, a clear distinction can now be made between sites which served maritime and terrestrial purposes based on the interpretation of the cultural material. The findings have produced a narrative detailing how a society has responded to wider environmental and social pressures driven by changes within Iceland and throughout Europe. The sites surveyed display unique variance in their characteristics of adaptation, reflecting a society which maintained a high degree of resilience and flexibility which essentially provides the foundation for one of the most successful fishing grounds in the world today.

Acknowledgements

A significant number of people need to be acknowledged as a result of their support and encouragement provided during the duration of this thesis. First and foremost, thanks go to my supervisors, Professors Richard Oram and Ian Simpson, two well-known and very professional academics. It has been a pleasure working with them over the years, and I am grateful for the encouragement and support they have provided since the moment the proposal was created. I would also like to take this opportunity thank the technical and administrative staff at the School of History and Politics and also the School of Biological and Environmental Sciences at the University of Stirling, in particular Dr. Alasdair Ross, Bill Jamieson and Scott Jackson, not only for their expertise in their field but also their friendship and ever-welcome brand of like-minded parochial humour.

A thank-you must also be given for the support received during my numerous trips to Iceland; to the Natural Science Institute in Bolungarvík, Fornleifastofnun Íslands in Reykjavik, and in particular Dr. Ragnar Edvardsson who shared his knowledge of Vestfirðir with me, allowing this project to develop.

Thanks must also go to my friends, office-mates past and present from Cottrell 4v11, and family present and absent who have all been supportive through my entire time at university.

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To anyone who happens to open this thesis and has thoughts about undertaking their own Ph.D., do it. It is a journey filled with a variety of emotions, but the experiences gained are priceless. Alongside the following published pages of research are years of undocumented experiences which go with them, and will provide many stories in the future. I hope that this thesis is proof that you do not need an enormous scholarship to conduct postgraduate research, as long as it is a project that you believe in and put your heart into. A little bit of funding will come along, but make sure you have the dedication as well as the determination, and support from those around you.

Stuart J. L. Morrison

University of Stirling, Scotland

May, 2012.

Thank-you to Danielle, for simply being there and putting up with my continual narrative of all things fish.

Day, after day, after day…

THIS IS FOR MY PARENTS, JIM AND ANNA.

THANK YOU.

“Meet the new boss,

Same as the old boss.”

Townshend, 1971.

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Chapter One – Introduction

The systematic utilisation of maritime resources is a process which has allowed societies to flourish for millennia. From as early as 7000 BP, the exploitation of aquatic and riverine resources in an organised manner has been undertaken, predominantly for fish but also for whales, sharks and shellfish.[1] Today, a society which has access to rivers and open seas may base much of its attention around the maritime environment; Iceland is no exception given that its seas are among the most prolific fishing grounds in the world.[2] Simply looking at a map, the country appears to be at a disadvantage by being geographically marginal in the middle of the North Atlantic, however, if this isolation is indeed a disadvantage, it can be somewhat counterbalanced by the abundance of food resources found in its rivers, fjords and seas (Figure 1).

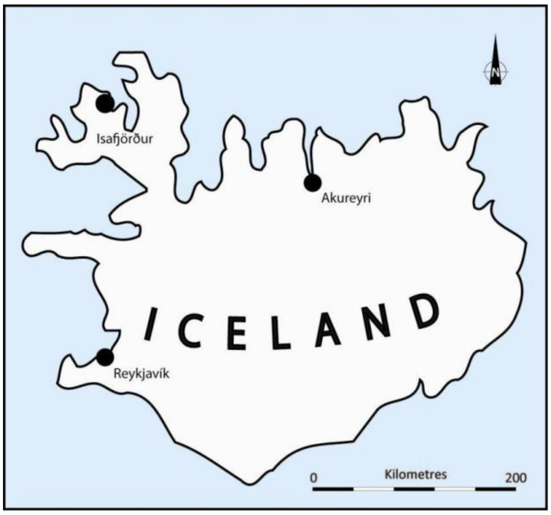

Figure 1: Map of Iceland with major population centres

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[1] M.C. Lillie & M. Richards, 'Stable isotope analysis and dental evidence of diet at the Mesolithic-Neolithic transition in Ukraine', *Journal of Archaeological Science*, 27 (2000), p.965-72; C. Bonsall, G.T. Cook, R.E.M. Hedges, T.F.G. Higham, C. Pickard & I. Radovanovic, 'Radiocarbon and stable isotope evidence of dietary change from the Mesolithic to the Middle Ages in the Iron Gates: New results from Lepenski Vir', *Radiocarbon,* 46 (2004), p.293-300.

[2] S. Jonsson, 'Icelandic Fisheries in the Pre-Mechanisation Era *c.*1800-1905; Spatial and Economic Implications for Growth', *Scandinavian Economic History Review,* (1983).

Today, the fishing industry in Iceland provides a significant proportion of national employment and export earnings. Although this has said to have reduced over recent years,[3] Icelandic fish firms are continuing to report record catches and earnings in a time when marine populations are said to be shrinking.[4] Fishing is something which has been regarded of importance in the country, as demonstrated by the lengths Icelanders have gone to protect and extend their territorial waters at various times throughout history. High profile conflicts were witnessed during the AD 1970s, and disputes still continue right through to the present day. During the summer of AD 2010, the differences between Iceland and the European Union over catches saw unfavourable treatment (in the view of Icelanders) handed out to Icelanders as they attempted to land catches in Scotland.[5] Two years later, this saga is far from being over, and as a form of homage to the past yet nowhere near as severe. This conflict of interest has been coined, the *Mackerel Wars* by the press.[6] As Iceland negotiates its position to potentially become part of the European Union, despite being regarded as part of the common market for many years, it still has issue with the idea of giving up the contents of its waters to overseas fishermen. The country wants exception from the rule to keep fish

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[3] Statistics Iceland, 'Statistics Iceland', <www.statice.is/uploads/files/LH08/L080310.xls> [Accessed 27/7/2010]. Employment is around eight percent and export earnings around forty percent (2006 figures). The post-2008 global recession has had a further negative impact on national employment.

[4] Fish Update, 'Iceland fish firm reports big rise in trawler earnings', http://fishupdate.com/news/fullstory.php/aid/14863/Iceland_fish_firm_reports_big_rise_in_trawler_earnings.html> [Accessed 15/02/2011].

[5] For details on the Cod Wars of the 1490s, see: D.E. Vasey, 'Population Regulation, Ecology and Political Economy in Preindustrial Iceland'. *American Ethnologist*, 23 (1996) p.366-92. For the Cod Wars of the 1970s, see: A. Welch, '*The Royal Navy in The Cod Wars: Britain and Iceland in Conflict 1958-1976',* (Liskeard, 2006).

[6] Deadline News, 'Mackerel Fishermen Wage War Against Foreign Pirates', <http://www.deadlinenews.co.uk/2012/01/01/mackerel-fishermen-wage-war-against-foreign-pirates/>, [Accessed 05/01/2012].

stocks to themselves,[7] much along the same lines as Norway in the AD 1990s.[8] Rich maritime traditions have developed over the course of Iceland's 1,100 years; fish are still found symbolically on the nation's coins, and from AD 1591 until AD 1903 their image appeared on the national coat of arms.[9] These symbols underscore the importance this valued marine resource had for Iceland.

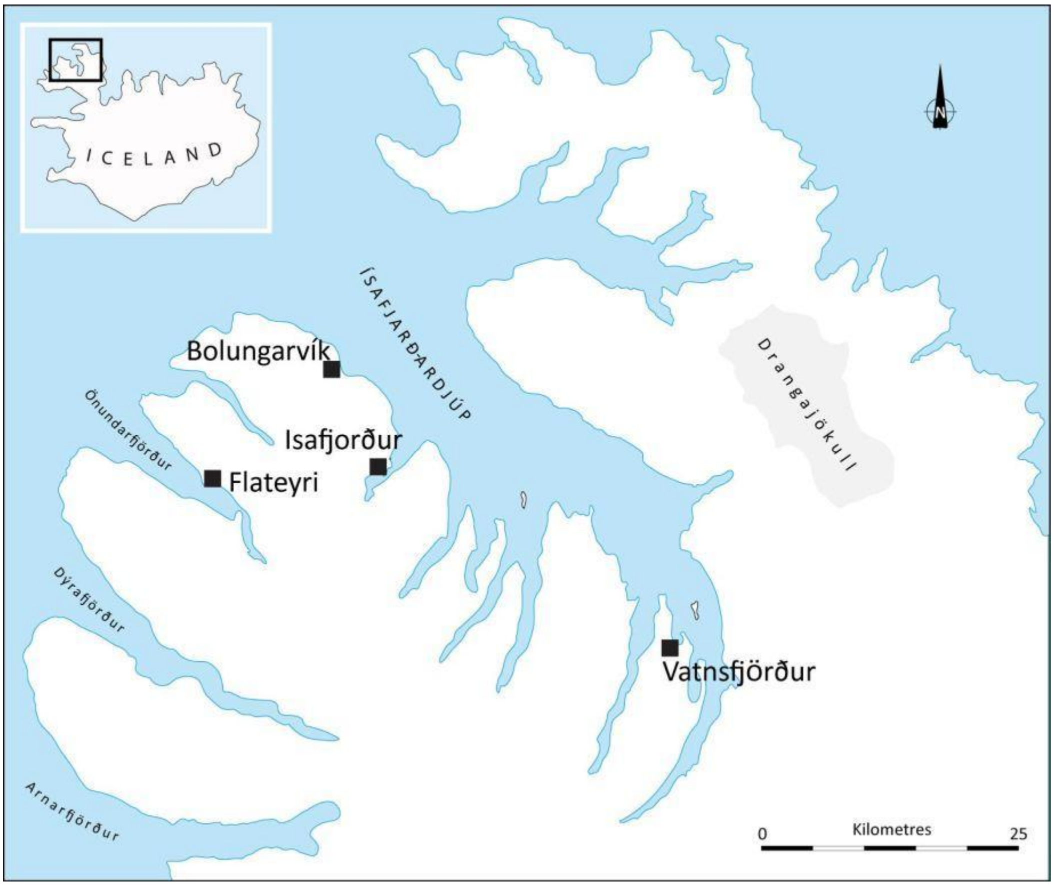

Figure 2: Vestfirðir, with key present-day settlement locations

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[7] European Parliament, 'Iceland's EU Membership Progress' <http://www.europarl.europa.eu/en/pressroom/content/20110318IPR15863/html/MEPs-welcome-Iceland%27s-progress-towards-EU-membership> [Accessed 16/11/2011].

[8] EU Observer, 'Iceland: EU membership depends on fishery 'superpowers'' <http://euobserver.com/15/32555> [Accessed 16/11/2011].

[9] J. Jónsson, 'Fisheries off Iceland, 1600-1900', *ICES Mar. Sci. Symp.*, 198 (1994), p.3-16.

Despite this importance, it is still unclear when the specialist extraction and exploitation of fish began in Iceland, particularly in Vestfirðir (Figure 2). By piecing together a coherent account of how processes were undertaken in the past, the understanding of how societies developed and flourished can be obtained. Understanding the role of historical fishing communities in Iceland is a key component in understanding the pre-modern economic development of Iceland from both environmental and cultural perspectives. When studying the literature on the more recent history of fisheries in Iceland, one may well be forgiven for thinking that specialist exploitation did not take place until the introduction of sailing vessels for specialist fishing owned and operated by Icelanders in the early nineteenth century, development of sailing ships in the early nineteenth century, or when the first motor powered boat arrived in the country in AD 1902.[10] Part of the misconception this may be attributed to the fact that systematic catch records only span back to just over a century.[11] Fragmented fisheries data in Iceland are available from around AD 1850, with official statistics beginning in AD 1897.[12] The sheer numbers of fish caught using steam, then diesel powered vessels, has somehow encouraged most authors to dedicate very little wordage towards explaining how the industry arrived at that mechanised stage.

Aside from understanding the nature and development of fishing communities, this research aims to contribute towards the wider cultural identity and heritage of Vestfirðir and Iceland. Rural regions are finding themselves increasingly isolated, with

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[10] J.T. Thór, 'Icelandic Fisheries, *c*.900-1900', in D.J. Starkey, J.T. Thór & I. Heidbrink, (eds.), *A History of the North Atlantic Fisheries Volume 1: From Early Times to the Mid-Nineteenth Century,* (Hull, 2009).

[11] J.H. Barrett, A.M.Locker & C.M. Roberts, 'The Origins of Intensive Marine Fishing in Medieval Europe – The English Evidence', *Proceedings of the Royal Society London Biological Sciences*, 271(2004), p.2417-421.

[12] Jonsson, 'Icelandic Fisheries in the Pre-Mechanisation Era c.1800-1905; Spatial and Economic Implications for Growth'.

the need to develop modern economic avenues in order to combat dwindling populations and reduced economic opportunities through traditional means. Eastern Iceland has turned to controversial large-scale power generation (with full government support), permanently altering the landscape and destroying the cultural remnants contained within, to much widespread national and international protest.[13] Almost all major glacial rivers have been identified by the governing authority, to be harnessed as part of their renewable energy plan for the next few decades,[14] which can potentially have a profound impact on the landscape.

Authorities controlling Vestfirðir have decided not to pursue this avenue despite it being economically lucrative, instead opting to tap into the tourism economy. Investment is being made in finding out more about their heritage, and improvements are being made to infrastructure to make the region more accessible. The findings in this research will have the potential to be integrated with other landscape and heritage studies, contributing towards a regional and cultural identity, which will hopefully provide the economic rewards and incentives to help reverse the trend of populations migrating from the area, as well as boosting tourism.

Fishing itself is such an important activity in Iceland, both economically and culturally. This study will begin to explore the role of fish in Iceland's history, teasing out a detailed narrative relating to the way in which the resource was exploited.

Even those who have dedicated their effort to understanding the historical development of specialist fishing communities have provided a variety of interpretations. Many of

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[13] BBC News, 'Bjork scorns 'crazy' Iceland smelter plan' <http://news.bbc.co.uk/1/hi/sci/tech/2602167.stm> [Accessed 16/11/2011].

[14] Ecologic Events, 'Hydropower Master Plan' <http://www.ecologic-events.de/hydropower2/documents/IS_Einarsson_master_plan_sep2011.pdf> [Accessed 16/11/2011].

these have emerged over the past two decades as interest has grown both in the understanding of past environments and Icelandic archaeology in general.[15] The task has been unenviable, given that the oceans of the world were being exploited long before scientists began writing papers on the subject.[16] It is suggested that the early pan-European fish trade, thought to date prior to the end of the first millennium AD, took a century even to be noticed in the surviving historical record,[17] let alone for observers to develop a systematic series of statistical results or documents which can be regarded as reliable historical accounts.

The traditional narrative, driven by late-medieval and pre-modern opinion, is that specialist fishing communities emerged in Iceland during the Middle Ages and continued to develop after. Ocean fishing was regarded by some as a part-time activity supplementing a terrestrial-based economy, and that a fishing industry emerged in the nineteenth century as a result of free trade.[18] This notion has some substance behind it, as fishing did become a year-round activity around this time, however, the main proponent of this thesis, Eggertsson, neglects to mention in detail any sort of specialist marine extraction which took place before this period, ignoring alternative perspectives.

Opinions which oppose Eggertsson can be found in research based on early documentary sources, and some of these sources vary in the reliability of their content.

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[15] The field of environmental history, which has its roots in the 1970s environmental movement, has grown enormously as people seek to understand what global environments were like in the past.

[16] C. Roberts, '*The Unnatural History of the Sea: The Past and Future of Humanity and Fishing'.* (London, 2007).

[17] J.H. Barrett, A.M. Locker, & C.M. Roberts, `Dark Age economics' revisited: The English fish bone evidence AD 600–1600', *Antiquity*, 78 (2004), p.618–36.

[18] T. Eggertsson, 'No experiments, monumental disasters: Why it took a thousand years to develop a specialized fishing industry in Iceland', *Journal of Economic Behaviour and Organization*, 30 (1996), p.1-23.

Sagas are the most fictional, using true events to develop an over-embellished narrative, however, some later published political accounts such as *Diplomatarium Islandicum* are more reliable. Some Icelandic scholars view the sagas with great respect, others as quasi-historical tales of a sub-standard quality to those being produced in contemporary Europe.[19] Even today, debate rumbles on regarding the validity of saga content, the latest being research on sunstones, used for navigation, supporting information found within the sagas.[20]

A trade in fish can be established from record sources by the late thirteenth century; a document of King Eiríkr Magnússon mentions *skreið* (dried Cod: see Figure 3 and Figure 4) being exported from Iceland to Norway in AD 1294.[21] Icelandic fish is also mentioned as being imported into England by AD 1307.[22] This matches the recent narrative that fish from northern locations were finding their way into the markets of mainland Europe sometime after the thirteenth century.[23] Saga evidence also indicates the importance of fish within early Icelandic society; *Bandamanna Saga* mentions an individual building his wealth on the back of selling *skreið* in *Vestfirðir* and subsequently

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[19] Byock, *Viking Age Iceland* (London, 2000), p.154.

[20] G. Horváth, A. Barta, I. Pomozi, B. Suhai, R. Hegedüs, S. Åkesson, B. Meyer-Rochow & R. Wehner, 'On the Trail of Vikings with Polarized Skylight: Experimental Study of the Atmospheric Optical Prerequisites Allowing Polarimetric Navigation by Viking Seafarers'. *Phil. Trans. R. Soc. B,* 366 (2011), p. 772-782; New Scientist, 'Vikings' crystal clear method of navigation' < http://www.newscientist.com/article/dn20052-vikings-crystal-clear-method-of-navigation.html> [Accessed 03/02/11]; Nature, 'Did Vikings navigate by polarized light?' <http://www.nature.com/news/2011/110131/full/news.2011.58.html> [Accessed 03/02/2011].

[21] *Diplomatarium Islandicum*, Volume 2, (1893), p.287.

[22] *Diplomatarium Norvegicum,* Oldbreve til Kundskap om Norges indre og ytre Forhold, Sprog, Slegter, Seder, Lovgivning og Rettergang i Middelalderen XIX. Aktstykker vedrørende Norges Forbindelse med de Britiske Øer I, Kristiania (1914).

[23] Barrett *et al.,* 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

moving overseas with his profits,[24] and *Laxdaela Saga* refers to Iceland as a fishing camp.[25] While saga evidence composed in the late twelfth and early thirteenth centuries AD purports to document life between the ninth and eleventh centuries, issues of validity do arise. This is due to the exaggeration and the period of time which passed between events supposedly taking place, passing into oral tradition, before finding their way on to parchment centuries after the event supposedly happened.[26] Sagas were often used as a way of legitimising your right to something, a characteristic which brings with it broader exaggeration. Earlier sagas were composed not only to document this oral history but support the ancestry and lineage of individuals and their families. Embellishment of true events is partly understandable; nobody wanted to be descended from slaves or scoundrels.[27] Further embellishment has taken place in the eyes of some scholars, particularly Byock, who sees twentieth century Icelandic nationalism responsible for resurgence in the idea that the contents of the sagas contain a significant proportion of truth.[28] Different scholars use sagas with varying degrees of reliability depending on their own personal interpretation.

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[24] W. Morris & E. Magnússon, '*Bandamanna Saga*', (1891). <http://www.sagadb.org/bandamanna_saga>

[25] M. Magnusson, & H. Palsson, *Laxdaela Saga,* (London, 1975).

[26] Orally transmitted information and verse from this era can, in some views, contain a high transmissional accuracy, although caution should still be used.

[27] M. Magnusson, *Iceland Saga*, (Stroud, 2005), p.72.

[28] J.L. Byock, 'The Age of the Sturlungs' in E. Vestergaard, (Ed.). '*Continuity and Change: Political Institutions and Literary Monuments in the Middle Ages'.* Proceedings of the Tenth International Symposium Organized by the Centre for the Study of Vernacular Literature in the Middle Ages. (Odense, 1986), p.27-42.

Figure 3: Dried Cod, known as *Skreið*, hanging on racks

Figure 4: *Skreið* hanging on racks, springtime sight in Vestfirðir

These early sources have provided much basis for a variety of interpretations. They have created a pedestal for some who argue for the formation of an early development of specialist fishing activity. Friedland discusses a vibrant trade between Iceland and Europe from the ninth to eleventh centuries; early Icelandic traders were said to be travelling to Dublin from around AD 900 (although there is no specific mention of fish being traded).[29] Thór makes a specific reference to fishing and fishing stations, saying that by the eleventh century, fishing stations in the west and southwest of Iceland were in existence, and may have been in place even earlier.[30] This early development was said to have been driven by internal demand for domestic consumption, with only the surplus finding its way into merchants' hands for export. Zori identifies Icelandic society as being heavily dependent on marine resources from its earliest period, with consumption reducing after the thirteenth century.[31] Further details regarding this hypothesis remain illusive. Thinking along the same lines but in a slightly later time period is Thorláksson, who suggests that by the mid-thirteenth century, there was a vigorous internal cod trade in Iceland which subsequently grew and developed into an export market.[32] The firm establishment of this remains unclear, and it could indeed be that what is described by Thór is directly related to the developments outlined by Thorláksson. Karlsson refers to large-scale exports of fish from the AD 1260s onwards from Iceland,[33] which coincides with Barrett *et al.* observing Europeans travelling more frequently to 'northern waters' for their maritime resource needs.[34] Echoing Karlsson, Thorláksson and Barrett *et al.*'s theories but putting the timeframe slightly later is Byock, who suggests that Iceland began creating surplus for trade after English merchants began travelling to the island for that purpose in the early fourteenth

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29 K. Friedland, 'The Hanseatic League and Hanse Towns in the Early Penetration of the North'. *Arctic*, 37 (1984), p.539-43.

30 T. Thór, *Sjósóku og svávarfang: Saga Sjávarútvegs á Íslandi.* (Akureyri, 2002). (English Summary).

31 D.M. Zori, *From Viking Chiefdoms to Medieval State in Iceland; The Evolution of Social Power Structures in the Mosfell Valley*. Unpublished Ph.D. Thesis, (University of California Los Angeles, 2010).

32 H. Thorláksson, 'Vaðmál og verðlag. Vaðmál í utanlandsviðskiptum og búskap Íslendinga á 13. og 14. Öld'. (Reykjavík, 1991).

33 G. Karlsson, *Iceland's 1000 Years*, (London, 2000), p.107.

34 Barrett *et al.*, 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

century. Based on the interpretation of the historical sources by the aforementioned authors, is appears that there was some specialist fishing and production taking place in Iceland, possibly as early as the eleventh century but certainly by the time the Middle Ages commenced. What is still unknown, are more exact dates regarding the development and how it evolved to become part of an international trading market.

Recent archaeological and historical research, focussing on the Vestfirðir region of Iceland has suggested that the beginnings of specialist marine-based exploitation goes further back than previously thought, to the century immediately following *Landnám*. The traditional narrative regarding settlement suggests that the broad plains and more favourable climate found in southern and western Iceland were more attractive to the *Landnámsmen* seeking pasture, a perspective which may be down more to the lack of research efforts in other areas than to environmental favouritism on the part of the first settlers.[35] This perspective also clashes with the archaeological evidence that there were farms established in Vestfirðir shortly after *Landnám.* It may have been that the nature of archaeological investigation in the past was driven more by a desire to verify what the saga literature has to say, subsequently hampering development in some regions, with some archaeologists pursuing high status remains and being directed away from what they saw as less valuable, undocumented sites. It would discourage archaeologists to excavate areas occasionally referred to in the selected literature as the *poor land in the north*.[36] Modern archaeological and zooarchaeological methodologies, however, have been applied at Akurvík in Vestfirðir and its associated farm site at Gjögur, both coastal sites located in this traditionally economically 'poor' east Vestfirðir area. This work has revealed evidence of a tenth century trading network in this region

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[35] K.P. Smith, '*Landnám*: The Settlement of Iceland in Archaeological and Historical Perspective'. *World Archaeology,* 26 (1995), p.319-47.

[36] Á. Magnússon, & P. Vídalíns, '*Jarðabók Árna Magnússonar og Páls Vídalíns*', (Copenhagen, 1940).

of Iceland, indicating that the knowledge which we have accumulated since Icelandic archaeology took off does not necessarily reflect an accurate history, but a representation of sites contributing towards a narrative, dictated by a preferential excavation strategy.

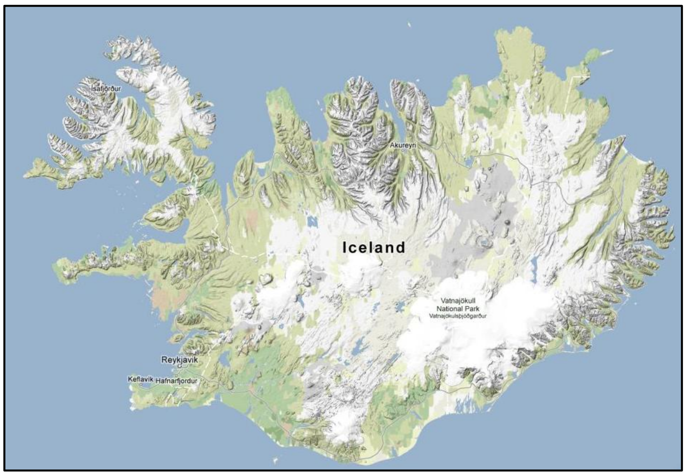

Figure 5: Terrain map of Iceland. Image courtesy of Google

The farm site at Vatnsfjörður, a location mentioned in *Landnámabók* as dating from the ninth century, is positioned at the heart of the Vestfirðir region. This is a region on the northwestern periphery of Iceland, containing steep cliffs and deep fjords and little in the way of flat terrain suitable for arable or pastoral farming (Figure 5, Figure 6). Excavations have been undertaken at Vatnsfjörður since AD 2003, and Edvardsson and McGovern perceive a degree of wealth contained within the archaeological record, in the form of cultural deposits, and not represented elsewhere in the region. Given the perceived limited scope for exploitation of terrestrial resources beyond a subsistence level, it is suggested that the wealth gained is a direct result of specialist trade in marine produce from the site's earliest period.[37] With Vatnsfjörður being a farm site inland, wealth must have been accumulated from elsewhere through the ownership of lands or

[37] R. Edvardsson & T.H. McGovern, 'Archaeological Excavations at Vatnsfjörður 2003-04'. *Archaeologia Islandica,* 4 (2005). p.16-30.

fishing stations, or have been inherited. If this wealth has been accumulated through the exploitation of marine goods, evidence can theoretically be obtained from conducting research at known historical fishing stations known to be associated with the farm site.

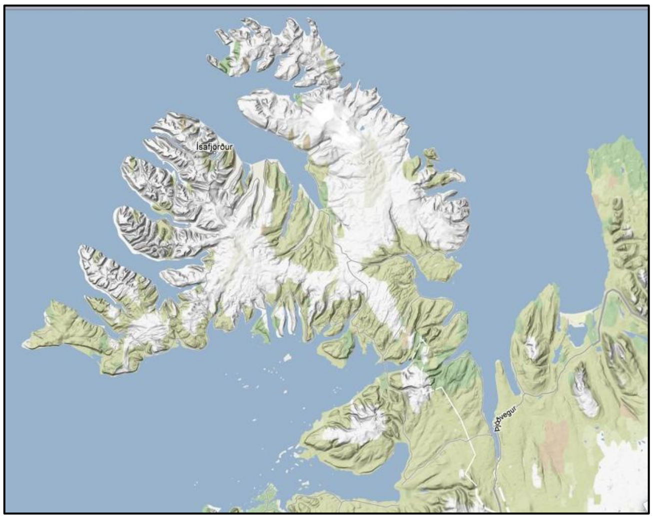

Figure 6: Terrain map of Vestfirðir. Image courtesy of Google

In developing this theory of accumulated wealth through marine exploitation, Edvardsson has studied the work of Lúðvík Kristjánsson, who divided fishing stations into four historical categories. These were *heimræði* (home station), generally used by a fisherman and his farm hands and located fairly close to the main farm; *viðleguver* (shared station), which was a *heimræði* that was shared and where many farmers from throughout the region congregated; and *útver* (outlying station), located on farmland but not close to the farm itself and only used by fishermen. A *blönduð ver* (mixed station) is a combination of all three fishing sites, with *verstoð* (hunting station) being a site away from the farm in similar terrain to *útver* in rough inhospitable places both used for hunting and fishing.[38] These categorisations are primarily based on the historical record, which in places lacks the required detail for an in-depth analysis. This imprecision prompted the development of a revised model based on the two varieties of

[38] L. Kristjánsson, '*Íslenskir sjávarhættir*, Vol. 1', (Reykjavík, 1983).

fishing station which have emerged through archaeological and zooarchaeological investigations, a logical step given the ambiguous nature of historical material. These are *inner fjord* sites, which are said to contain a more varied species of fish, and *outer fjord* sites which contain more homogeneous remnants of past fishing activities, mainly the remains of larger cod species.[39] This classification is very much in its infancy and its development will be assisted through the application of new methodologies such as geoarchaeology and thin section micromorphology. An in-depth regional field study was conducted by Fornleifastofnun Íslands in AD 2005 which identified field sites which provide evidence to suggest they were used for specialist fishing purposes.[40] Further study of these sites will also assist in the development of Edvardsson's revised fishing station categorisation.

By having a categorisation establishing the role of each fishing station, the details of a historical development of market potential can begin to be developed. The term *specialist* refers to the exploitation of the marine resource for trading, opposed to fishing on a subsistence level for personal and local consumption. Specialist exploitation on a commercial level can be used to service both domestic and export demands, which somewhat complicates the understanding of fishery development. It is thought that two different end products, or saleable market products, were produced in order to take advantage of two different markets.[41] Fish for domestic consumption were composed of fresh and saltwater species, caught in a range of sizes, obtained and landed within the

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[39] C. Amundsen, S. Perdikaris, T.H. McGovern, Y. Krivogorskaya, M. Brown, K. Smiarowski, S. Storm, S. Modugno, M. Frik, M. Koczela, 'Fishing Booths and Fishing Strategies in Medieval Iceland: an Archaeofauna from Akurvík, North-West Iceland'. *Environmental Archaeology*. 10 (2005), p.127-42.

[40] O. Aldred, 'Landscape Research in the Northwest: Vatnsfjörður Peninsula. Fornleifastofnun Íslands Report FS298-03094', (Reykjavík, 2005).

[41] R. Edvardsson, 'Commercial and Subsistence Fishing in Vestfirðir: A Study in the Role of Fishing in the Icelandic Medieval Economy', *Archaeologia Islandica,* 4 (2005), p.51-67.

inner fjord. Fish for an export market were predominantly larger cod species, caught at deepwater offshore grounds and landed at outer fjord sites.[42] By positioning the fishing station as close to the deepwater ground as possible, the highly variable weather experienced in this part of the world poses less of a threat to the safety of fishermen in open rowing boats than if they were positioned further into the fjord.[43] This allowed fishermen to take advantage of breaks in the weather, get to the grounds and back to the safety of land with their catch in as short a time as possible. These fish were of a standard size, much larger than those found domestically, catering for a specific market demand. Larger fish were perfect for the manufacture of *skreið*, a product unique to northern latitudes where the climate permits the air-drying of the split and gutted fish.[44] This was a product which, when dried, could be stored for well over a year, ideal for consumption during lean periods such as winter. This attribute alone rendered it attractive to Icelanders and foreigners alike.

The original colonisation of Iceland would most likely have taken place with the understanding that resources on the island would be plentiful and in abundance. It is, however, a country on the margins, uninhabited until the late ninth century, meaning that changes to the environment and society may have more pronounced impacts here, even more so given that it is one of the few countries whose origins came into being in the full light of history.[45] It is an ideal location to be investigated from an environmental historian's perspective, as there is an importance in reconstructing past landscapes and understanding what they were like and how they functioned before societies entered

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[42] This theory would depend on the matching of the date of emergence of the fishing site along with evidence of export trading patterns.

[43] The average range of a typical six-oared vessel was around twenty kilometres per day.

[44] Amundsen *et al.,* 'Fishing Booths and Fishing Strategies in Medieval Iceland'.

[45] R.F. Tomasson, '*Iceland, The First New Society'.* (Minnesota, 1980).

and rearranged them.[46] The landscapes and seascapes developed free of anthropogenic interference, before the *Landnám* of the ninth century, and with a younger age, this investigation should be theoretically easier to understand in comparison to more ancient landscapes. By developing a historical chronology of fishery development, supplemented with research from historical sources and modern-day environmental records, it will allow the assessment on how Icelanders imposed themselves on a pristine landscape and responded to those broader changes in environment and society.

This research can also be integrated into the contemporary concerns relating to the environment as well as environmental history, and the most prevalent themes can begin to be considered. These include resilience, sustainability, the management of common resources, environmental impacts (and responses to), how humans interacted with the 'natural' world (and in the case of Iceland, a pristine landscape), and how this created a society with a rich maritime culture. On a more detailed level, it can begin to consider how the environment changed over time, consequences of a changing environment and society, and how the attitudes of society responded to these changes. Each of these themes carry rich interest and a contemporary link given their association with the most pressing environmental concerns today, mainly a changing environment and how people respond to this. It is important not to construct an entirely declensionist narrative as is common with some environmental histories, as the changes which have taken place in Icelandic society, for good or bad, have permitted the society to flourish and develop and provide us with the culturally diverse country we have today. As night follows day, change happens, and it is important to understand how people respond to these changes, rather than just focussing on the changes themselves.

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[46] D. Worster. 'Doing Environmental History' in Worster, D. & Crosby, A.W. (eds.), '*The Ends of the Earth: Perspectives on Modern Environmental History'*. (Cambridge, 1988).

Chronological development is a key variable in the understanding of historical fishing communities. Previous studies in Caithness, Northern Scotland and Vesterålen, Northern Norway have provided insight into when specialist fishing communities emerged at these locations.[47] At both of these locations, which potentially may have been inhabited for over 1,000 years, there was a lack of understanding regarding how the communities developed given that the historical record was either deficient or contradictory. Both places reveal an on-site presence of fish processing remains pre-dating the specialist fishing community era, and an evolution from a subsistence to specialist procurement strategy. One of the Norwegian sites was previously thought to have developed in the thirteenth century when a specialist fishing community was imposed on a previously unoccupied spot. However it was revealed that fish were being extracted here before the construction of *fiskevær* and the implementation of the *Jektefart* system. These results were achieved by applying a geoarchaeological methodology to analyse and understand the cultural signatures contained within the landscape, and interpreting these variables to provide a historical understanding.

This research will provide detail regarding the origins and development of specialist fishing communities, this time in a pristine landscape,[48] detailing not just the emergence of the fishing sites but also analysing the development and use of these sites over time. Settlement on a landscape previously free from direct anthropogenic influence creates a laboratory-like environment where it is theoretically possible to piece together human

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[47] I.A. Simpson, S. Perdikaris, G.Cook, J.L. Campbell & W.J. Teesdale, 'Cultural sediment analyses and transitions in early fishing activity at Langenesværet, Vesterålen, northern Norway', *Geoarchaeology*, 15 (2000), p.743-63; I.A. Simpson & J.H. Barrett, 'Interpretation of Midden Formation Processes at Robert's Haven, Caithness, Scotland using Thin Section Micromorphology'. *Journal of Archaeological Science*, 23 (1996), p.543-56.

[48] Other than the Faeroe Islands, Iceland is the only permanent extension to the Scandinavian world as a result of Norse expansion, unlike mainland Scotland, Orkney, Shetland and Greenland where there is a record of an indigenous population.

impact within an undisturbed region. Landscapes and the societies who inhabit them in their very nature are not static, and by charting the changes observed at these sites after *Landnám*, we can begin to address the question of how people responded to the social and environmental drivers which influenced their day to day living. By applying the technique of thin section micromorphology, the interpretation of undisturbed soils and sediments at a microscopic level, alongside soil chemical analysis, the existing archaeological and zooarchaeological research can be integrated with the results, and alongside the existing historiographical and environmental work. This suite of data can be seen as complementary and as permitting development of a broader an understanding of the maritime landscape of Vestfirðir.

Application of an integrated methodology, including thin section micromorphology, the interpretation of the record contained within undisturbed soils and sediments may also go some way to validate the theory of Edvardsson and McGovern which proposes that the origins of wealth at Vatnsfjörður came from one economic activity.[49] The establishment of fishing booths on the coast is a process which took considerable effort and used a sizable proportion of resources in the form of turf. It may be that the booths were not for the sole purpose of fishing stations, and it may be that they took on the role of shieling huts outwith the fishing season. Despite bones and other organic artefacts being under-represented in some Viking Age assemblages as a result of preservation issues, the residues which do remain within the soils and sediments record may still be visible at a microscopic scale, and potentially answer the question of whether what are referred to as fishing stations had a secondary, terrestrial function.

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[49] Edvardsson & McGovern, 'Archaeological Excavations at Vatnsfjörður 2003-04'; Fornleifastofnun Íslands, 'Fornleifarannsókn í Vatnsfirði við Ísafjarðardjúp sumarið 2004'. FS249-03093. (Reykjavík, 2004).

Knowledge and understanding of fishing communities, their history and the trade associated with them is regarded as critical to the understanding of the Viking Age in the North Atlantic region.[50] There is no better way of understanding landscape changes than in the transition from a formerly pristine state into a cultural landscape which occurred wholly within the historical era and within relatively well known chronological and ecological parameters.[51] By undertaking an interdisciplinary research strategy, it firstly allows the establishment of a chronological framework before the relevant research areas developed. This method will permit the research questions contained within this chapter to be answered, alongside any questions which arise as a result of the research process.

The aim of this research is to adopt the aforementioned method of analysis, which will permit the following research questions to be answered;

1. *When did specialist fishing locations first emerge in Vestfirðir, and are there observations within the geoarchaeological record to suggest a subsistence to specialist transition?*

2. *Were specialist fishing locations occupied seasonally, or occupied throughout the year?*

3. *Is there any evidence within the cultural record of the soils and sediments to suggest that activities other than fishing were taking place?*

4. *What events, if any, were driving the development of specialist fish exploitation?*

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[50] J. Barrett, R. Beukens, I. Simpson, P. Ashmore, P. Poaps & J.Huntley, 'What was the Viking Age and when did it happen? A view from Orkney'. *Norwegian Archaeological Review,* 33 (2000). p.1–39.

[51] Tomasson, '*Iceland, The First New Society'.*

5. *Of all the sites surveyed, at what point in the geoarchaeological record can the most intense period of occupation be observed, and what can be observed during specific temporal phases?*

6. *On the evidence provided, can this research support the theory of previous research which attributes the wealth found in the archaeological record at Vatnsfjörður to the exploitation and control of the maritime environment?*

7. *Can the establishment of Iceland be regarded as a Scandinavian trading post and an economic extension, or was it settled by people who intended to continue their chieftain-based lifestyle and live by subsistence means which so happened to evolve into a major provider of specialist marine products?*

8. *Are the sites surveyed comparable, does the geoarchaeological record correlate well with the documentary and climate history record, and what material can now be expected to be found within the geoarchaeological record at specialist fishing locations in the light of this research?*

Theoretically, the findings achieved using this methodology can be transferred elsewhere and permit the assessment of human impact on other landscapes and seascapes throughout the world.

The objectives of this research are to bring together regional and site-based interpretations, bringing together historiographical and geoarchaeological narratives to give a site-based level of detail within a broader context. It is bringing together humanities and sciences to develop and contribute towards a new understanding of fishing in Iceland, helping to outline phases of development and abandonment, and place these into a wider narrative, not just relating to Iceland but also in a global environmental context. By answering the above research questions, a wider resonance can begin to be understood, enquiring as to how did the landscape respond to anthropogenic impacts, and subsequently how did humans respond to these changes. Exactly how resilient were these environmental and social systems which can be identified since post-*Landnám* Iceland? And there is the research in a wider context, and how was Iceland in a broader North Atlantic perspective? No such narrative presently exists, and the development of one can potentially help in the enhancement of the cultural and historical background of Vestfirðir.

Chapter Two – A Historiographical and Environmental Background

Introduction

This chapter aims to provide the broader environmental, historical and social context in which to place the research findings found in chapter four. A detailed narrative spanning over 1,000 years will provide a framework in which the findings from the geoarchaeological investigations can be synthesised. This is a critiqued body of knowledge brought together in a chronological manner, detailing the highs and lows of Icelandic society in reference to maritime communities. Given the nature of the topic, a strong emphasis is placed on the environmental narrative, in the manner in which this has shaped, alongside economic, political and social factors, the pattern of Icelandic life.

Figure 7: Vatnsfjörður Coastline, steep cliffs and deep fjords, April 2006.

Considerable effort has been made in a variety of research arenas to explore numerous themes oriented around the economic, social and environmental histories of Iceland, with the latter extending as far back as several centuries before the country was permanently populated. The histories which have been composed vary in the value and volume of their content, with social history receiving the most attention; this pattern commenced with the committal to writing of Iceland's sagas. The 'natural histories' created in the eighteenth century went some way to modernising the image of Iceland, transforming it from an object of derision and mythical backwater to a valued part of the Danish kingdom.[52] Such documents, which reached a wider audience than anything before them, still contained their fair share of error and misinformation, and they were responsible for painting particular regions of Iceland in a less than positive light.[53] The single language and ideas used in such volumes, created a single dimension of interpretation in many contexts, including environmental and social aspects. This was an erroneous, homogeneous impression of Iceland, presented by the strongest voices to the outside world. Environmental and social conditions are seldom distributed through a society with equality.[54] The coastal dwellers in more hostile terrain behaved differently to the predominantly pastoral farmers in inland sheltered areas. The open, flat plains of the south, for example, are in stark contrast to the comparatively sheltered steep cliffs and deep fjords of the northwest, typically viewed as ideal locations for activities such as launching and landing boats. It is safer to land a boat on a rocky foreshore than a flat, sandy expanse due to the power of incoming waves. The more geographically outlying areas are treated as marginal and unimportant given that they

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[52] E. Ólafsson & B. Pálsson, '*Reise igiennem Island',* (Sorøe, 1772).

[53] According to Edvardsson, these perceptions helped fuel the idea that Vestfirðir was and always had been an economic backwater, whereas he argues that the exact opposite was indeed the case. R. Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland*'. Unpublished PhD thesis, (City University, New York, 2010); J. Anderson, *Nachrichten von Island, Grönland, und der Strasse Davis*, (Hamburg, 1746). This volume was translated from Danish to English, leaving out the most critical aspects of Danish mercantile involvement with Iceland, indicating the level of censorship and acknowledgement undertaken by the Danes wanting to create an immaculate history of themselves.

[54] Worster. 'Doing Environmental History'.

were regarded as atypical and not adhering to the wider contemporary socio-economic pattern within Iceland and the rest of the Danish kingdom.[55] It has taken considerable time for some regions of Iceland to shake off the image created by eighteenth century visitors and writers, and progress to give a more accurate depiction is still ongoing.

Environmental History and Iceland

Environmental histories concerning Iceland are still somewhat in their infancy, much like the discipline itself. Environmental history developed as a result of environmental activism during the AD 1960s, driven primarily by environmental concerns. It evolved in subsequent decades and is still essentially in the developmental stage.[56] Such studies have been undertaken predominantly with their focus on the terrestrial landscape rather than the maritime context,[57] and little consideration has been given to interpret the maritime and terrestrial landscapes as one. These landscape-based studies, however, have helped to begin an image transformation of early settlers, from that of resource-hungry savages to more sophisticated groups of individuals, aware of their environmental context and impacts, but doing so in a newer and more marginal environment. The studies have pioneered a revised way of thinking away from the approaches taken in the past, with the logical step now being to widen this revised research strategy into a maritime arena.

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[55] K. Oslund, 'Nature in league with man: conceptualising and transforming the natural world in eighteenth-century Scandinavia'. *Environment and History*, 10 (2004), p.305-25, outlines the impression contemporary writers had of Iceland at the time.

[56] For further details and discussions, see J.R. McNeill, 'Observations on the Nature and Culture of Environmental History'. *History and Theory*, 42 (2003), p.5-43; Worster. 'Doing Environmental History'.

[57] I.A. Simpson, W.P. Adderley, G. Guðmundsson, M. Hallsdóttir, M.Á. Sigurgeirsson & M. Snæsdóttir, 'Soil Limitations to Agrarian Land Production in Premodern Iceland', *Human Ecology*, 30 (2002), p.423-43.

With the growing global interest in environmental issues and the recognition that analysis of historical environments can give a new found perspective on economic, social and environmental histories, the environmental arena is receiving more interest. Attempts at history solely from a documentary perspective do not necessarily provide adequate depth to investigations regarding the multiple aspects of the environment, calling for the integration of data from a variety of different sources. One example of this is the finely-detailed regional climatic records assembled from both historical and environmental sources, which have provided at times a decadal impression of Iceland's climate since *Landnám.*[58] Such records have proved to be highly valuable and will be integrated and analysed over the course of this chapter, as it develops a thematic and chronological framework. This framework will be integrated with the results of the geoarchaeological investigations found in chapter four, and subsequently discussed in chapter five. Given that there is such a variety in both quality and detail of these resources, coupled with the ever-challenging issue of reliability,[59] careful consideration and critique is required in order to construct a narrative suitably robust to be analysed in conjunction with the geoarchaeological interpretations, and detailed enough to answer the key research questions.

Norse Origins

Before the Norse arrived in Iceland much trading and raiding had been done from Scandinavia to their older western colonies in Britain and Ireland, as well as to mainland

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[58] A.E.J. Ogilvie, 'The Past Climate and Sea Ice Record from Iceland, Part 1: Data to A.D. 1780'. *Climatic Change*, 6 (1984), p.131-52.

[59] A.E.J. Ogilvie, 'Historical Ecology, Climate Change, and implications for climate science in the twenty-first century'. *Climate Change,* 100 (2010), p.33-47.

Europe (Figure 8).[60] The development of boat technology, from the Hjortspring Boat to the Oseberg Ship,[61] facilitated large-scale movement across seas and oceans. This factor, alongside economic intensification, military advances, population growth and climatic favourability were said to be amongst the main drivers of Norse expansion.[62] The developed seafaring skills were permitting the acquisition of wealth from raiding, protection racketeering and large-scale slaving, as well as fishing and other maritime trade. The gains from these exploits were said to be fuelling political developments in Scandinavia, the nature of these developments, however, remain widely debated.[63]

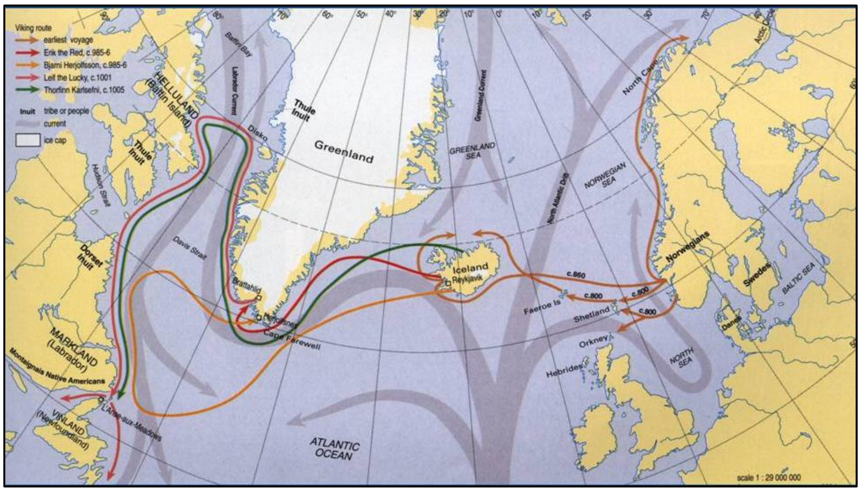

Figure 8: Map depicting the movement of the Norse across the North Atlantic. Image courtesy of Dr. Colleen Batey, University of Glasgow

The Norwegian archaeological record for the period around the end of the ninth century does not reveal any dramatic cultural shifts or changes, suggesting a firm establishment

[60] H. Zimmer, 'Über die frühesten Berührungen der Iren mit den Nordgermanen' in 'Sitzungsberichte der Königlich Preussischen Akademie der Wissenschaften', (1891). p. 279-317; S. Perdikaris & T.H. McGovern, 'Cod Fish, Walrus and Chieftains: Economic intensification in the Norse North Atlantic', in T.L. Thurston & C.T. Fisher, (eds.), '*Seeking A Richer Harvest: The Archaeology of Subsistence Intensification, Innovation, and Change'*, (New York 2006), p.193-216.

[61] For more details on the advances of ship technology, see J. Haywood, '*Encyclopaedia of the Viking Age*', (London, 2000).

[62] Perdikaris & McGovern, 'Cod Fish, Walrus and Chieftains'; J.H. Barrett, 'What caused the Viking Age?' *Antiquity,* 82 (2008), p.671-85.

[63] For a synthesised version of some of these events, see A. Forte, R. Oram & F. Pedersen, '*Viking Empires*'. (Cambridge, 2005).

of a continued and particular way of life orientated around trade and exchange.[64] Despite continuity being experienced in Norway, this was not representative of what was happening elsewhere.[65] As mentioned in chapter one, the advances and developments migrating across the ocean occurred during a period of more benign climate said to have commenced around the turn of the tenth century and lasting through to the late thirteenth century when particular deterioration was observed from the AD 1280s onwards. The severity increased through the years AD 1315-22, recognised as the Great European Famine. Though the severity was reduced after the 1320s, there were further sustained episodes of poor weather experiences in the late fourteenth and early fifteenth centuries. Between AD 800 and AD 1300, the Irminger Current was said to be having a strong influence in the North Atlantic, increasing mean annual temperatures.[66] The mean annual temperature around AD 900 was 4.4°C. From around AD 980 onwards, the sea surface temperature is said to have increased between 1°C and 1.5°C compared to previous centuries.[67] The reduction of the influence of the Irminger current coincides with the AD 1280s decline in climatic conditions. Between the ninth and eleventh centuries there was said to be decreased levels of storminess in the North Atlantic as demonstrated by Greenland ice core evidence,[68] encompassing the period where Faeroe Islands, Iceland, Greenland and North America were all colonised

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[64] B. Myhre, 'The Early Viking Age in Norway', *Acta Archaeologica*, 71 (2000), p.35-47.

[65] For transitions overseas, see the work of Barrett *et al.,* 'Dark Age economics'.

[66] K.L. Knudsen, J. Eiríksson, E. Jansen, H. Jiang, F. Rytter, & E.R. Gudmundsdóttir, 'Palaeoceanographic changes off North Iceland through the last 1200 years: foraminifera, stable isotopes, diatoms and ice rafted debris'. *Quaternary Science Reviews*, 23 (2004), p.2231-246. The Irminger Current is also, on occasion, referred to as the East Greenland Current.

[67] M. Sicre, J. Jacob, U. Ezat, S. Rousse, C. Kissel, P. Yiou, J. Eiríksson, K.L. Knudsen, E. Jansen & J. Turon, 'Decadal variability of sea surface temperatures off North Iceland over the last 2000 years'. *Earth and Planetary Science Letters*, 268 (2008), p.137-42.

[68] A. Dawson, *So Foul and Fair a Day: A History of Scotland's Weather and Climate*, (Edinburgh, 2009), p.88.

by Norse settlers.[69] Despite long-term trends showing relative calmness of the seas, the climate was still frequently punctuated with unfavourable cold episodes.[70]

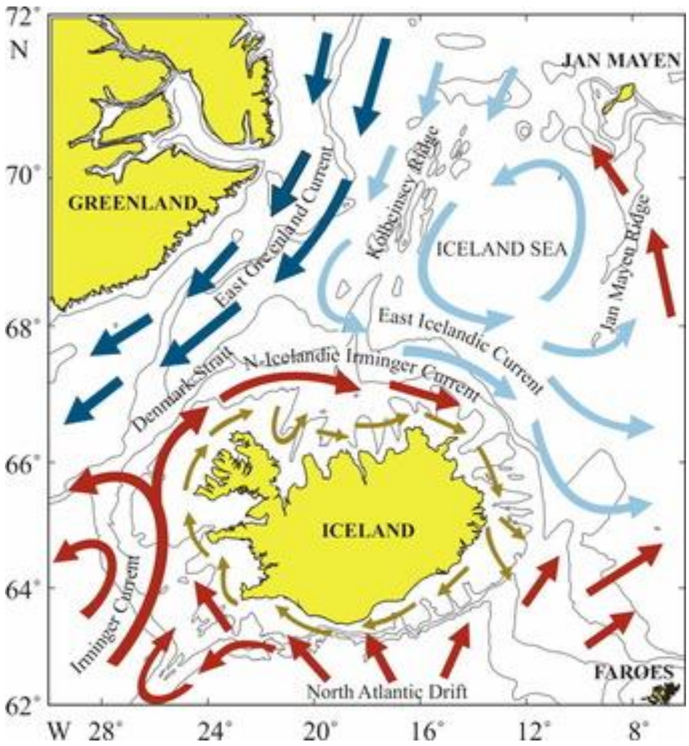

Figure 9: Present Day Ocean Currents around Iceland[71] (Courtesy of The Marine Research Institute)

Maritime Movement around Western Europe

It was not just Norse settlers who were navigating their way round the waters of Western Europe. International trading on a significant scale revived for the first time since the collapse of the late Roman silver economy as a part of European economic life at this time, with the establishment of important trade 'emporia' at locations such as Hamwic, Quentovic, Dorestad and Nantes, all ports accessible by boats from rivers and

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[69] Ibid., p.72. Faeroe was colonised in the ninth century, Iceland *c*.874, Greenland in the 980s and North America *c*.1000.

[70] Perdikaris & McGovern, 'Cod Fish, Walrus and Chieftains'.

[71] Icelandic Fisheries. <http://www.fisheries.is/ecosystem/oceanography/ocean-currents/> [Accessed 22/05/2012]

seas.[72] The *Papar*, solitude-seeking Irish monks were also said to be finding their way through the waters of the North Atlantic. In AD 825 the monk *Dicuil* himself said that he sailed to some northern island, with modern commentators assuming that this location was Iceland.[73] Further mentions of the *Papar* make their way into the twelfth century saga *Íslendingabók* through the documentation of oral testimony, but the absence of archaeological evidence and the way in which Christian ideology was being promoted in Iceland at this time make these documents somewhat unreliable.[74] One entry from *Landnámabók* which has been supported by archaeological evidence describes the settlement of a permanent population in Iceland by around AD 874. Debate continues as to the finer details regarding this settlement, particularly the Scandinavian associations linked to this migration and the stimulus behind such an event.[75] The result of this is the absence of an explanation which is firmly established and universally accepted amongst scholars. Sagas hint at the island as a land of opportunity where resources were free, but not everyone was dropping everything for a life in the mid-Atlantic.[76] Regardless of the details, by the late ninth century, a society was in the process of establishing itself on a land-mass named Iceland, a society mainly Norse in character but also heavily influenced by Celtic culture.[77] Between *Landnám* and the start of what is termed the

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72 Oram, personal communication.

73 J.J. Tierney, '*Diculi: Libur de Mensura Orbis Terrae'*. (Dublin, 1967). A cave site at Kverkarhellir has been recently discovered and thought to have pre-Landnam origins. Details of this remain in the popular media rather than in formal publication. See tinyurl.com/kverkarhellir

74 For discussion on religion in early Iceland, see O. Vésteinsson, '*The Christianisation of Iceland*' (Oxford, 2000).

75 Recent debate suggests that an abundance of males in Scandinavian society may have been a contributing factor stimulating migration and exploration in the North Atlantic. Barrett, 'What caused the Viking Age?'.

76 Magnusson & Palsson, '*Laxdaela Saga'*, Chapter 2, details Ketil's sons who plan to migrate to Iceland and refer to it as a fishing camp. Ketil refuses to go, not implying that a life of fisheries was not for him, but the life he had in Norway was satisfying enough.

77 The genetic make-up of the *Landnámsmen* is said to have been influenced by the range of regions under Norse influence. See S. Goodacre, A. Helgason, J. Nicholson, L. Southam, L.

Icelandic Commonwealth Period (AD 930-1262), at least 10,000 and as many as 20,000 people were said to have migrated to Iceland.[78]

Post-*Landnám* Iceland

Once *Landnám* had commenced, the *Landnámsmen* were said to have begun the process of developing a lifestyle oriented around pastoral farming, although a society was developing which was said to be heavily reliant on fish.[79] They began this by claiming their own bit of freehold, or absolute ownership of land or property.[80] Where there was grass, there would likely have been a farm, and in a landscape with no large predator mammals other than foxes, livestock could graze in upland areas without threat. From this, there developed what was to become the primary occupation and economic contribution of early Iceland, animal husbandry; the keeping of mainly sheep and cattle.[81] Other species of livestock which found their way to early Icelandic farms from the initial voyages were goats, geese, pigs, chickens and dogs,[82] but over subsequent

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Ferguson, E. Hickey, E. Vega, K. Stefánsson, R. Ward, B. Sykes, 'Genetic Evidence for a family-based Scandinavian settlement of Shetland and Orkney during the Viking periods'. *Heredity* (2005) p.1-7; G. Jones, '*The Norse Atlantic Saga'*, Oxford (1964), p.23; P. Urbánczyk, 'Ethnic aspects of the settlement of Iceland', in B.E. Crawford & J.G. Jorgensen (Eds.) '*Papa Stour and 1299: Commemorating the 700th Anniversary of Shetland's First Document',* (Lerwick, 2002), p.155-66. Recent work by Urbánczyk proposes that Slavic people may have made up an increasing proportion of the *Landnámsmen*, although this proposal is somewhat controversial. A-M. Long, personal communication.

[78] Forte, *et al., 'Viking Empires'*, p.333.

[79] Zori, *From Viking Chiefdoms to Medieval State in Iceland.*

[80] B. Cunliffe, '*The extraordinary voyage of Pytheas the Greek: The man who discovered Britain',* (London, 2002).

[81] G. Sveinbjarnardóttir, *Farm abandonment in medieval and post-medieval Iceland: an interdisciplinary study.* (Oxford 1992). This concept suggests Iceland is uniform and suitable for pastoral farming, which it is not. See the debate on homogeneity later in this chapter.

[82] Eggertsson, 'No experiments, monumental disasters: Why it took a thousand years to develop a specialized fishing industry in Iceland'; Byock, *Viking Age Iceland*.

centuries some of these species would all but disappear from the cultural record.[83] The reduced numbers of goats and pigs in zooarchaeological assemblages from the centuries after *Landnám* may reflect two schools of thought, currently being debated, as to their role in early Icelandic society. Their removal could suggest awareness of the destructive nature of pig foraging habits, which were becoming increasingly detrimental to Iceland's landscape and accelerating landscape degradation.[84] Sheep were also destructive and remain so in the present day (Figure 10). A second school of thought could be that these destructive properties were recognised prior to *Landnám*, and that they were introduced to accelerate the process of woodland clearance. With their job done, there was no need for them to be in Iceland any longer, contributing towards further landscape degradation. Soil erosion increased dramatically on a regional scale in Iceland after 900.[85] Some say this coincides with a period of cold weather,[86] further compounded by reduced biomass production, however, as already mentioned, alternative evidence reveals increasingly favourable temperatures. It may indeed be that what has been observed is a short, swift decline in environmental conditions. If this was the case, even after observing these changes, Icelanders appear not to be proactive enough in an environment which continued to evolve around them to develop

[83] T.H. McGovern, S. Perdikaris, Á Einarsson & J. Sidell, 'Coastal connections, local fishing, and sustainable egg harvesting: Patterns of Viking Age inland wild resource use in Mývatn district, Northern Iceland'. *Environmental Archaeology,* 11 (2006), p.187–205.

[84] Studies have looked extensively at landscape degradation, concluding that it is a process which took place throughout Iceland's history at varying degrees of intensity (R. Ólafsdóttir & H.J. Guðmundsson, 'Holocene landscape degradation and climatic change in northeastern Iceland'. *The Holocene*, 12 (2002), p.159-67). This process took place prior to *Landnám*, but it is a process which has been increased and became heavily conditioned by terrestrial anthropogenic activity. (I.A. Simpson, A.J. Dugmore, A.M. Thomson & O. Vésteinsson, 'Crossing the thresholds: Human ecology and historical patterns of landscape degradation', *Catena*, 42 (2001), p.175-92; Morrison, '*The Contribution of Summer Grazing'.* Its growth has conditioned human behaviour as people move away from denuded and unusable landscapes.

[85] H.J. Guðmundsson, 'A Review of the Holocene Environmental History of Iceland'. *Quaternary Science Reviews*, 16 (1997), p.81-92.

[86] Á. Geirsdóttir, G.H. Miller, T. Thordarson & K.B. Ólafsdóttir, 'A 2000 year record of climate variations reconstructed from Haukadalsvatn, West Iceland'. *J Paleolimnol*, 41 (2009), p.95-115.

sustainable land-use strategies, resulting in irreversible ecosystem damage.[87] It is around this time that *Grettir's Saga* tells us that *land is becoming scarce but the resources plentiful that man had of them what he would*.[88] This gives the impression of a time of plenty, and little consideration beyond the self. Given that Icelanders may have been responding to landscape pressures, resources would have been at the forefront of their minds and to behave in such a manner appears rather reckless. The saga sources, perhaps, are not revealing the complete story.

Figure 10: An Example of Landscape Erosion Accelerated by Sheep Grazing, Mývatnssveit, Summer 2004.

Transfer of Knowledge from Norse Landscapes

The skill to be pastoral farmers would have originated from lands throughout the Norse kingdom, demonstrating a transfer of knowledge from one landscape to another. Fishing was part of everyday life in coastal Scandinavia, and this system would have

[87] Simpson *et al.,*'Crossing the thresholds'.

[88] Grettir's Saga, chapters 9 and 11, in W. Pencak, '*The Conflict of Law and Justice in the Icelandic Sagas'*. Rodopi, (1997). p.37.

transferred over automatically as a natural extension to this.[89] Scandinavia, the Hebrides, the Highlands of Scotland and Ireland were all under Norse control, yet all contained a variety of landscapes from the mountainous uplands in Scotland to the coastal areas of Ireland and modern day Argyll. These were people experienced in the dual economy of fishing and farming.[90] Marine resources would have been an essential component during initial settlement as livestock numbers were built up.[91] However, alongside this knowledge transfer was a need for adaptation to the Icelandic landscape. Despite having characteristics similar to what is found throughout the Norse kingdom, particularly Norway and parts of Scandinavia, Iceland was not identical. Much like westerly migrating farmers within early twentieth century North America, there was a need to quickly adapt to the new terrain, particularly the difficulties associated with erosion of the Icelandic andosolic soils.

The Icelandic Landscape

Uniform is not a word which can describe the Icelandic landscape given the range of terrain; from the coastal fjords and deltas to the inland deserts and fertile valleys. The country is susceptible to a variety of environmental conditions, from the wide-ranging topography and relief which, combined with the often erratic weather conditions, contribute to the creation of an inhospitable landscape with poor vegetation regeneration. The interior of the country is classified as an Arctic desert, contributing (alongside glaciers) up to eighty percent of the total island surface which cannot support a permanent human population.[92] This variety would suggest that farming across

[89] Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland',* p.267.
[90] Thór, 'Icelandic Fisheries, *c*.900-1900', p.323.
[91] Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland',* p.271.
[92] Jones, '*The Norse Atlantic Saga'.*

Iceland brought widely differing levels of success. In the more marginal areas such as Vestfirðir, the farming which did take place would not have sustained any significant population.[93] With it being topographically similar to the western fjords of Norway, and in light of the evidence for a transfer of knowledge from Scandinavia, it would not be rash to suggest that if specialist fishing communities were to establish themselves in early Iceland; this would be the ideal place. It is interpreted that fishing in this region was the primary subsistence occupation from an early period.[94]

Impacts of Soil Erosion

The above-mentioned landscape degradation would have increased pressure on resources as the areas affected grew in size. There are records of farms being abandoned in the centuries immediately after *Landnám* as a result of such degradation.[95] Farms were being abandoned but the population continued to grow; by the end of the Commonwealth period in the AD 1260s the population is believed to have reached between 40,000 and 60,000,[96] squeezing more people into a declining and dwindling utilisable area. This was not the only pressure on the landscape and resources; several volcanic eruptions occurred during the tenth century which brought significant environmental impacts. The first notable historical eruption took place in AD 920 possibly causing damage to land and property, however, the Laki/Eldgjá eruption which lasted from AD 934 to AD 940 is said to have been the largest flood basalt eruption in historical times and the largest in terms of volume of sulphur dioxide being

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[93] Edvardsson & McGovern, 'Archaeological Excavations at Vatnsfjörður 2003-04'; Fornleifastofnun Íslands, 'Fornleifarannsókn í Vatnsfirði við Ísafjarðardjúp sumarið 2004'.

[94] Aldred, 'Landscape Research in the Northwest' p.3.

[95] McGovern, *et al.*, 'Coastal connections, local fishing, and sustainable egg harvesting'.

[96] Haywood, '*Encyclopaedia of the Viking Age', p.*31.

released into the atmosphere.[97] There is reference to this in the historical record, and if we compare some aspects to some later, smaller eruptions, the significance of the impacts can begin to be observed and understood.

The ingestion of toxins would have brought widespread deaths in both humans and livestock. Direct impacts of the volcanic eruption can be viewed in skeletal evidence which reveals bone formations through fluoride ingestion.[98] Livestock populations, which people would have still been building up after settlement, were severely impacted.[99] Grasses and crops would also be directly affected through the increase in the acidity of precipitation and the cooling of the climate caused by the aerosols remaining in the atmosphere,[100] a characteristic and disturbance which may appear evident in future high resolution pollen analysis. In a society still practicing gathering techniques there would have been an impact on the food obtained through this method. Drought and frost were also observed after these eruptions as the atmospheric veil remained.[101] Potentially, and possibly most importantly, was the significant impact on inland waterways. Later accounts detail volcanic deposits acidifying rivers, predominantly in the southern part of the country, leading to mortality. Given the magnitude of this eruption, there needs to be serious consideration of the impact this would have had on maritime resources, and the subsequent reduction on the freshwater catch. What freshwater fish which remained would have been fewer in number,

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[97] Ljósufjöll <http://www.volcano.si.edu/world/volcano.cfm?vnum=1700-03=&volpage=erupt>

[98] H. Gestsdóttir, P. Baxter G.A. & Gísladóttir, 'Fluoride poisoning in victims of the 1783-84 eruption of the Laki fissure, Iceland'. Fornleifastofnun Íslands, FS328-04291. (Reykjavík, 2006)

[99] Fornleifastofnun Íslands, 'Annual Report', Reykjavík (2004).

[100] R.B. Stothers, 'Far Reach of the Tenth Century Eldgjá Eruption, Iceland', *Climatic Change*, 39 (1998), p.715-726.

[101] Dawson, *So Foul and Fair a Day,* p.95.

becoming something more associated with the elite members of society, pushing the lower echelons of society to seek their resource further out to sea.

Impacts of Environmental Events

It is likely that the direct impact of these eruptions would have been the periodic famine and sickness which occurred in Iceland from the early tenth century onwards.[102] Volcanic eruptions are suggested to be causal factors in rises in the numbers of cases of smallpox and famines as the population becomes weaker.[103] The Eldgjá eruption is an event of enormous magnitude, although impacts recorded do not seem as widespread as later, larger eruptions. This may have something to do with the timing of the eruption, in an era not well represented in the historical record, or the fact that despite these events taking place, Iceland's population (assisted by those killed as a direct result of the eruption) was still sufficiently low and thinly distributed that the country remained well within its thresholds and impacts were not as severe. Investigation of any absence or continuity within the coastal geoarchaeological record may provide greater understanding of these events and the way in which resources were obtained and lifestyles altered.[104]

With the disruption caused by landscape degradation, volcanic eruptions, climatic deterioration and recording growing periods of sickness, the story of Iceland immediately after *Landnám* changes slightly from the traditional narrative of unperturbed migration, settlement, population increase and the building up of

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[102] Byock*, Viking Age Iceland,* p.57.

[103] Ibid., p.152.

[104] Stothers details some key events which take place during the tenth century. In an attempt to provide an integrated narrative, some of the statements are highly assumptive, something acknowledged by the author himself who is looking to stimulate research in the area.

livestock.[105] Periodic natural agency appears to have assisted in the shaping of the culture of Iceland, at least as much as social or political decisions, with some scholars agreeing on the scale such impacts were having.[106] This is not a new idea, as it has been proposed that genetic makeup is less to do with migration patterns, but more to do with who can survive epidemics such as smallpox.[107] It is unlikely that such a sequence of events would pass without disruption to the social fabric of the country, although these changes were not yet clear. With so much disruption to the terrestrial environment, this may have been the time when Icelanders turned their attentions more to the maritime environment. It could be that the landscape theory has been over-subscribed; Norse people had the knowledge and skill to exploit marine resources from the beginning and it would be negligent on their part if this was widely ignored. The pressures of the tenth century, caused by prevailing environmental conditions, may have brought it to the fore. This concept will be discussed after archaeological, zooarchaeological and geoarchaeological investigations have taken place.

Archaeological Background, post-*Landnám*

The growth in maritime use is a valid hypothesis. If there was a growth in maritime use, it is essential that the validity of this hypothesis is first tested. Archaeological sites in the Mývatnssveit region have yielded bone assemblages which suggest that fish were caught and processed elsewhere, before being transported to inland locations from the ninth century onwards, immediately or shortly after *Landnám.* At Hrísbrú in southwest Iceland, the diet of *Landnámsmen* was substantially supported by fish until a dramatic

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105 *Landnámabók*. <http://www.snerpa.is/net/snorri/landnama.htm>

106 A. Dugmore & O. Vesteinsson, '*Black Sun, High Flame, and Flood: Volcanic Hazards in Iceland',* in J. Cooper. & P. Sheets, (eds.), '*Surviving Sudden Environmental Change,* (Colorado, 2012).

107 D. MacKenzie, 'Icelanders Argue Over Their Ancestors', *New Scientist*, 2032, (1996).

reduction in the thirteenth century.[108] From the AD 900s onwards, the zooarchaeological record reveals growth in the consumption of fish in Iceland,[109] as well as documentary evidence of the first fishing huts being taxed at Bolungarvík in Vestfirðir.[110] There are archaeological remains of boats designed for use in inshore waters dating to the tenth century AD from a site at Dalvík in north Iceland and Patreksfjörður in Vestfirðir.[111] Over time, the assemblages contained reduced numbers of freshwater species and more salt water species, something which has been attributed to the silting and deteriorating quality of freshwater environments, possibly through landscape degradation. This particular theory is still contentious.[112] Marine remnants from Granastaðir near Eýjafjord, an inland site dating to the tenth century, show fish being consumed alongside livestock, neither revealing any exclusivity.[113] At Skuggi, an inland site in north Iceland settled from the mid tenth century, fish bones appear dominant from the mid eleventh to the mid twelfth centuries AD, with no freshwater species identified so far.[114] This echoes the pattern of ninth century AD Mývatnssveit, of

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108 Zori, *From Viking Chiefdoms to Medieval State in Iceland*, p.419.

109 T.H. McGovern, G. Bigelow, T. Amorosi & D. Russell. 'Northern islands, human error and environmental degradation: A view of social and ecological change in the medieval north Atlantic', *Human Ecology*, 16 (1988), p.225-70.

110 '*Íslenzk fornit'* (1968) in Thór, 'Icelandic Fisheries, *c*.900-1900', p.325; Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland'.*

111 Thór, 'Icelandic Fisheries, *c*.900-1900', p.326.

112 I. T. Lawson, F. J. Gathorne-Hardy, M. J. Church, A. Einarsson, K.J. Edwards, S. Perdikaris, T.H. McGovern, C. Amundsen & G. Sveinbjarnardóttir, 'Human impact on freshwater environments in Norse and early medieval Iceland.', in 'Dynamics of northern societies : proceedings of the SILA/NABO Conference on Arctic and North Atlantic Archaeology, Copenhagen, May 10th-14th, 2004'. (Copenhagen, 2006), p375-82; P. Holm, 'Fishing Down the North Sea', in H. Bernd, (Ed.), 'Beiträge zum Göttinger Umwelthistorischen Kolloquium 2007 – 2009', (Göttingen, 2010).

113 Y. Krivogorskaya, S. Perdikaris & T.H. McGovern, 'Fish bones and fishermen: The potential of zooarchaeology in the Westfjords'. *Archaeologia Islandica*, 4 (2005), p.31–51.

114 R. Harrison, 'Skuggi in Hörgárdalur, N. Iceland: Preliminary report of the 2008/2009 archaeofauna'. NORSEC Zooarchaeology Laboratory Report No. 50 (2010). This assemblage may be dictated by status; lower status groups consume coastal produce, with freshwater species consumed by higher status individuals. This echoes the problems of only one site being excavated so far.

a vibrant and reliant coastal to internal trading network within Iceland bringing processed fish inland, and the growth in number of coastal species over freshwater species. The archaeological evidence on this occasion is also supported by numerous passages from some Icelandic sagas. *Grettir's Saga*, which is thought to record tenth century circumstances, tells of a struggle for resources and someone being murdered in a quarrel over fish.[115] In the same saga Grettir's brother Atli, described as a *mighty bonder,* visits a coastal settlement at Snæfellsnes to purchase seven packhorses worth of *skreið.*[116] The *Saga of Gudmund the Worthy* refers to a commercial enterprise, when Thorvard Kamphund used his ship to transport foodstuffs too heavy for horseback from Siglunes at the mouth of Eýjafjord, to the major regional port at Gásir.[117] *Finnboga Saga* talks of large movements of men in the autumn months to purchase *skreið*.[118] The contemporary consumption patterns and literary references represent an active coastal-internal trading system and reflect the importance of fish in early Iceland.[119]

Environmental Change in the Late Tenth Century, and Potential Impact on Fishing

If a noticeable deterioration in the climate did take place from the AD 980s onwards, this may have resulted in a further reduction in biomass production, imposing greater

[115] Grettir's Saga chapter 62 in Pencak, '*The Conflict of Law and Justice in the Icelandic Sagas'*, p.46.

[116] Ibid., chapter 42. Atli was described as a successful farmer and might have been exchanging some of his farm produce, possibly part of a *vaðmal* network of the time. In chapter 11 of Grettir's Saga, there is a reference to an inhabitant of Reekfirth called Thorgeor, who was always out fishing as in those days the firths were full of fish. This would imply that when the saga was composed, possibly sometime in the thirteenth century, the fish population levels within the firths were not the same levels as the time the narrator is describing. This would therefore suggest that success was not as widespread when fishing the firths, calling for the need to move further out to sea to the deep water fishing grounds as a result of overfishing or climatic and oceanographic changes.

[117] Saga of Gudmundr the Worthy.

[118] Finnboga Saga, chapter 44, p.333.

[119] T.H. McGovern, S. Perdikaris & C. Tinsley, C., 'Economy of *Landnám*: the evidence of Zooarchaeology' in A. Wawn & Þ. Sigurðardóttir, (Eds.), 'Approaches to Vinland'. Nordal Institute Studies 4, (Reykjavík, 2001).

pressure on terrestrial resources. Climate may have been on the downturn slightly earlier, as a 'Great Dearth Winter' was reported in AD 975 with widespread food shortages.[120] This event was also repeated a decade later.[121] Further pre-dating this was an episode in the AD 960s where the skies were said to have darkened, possibly as a result of a volcano or a solar eclipse, the chroniclers of the time could not firmly establish its cause.[122] This was a period of reduced volcanic activity in Iceland, suggesting that the scenario could have been significantly worse if Hekla or Laki decided to erupt once more. This episode of periodic catastrophe may be the early signs that Iceland's ecological limits had been reached. The pressures caused by famine would have prompted people to search for resources elsewhere, potentially fuelling the investment needed to develop more maritime resource exploitation during the tenth century. This is reflected in what Thór suggests as a class of fishing farmers emerging in Iceland around AD 1000; they cultivated land and raised livestock, but their main income came from fishing.[123] This categorisation, although perhaps valid, appears generic, almost a one-size-fits-all hypothesis which does not reflect the regional diversity to be expected in such a widely-varying country, with each region finding itself under its own unique set of scenarios. Further in-depth analysis is required to develop this idea.

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[120] A.E.J. Ogilvie, 'Climatic changes in Iceland AD c. 865 to 1598', *Acta Archaeologica*, 61(1991), p.233-251; R.F. Tomasson, 'A Millennium of Misery: The Demography of the Icelanders'. *Population Studies*, 31 (1977) p.405-27, mentions people eating ravens, then foxes, then things that ought not to be eaten, before mentioning that the old and helpless were killed by throwing them over the cliffs.

[121] Tomasson, 'A Millennium of Misery: The Demography of the Icelanders' refers to Njals Saga which documents a lack of hay and food. No mention is made of fish here.

[122] Dawson, *So Foul and Fair a Day,* p.94.

[123] Thór, 'Icelandic Fisheries, *c*.900-1900'.

Europe-Wide Fishery Development

The growth in fishing around this time is not an event limited to Iceland. In England, northern Scotland and the Baltic region there were significant rises in the capture of herring and cod, revealing itself within the archaeological record around AD 1000. These salt-water species were replacing freshwater species as a component of the European diet and through the eleventh and twelfth centuries, they become an integral part of bone assemblages dominating by up to seventy percent and eighty percent.[124] This trend may be somewhat related to the famines experienced in England around the beginning of the eleventh century, causing a reactionary response to the shortage of foodstuffs, or that new knowledge of fish processing was being acquired. Before the end of the first millennium, mainland British zooarchaeological assemblages contained mainly freshwater species such as barbell, bream, pike, salmon and sturgeon, but after *c.* AD 1000 marine species predominate. This phenomenon has been coined the *fish-event horizon*,[125] and is said to also coincide with a peak in Anglo-Scandinavian political, cultural and economic interactions.[126] This late emergence can be supported by the fact there was no word for cod in Anglo-Saxon English.[127] The transition from predominantly freshwater to saltwater species may have been triggered by the climatic deterioration in the years around AD 980, reducing terrestrial output, coupled with the growth in the European population which would have been demanding a cheap source of protein.[128] Freshwater species may simply not have been able to fulfil demand on its

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124 Perdikaris & McGovern, 'Cod Fish, Walrus and Chieftains'.

125 Barrett *et al.,* 'Dark Age economics'.

126 McGovern, *et al.,* 'Coastal connections, local fishing, and sustainable egg harvesting'.

127 W. Sayers, 'Some fishy etymologies: Eng. Cod, Norse, orskr, Du. Kabeljauw, Sp. Bacalao'. *NOWELE: North Western European Language Evolution*, 41(2002), p.17-30, (cited in Barrett *et al.,* 'Dark Age economics').

128 C.M. Woolgar, 'Food and the Middle Ages', *Journal of Medieval History*, 36 (2010), p.1-19.

own. The cooler period of this time was followed by periods of exceptional warmth during the eleventh and twelfth centuries,[129] although there were short, colder episodes experienced sometime between AD 1050 and AD 1100.[130] From around AD 1000 onwards, surpluses of fish were apparently being distributed throughout trading networks at an unprecedented level,[131] firmly establishing fish as a dietary staple. It would become a much-traded commodity throughout Europe, and with population growing particularly fast after AD 1050, demand would no doubt have increased over time.

Zooarchaeological Evidence

Butchery marks and bone distribution has been developed as a presence and absence indicator of specialist fish exploitation in the North Atlantic region.[132] Excavated sites have been defined as processing sites or consumption sites. At locations where processing occurred, crania and mouth parts were cut off and disposed of. Depending on whether the fish was air dried, flat dried or salted, variable lengths of the vertebral column are also present. The cleithrum, a part of the fish found near the gills, helps hold the fish together and tends to travel with the fish to the site of consumption.[133] The robustness of the cleithrum means it is often readily preserved and identifiable to species and family level, giving a detailed background of consumption sites and the types of fish being consumed. A comparison of coastal and inland sites has shown

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129 Ogilvie, 'Historical Ecology, Climate Change'.

130 Geirsdóttir *et al.,* 'A 2000 year record of climate'.

131 Barrett *et al.,* 'Dark Age economics'.

132 S. Perdikaris & T.H. McGovern, 'Viking Age Economics and the Origins of Commercial Cod Fisheries in the North Atlantic' in O. Sickling & Abreu-Ferreira (eds.) 'Beyond the Catch: Fisheries of the North Atlantic, the North Sea and the Baltic, 900-1850', (Brill, 2008).

133 Perdikaris & McGovern, 'Cod Fish, Walrus and Chieftains'; Krivogorskaya *et al.,* 'Fish bones and fishermen'.

coastal sites retaining between zero and four percent of cleithera in their zooarchaeological assemblages, with the inland site retaining between ten and forty percent.[134] These figures do contain some variance, and future investigations may be able to provide a more accurate figure, however, they do give insight into the presence or absence of processing or consumption at specific locations.

Archaeological Evidence at Icelandic Fishing Sites

Archaeological excavations at Akurvík, in Vestfirðir's Strandasýsla hreppur, have produced radiocarbon dates which reveal a coastal site functioning as a fishing station dating to the eleventh century.[135] At Akurvík are a series of lightly constructed, superimposed seasonal fishing booths highlighting impermanent occupation and periods of abandonment and re-use. This site was controlled by the nearby farm at Gjögur, located three kilometres away, and the catches probably found their way into the regional economy of northern Iceland as well as aiding the local economy of Gjögur itself. The catches of this time contained a greater diversity of both fish size and species than is found at later periods. The site at Eýri produced a different pattern, one of a farm engaged in both consumption and commercial processing consumption of fish on a much smaller scale.[136] These findings have fuelled the hypothesis of Edvardsson, who sees the trade and exchange of marine surpluses as being at the core of Vestfirðir's economy. Outside of Vestfirðir, a site at Hvalfjörður, northeast of Reykjavík, occupied between AD 1245 and AD 1375, shows fishing station-like characteristics.[137] Until large-

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[134] Amundsen *et al.,* 'Fishing Booths and Fishing Strategies in Medieval Iceland'.

[135] Krivogorskaya *et al.,* 'Fish bones and fishermen'.

[136] R Harrison, 'Preliminary Assessment of the faunal remains from the 2007 Midden Excavation in Eýri, Westfjords'. NORSEC Zooarchaeology Laboratory Report No. 42, (2008).

[137] M. Gardner & N. Mehler, 'English and Hanseatic Trading and Fishing Sites in Medieval Iceland: Report on Initial Fieldwork', *Germania*, 85 (2007), p.385-427.

scale excavations have been conducted here, however, understanding of the site will remain limited. A site at Sauratún is thought to compare with Akurvík in terms of relative material comparison. It is mentioned in the written sources dating to AD 1437, but abandoned by AD 1500.[138] Avík, north of Akurvík, is mentioned in the thirteenth century sources as being an important fishing site, but no mention of the actual fishing station.[139] The most recent excavations within Vestfirðir have taken place at Gufuskalar on the Snæfellsnes peninsula south of the study area for this project, revealing a location containing a fish-rich deposit dating from AD 1433-1466,[140] suggesting the beginnings of a significant phase of maritime exploitation dating from the fifteenth century onwards.

The emergence of a fishing site at Akurvík came during a time of some environmental pressure and change. In the AD 1050s there were successive seasons of famine,[141] possibly a result of the punctuations of previously mentioned inclement weather, resulting in widespread shortages of food. These events may have lasted long in the memory as grain hoarding by the elite and consumption of plant roots by the peasantry were taking place during the famine of AD 1095,[142] a famine thought to have been caused by drought culminating in the rise of food prices.[143] Climatically, there were a

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[138] Edvardsson, 'Commercial and Subsistence Fishing in Vestfirðir'.

[139] Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland'.*

[140] McGovern, personal communication.

[141] Tomasson, 'A Millennium of Misery: The Demography of the Icelanders'; Ogilvie, 'Climatic changes in Iceland'.

[142] D.E. Vasey, 'Population, Agriculture and Famine: Iceland, 1784-1785', Human Ecology, 19 (1991), p.323-50.

[143] Famine and hunger was the prevalent theme in a poem by Icelandic pastor Olafur Einarsson (1573 - 1659), discussing events which took place in centuries previous. *Formerly the earth produced all sorts of fruit, plants and roots. But now almost nothing grows....Then the floods, the lakes and the blue waves, brought abundant fish. But now hardly one can be seen. The misery increases more. The same applies to other goods*. In R.A. Bryson & T.J. Murray, '*Climates of Hunger',* (Madison, 1977), p.55.

cluster of bad years around this period.[144] These events stand out amongst what appears to be a quieter period when the climate, as mentioned, was by and large favourable and there was little in the way of volcanic activity. This indicates that the famines of the eleventh century may have been significant steps in establishing specialist fishing locations on the coasts of Iceland as people sought to obtain a more reliable, low-cost source of food at a time when the climate at times was becoming progressively unfavourable, population was still growing and some environmental pressures were prevalent. This date coincides with the species transition found in the Skuggi zooarchaeological assemblages, which shows exclusively saltwater species from the eleventh century onwards.[145]

The Twelfth to Fourteenth Centuries

The period AD 1100-1300 is viewed as a period of cultural change, both globally,[146] and in Norse-influenced landscapes.[147] The economics had changed, with cod constituting around eighty percent of Norway's export income by around AD 1100.[148] Herring were of similar economic importance to Denmark and Sweden at this time.[149] *Fiskevær*, specialist fishing stations, were emerging in Northern Norway around the AD 1300s. The original hypothesis was that these fishing stations were introduced to previously unoccupied landscapes, however, through geoarchaeological investigations this view

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[144] Dawson, personal communication.

[145] Harrison, 'Preliminary Assessment of the faunal remains'.

[146] P.D Nunn, & J.M.R. Britton, 'Human-Environment Relationships in the pacific Islands around A.D. 1300', *Environment and History*, 7 (2001), p.3-22.

[147] R. Edvardsson, C. Poulsen, M. Church, I.A. Simpson, W.P. Adderley, A. Pálsdóttir & T.H. McGovern, 'Archaeological Excavations at Qassiarsukt 2005 – 2006: Field Report'. (Náttúrustofa Vestfjarða/NABO/Grønlands Nationalmuseum & Arkiv, 2007).

[148] Barrett *et al.,* 'Dark Age economics'.

[149] P. Holm, 'Catches and manpower in the Danish fisheries, *c.*1200-1995', in P. Holm, D.J. Starkey and J. Thor (ed.), 'The North Atlantic Fisheries, 1100-1976: National perspectives on a common resource', (Esbjerg, 1996), p.177-206.

has since been revised. Sites at Langenesværet show this region has a history of specialist fish production from the early centuries AD which evolved into the *fiskevær* system.[150] At Bleik and Toften, two Iron Age sites in Norway, fish bone assemblages representing specialist extraction date to between the first and fifth centuries AD and seventh century AD respectively. This dating demonstrates that conditions were already in place to herald the development of *fiskevær*. Their emergence reflects a growth in the demand for maritime produce, significant enough to effectively conceal previous evidence for efforts at specialist exploitation in the past.[151] This is possibly something assisted by the manner in which the history was compiled. Western Norway appears to be a region where there was knowledge and experience of specialist exploitation of marine resources, and it is possible that some of this influence alongside many other aspects of Norse culture was transferred to Iceland.

A Growing Demand for Fish

A major contributor to the twelfth century increase in demand, aside from population growth, was Christian dietary laws. First introduced in the seventh century, these enforced compulsory fish eating days. Observance, if followed strictly, meant people were forbidden from eating flesh for 135 days of the year.[152] This shows the role of fish in culture and society, and how this served as a symbol of status in their contexts. Preserved fish were shunned by elites, as they preferred their produce to be fresh, which would suggest that the growth of dried fish consumption was either caused by the

[150] Simpson *et al., '*Cultural sediment analyses and transitions'.

[151] Egil's Saga tells of Thorlof Kveldlufsson who held a prominent position between *c.*AD 858 and 890 loading his boat with fish and other goods and heading to England to trade. He sent his men to Vågan, said to be the finest fishing grounds.

[152] R.C. Hoffmann, 'Medieval Europeans and their Aquatic Ecosystems', in 'Beiträge zum Göttinger Umwelthistorischen Kolloquium 2007-2008', (Graduiertenkolleg, 2008); M. Kowaleski, 'The Seasonality of Fishing in Medieval Britain', in S.G. Bruce, '*Ecologies and Economies in Medieval and Early Modern Europe; Studies in Environmental History for Richard C. Hoffmann'.* (Leiden, 2010).

changing status of the fish or a rapid increase of a lower class of population who did not have access to the same resources or products as before.[153] This rise in consumption may have driven people to the coasts in search of cod within the *stockfish window*, given that species below sixty centimetres in length (most likely caught in fjords and not deep water areas) tended to dry too hard. The transition observed in the zooarchaeology at Skuggi to a more preservable fish implies that it may have been a lower status site, and the transition may be reflecting changes in social behaviour which may have initially been driven by environmental change, but this was not the over-riding and determining factor.

As well as being a religious symbol, fish was also an excellent source of nutrition, especially protein. Demand was huge, and given that no fresh meat could be consumed between Michaelmas (late September) and Easter (sometime in March or April), storable fish became more of a commercial commodity. Aside from the demand for Icelandic and Norwegian *skreið*, landowners in mainland Europe were constructing artificial lakes for fish breeding,[154] reflecting the sizable efforts made to secure supplies of this versatile foodstuff.

Europe-wide Markets

Trade and exchange was undertaken openly between Norway and the rest of Europe. These links encouraged a growth in specialisation of fish production and permitted Norway to move away from widespread production of grain, something which was difficult to do due to relief and climatic conditions at northern latitudes despite there

[153] Kowaleski mentions a growing population as being the main stimulant in the growth of fish consumption in the eleventh century.

[154] There were apparently 22,000 ponds in Franconia and 25,000 in Bohemia alone. R. Hoffmann, 'Medieval Fishing' in P. Squatriti, (ed.) 'Working with Water in Medieval Europe'. (Leiden, 2000).

being periods of favourable climate. Deterioration of the climate in subsequent centuries would support the rationale behind this decision. Contemporary zooarchaeological assemblages, like those described by Barrett *et al.* show a reduction in species diversity and a greater specialism in fish remains; single species dominance within a specific size range.[155] By AD 1100, specialist fish production in Norway was well under way, pre-dating the *fiskevær* emergence of c. AD 1300. The Norwegian city of Bjørgvin, modern day Bergen, was founded in AD 1070 by King Olaf III, with a castle built around AD 1100 which dominated the harbour.[156] It developed commercially in the twelfth century AD to facilitate the export of a variety of goods, including fish, and most importantly, facilitated the collection of tax revenues. At this time, around eighty percent of Norway's exports constituted of cod. Coming in the opposite direction were substantial imports of cereals from England, as represented in the archaeological record.[157] It is unlikely that cereal production ceased entirely, however, vast bulks were making their way into Norway which simply could not be grown under the circumstances of the time, and the rising economic value of fish made this decision much easier. Rather than being traded directly through the most convenient coastal ports, all goods were required to travel through Bergen. The so-called *Jektefart* system, the sale of goods at northern locations such as Vågan before being transported down the coast to Bergen made Arctic Norway one of Europe's main exporters of fish from the twelfth century onwards. This early example of a hub-and-spoke distribution system continued for around two centuries.[158] With this growth it is understandable that changes in the

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[155] Barrett *et al.,* 'Dark Age economics'.

[156] Haywood, '*Encyclopaedia of the Viking Age',* p.31.

[157] Woolgar, 'Food and the Middle Ages'. Cereal production decreased in Norway *c.*1300, something attributed to the decline in climate and the increasing economic value of fish. Cornflour has been found at Bergen, however, there is no material in the pollen evidence to suggest it was grown in Norway.

[158] P. Urbanczyk, *Medieval Arctic Norway*, (Warsaw, 1992).

cultural record are observed. With this growth also came a widened sphere of influence, something which also became more prevalent within Iceland in the following centuries.

Whilst growth of specialist fishing communities coincided with burgeoning trade and exchange in Europe, the situation appears different in Iceland. The beginning of the twelfth century was on the whole climatically favourable, although there are some suggestions of dearth and regional variance.[159] Localised variance may have been a direct result of events such as Hekla's AD 1104 eruption, its second-largest eruption during historical times. This destroyed farms up to seventy kilometres away from the volcano, and was particularly focussed in the north of Iceland. Impacts could have been more severe, but the narrow plume and impacts on more marginal farms reduced the severity. Other eruptions occurred throughout the century but were on a smaller scale and coincided with phases of favourable climate. A great famine was said to have taken place in AD 1118-1119, although not all of the country was affected.[160] In some regions the fields were said *never to have been so fertile*,[161] but with famine recorded this shows that localised dearth may have been taking place. It also reflects the possibility that neighbouring regions were not willing to export their surpluses for fear of running short themselves, or that the areas where famine was taking place simply did not have any goods to trade with and credit facilities were not established. However, by the end of the century, dearth, famine and hardships amongst humans and livestock were said to be more widespread across the whole country. With the Little Climatic Optimum, said to have lasted from around AD 800 to AD 1150, over, the impact of poorer environmental

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[159] Tomasson, 'A Millennium of Misery: The Demography of the Icelanders'.

[160] *Ibid.*

[161] Þorgils saga ok Hafliða (the start of the Sturlunga Saga) refers to the scenario at Reykjahólar between 1117 and 1121.

conditions in the latter part of the twelfth century would have been felt by most.[162] These hardships fade into the background when compared to what would happen as the thirteenth century AD commenced. On top of these hardships, and in all possibility accelerated by their processes, was a loss of the land; degradation was becoming more widespread in Iceland and there is a growth in sediment influx into water courses observed during the twelfth and thirteenth centuries,[163] suggesting that whatever key component was holding the soil together was being lost. In the case of Iceland, vegetation cover was being lost as livestock continued to graze right down to root level and weather conditions (stormy, rainy, freeze/thaw, blustery winds) were optimal for the loss of soils.[164]

Impacts of Landscape Degradation on Aquatic Life

The influx of sediment into water courses is viewed by some as a form of pollution, an introduction of material through anthropogenic activity resulting in disturbance to the ecosystem. Given that landscapes in Iceland were degrading prior to Norse settlement,[165] it can also be viewed as an extension of a natural process. Lawson *et al.* see degradation as reducing the quality of water making it less favourable for aquatic populations to breed,[166] something echoed by Roberts, who sees freshwater populations

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[162] Geirsdóttir *et al.,* 'A 2000 year record of climate'.

[163] G. Sigurbjarnarson, 'The loessal soil formation and the soil erosion in Haukadalsheidi'. *Náttúrufræðingurinn,* 39 (1969), p.49-128. There needs to be an awareness that the dating controls in this source are not the strongest, however do provide a baseline from which to take narrative forward.

[164] Geirsdóttir *et al.,* 'A 2000 year record of climate'.

[165] Morrison, '*The Contribution of Summer Grazing'.*

[166] Lawson *et al., 'Human impact on freshwater environments'*.

being less inclined to spawn in waters which are of reduced clarity.[167] Geirsdóttir *et al.* view the influx of sediments as being conditioned by natural climatic processes.[168] Holm, suggests otherwise, seeing the influx of sediments, regardless of how they got there, increasing nutritional inputs of waters and in turn, increasing the productivity of the seas.[169] By establishing when these influxes took place and finding out if they correlate with any surge in maritime productivity, it will be possible to see which theory is best suited. There is some level of ambiguity given whether a clear-cut result can actually be obtained, then the nature of economics must be considered. If the influx mainly affected the fjords, it could result in a drop in open ocean productivity given that catches in the fjords fulfilled demand.[170] It may be possible in the future to measure influx levels and degradation patterns to establish the exact nutritional input into Icelandic waters, and if the scale and range of the input from the perspective of how far out to sea does this sediment nutrition gets carried. From a historical perspective, Holm's theory is the most plausible given that a distinct increase in the intensity of fishing activity in Icelandic waters is observable from the twelfth century AD onwards, although a contradiction to this is the shift to open-water species which may have been a direct result of contamination of inland water sources, as well as other over-riding environmental variables at work and the growing demand for dried fish.

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[167] Roberts, '*The Unnatural History of the Sea'*, p.23. Roberts makes specific reference to the Roman era and eleventh century England; R.C. Hoffmann, 'Frontier Foods for Late medieval Consumers: Culture, Economy, Ecology', *Environment and History*, 7 (2001), p.131-67.

[168] Geirsdóttir *et al.,* 'A 2000 year record of climate'.

[169] Holm, 'Fishing Down the North Sea'.

[170] A change in open-water productivity would give more insight into the destination of the procured product, given that Icelanders were said to be consumers of fish from the fjords and deep waters of the open sea. In addition, if there was a correlation observed between degradation and increased productivity of the sea, would this have reduced the concerns associated with degradation given that there was an up-side to erosion of the landscape?

Thirteenth Century Pressures

In the years around AD 1200, the widespread famine experienced was said to have had no parallels before or after,[171] although this testimony was composed before the extreme hardships endured during the eighteenth century. Lamb argues that from around AD 1200 onwards, sea ice in the North Atlantic underwent a considerable period of expansion.[172] Many poor people died of hunger at Hólar in AD 1204.[173] Hekla erupted early in the century, and the *Sand Winter* of AD 1226 caused widespread livestock deaths.[174] By this time there was a level of dependence on fish within Vestfirðir, which was also a key export item; in spring AD 1236 people nearly abandoned their farms through hunger before the fish arrived into Ísafjarðardjúp on their seasonal migration, allowing fish-farmers to obtain their catches.[175] The first recorded smallpox epidemic arrived on the island in AD 1241, carried on a ship from Denmark,[176] and is thought to have killed around 20,000 people.[177] This would likely have resulted in a direct impact on the labour force; given the poorer people who were living in the most marginal conditions would have been the ones undertaking the most intense manual work. The early AD 1250s were said to have been disastrous for food,[178] coinciding with a series of

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[171] Saga of Guðmundr Arason in Ogilvie, 'Climatic changes in Iceland'.

[172] Dawson, personal communication; H.H. Lamb, '*Climate: Present, Past and Future. Vol. 2: Climatic History and the Future*', (London, 1977).

[173] G. Vidfússon, J. Sigurðsson, Þ. Bjarnarson & E. Jónsson, (eds.), 'Biskupa Sögur 1-2, Hinn Íslenzka Bókmentfélagi', (Copenhagen, 1858-78).

[174] J. Jóhannesson & H. Bessason, '*Íslendinga Saga: A History of the Old Icelandic Commonwealth'.* (Manitoba, 1974).

[175] J. Jóhannesson, M. Finnbogason & K. Endjárn (eds.), '*Sturlunga Saga 1-2',* (Reykjavík, 1946).

[176] Rolleston (1937) in Hopkins, 'The Greatest Killer; Smallpox in History', (Chicago, 1983).

[177] D.R. Hopkins, *The Greatest Killer; Smallpox in History*. p.28; E. A. Fenn, '*Pox Americana: The Great Smallpox Epidemic of 1775-82'*, (New York, 2001), p.229.

[178] Ogilvie, 'Climatic changes in Iceland'.

poor winters, some of which were exceptionally cold, others exceptionally wet.[179] The historical sea surface temperature record, a modern assumption based on proxy data, was said to have taken a brief cold turn around AD 1250,[180] likely to have had an impact on the fisheries and overall climate, with a cold snap being reflected in sediment cores.[181] The colder temperatures experienced was said to be caused by an increase in summer sea ice, which would result in a direct cooling of pasture.[182] A volcanic eruption was said to have taken place in AD 1258 in Central America, resulting in the global cooling of temperatures.[183] There was said to have been the beginning of a decade of famine from AD 1261 onwards,[184] and a high frequency of sickness from the AD 1270s onwards, something which is suggested to have lasted right the way through to the AD 1390s and followed by the plague.[185] It is worth noting that the Great Mortality of AD 1347-52 did not reach Iceland, but it was affected by later epidemics such as the one in AD 1402. In AD 1274, twenty-two polar bears were reported to have been killed, travelling from Greenland on the growing frequency of sea ice. The following year, twenty-seven were recorded as being killed as sea ice began to surround Iceland.[186]

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[179] Ibid.

[180] Sicre *et al.,* 'Decadal variability of sea surface temperatures'.

[181] Geirsdóttir *et al.,* 'A 2000 year record of climate'.

[182] T.H. McGovern, O. Vésteinsson, A. Friðriksson, M. Church, M. Lawson, I.A. Simpson, A. Einarsson, A. Dugmore, G. Cook, S. Perdikaris, K.J. Edwards, A.M. Thomson, W.P. Adderley, A. Newton, G. Lucas, R. Edvardsson, O. Aldred & E. Dunbar, 'Landscapes of Settlement in Northern Iceland: Historical Ecology of Human Impact and Climate Fluctuation on the Millennial Scale'. *American Anthropologist*, 109 (2007), p.27-51.

[183] J. Emile-Geay, R. Seager, M.A. Cane, E.R. Cook & G. Haug, 'Volcanioes and ENSO over the Past Millennium', *Journal of Climate,* 21 (2007), p.3134-148.

[184] Dawson, personal communication.

[185] Jóhannesson & Bessason, '*Íslendinga Saga'.*

[186] Dawson, personal communication; Þ. Thoroddsen, '*Árferði á Íslandi í þúsund ár*'. Hið íslenska fræðafélag, Kaupmannahöfn 1916-1917. (1917). p.364-65.

Despite these experiences of famine and livestock dearth, the zooarchaeological record reveals growth in the numbers of sheep in Iceland after AD 1200. There may be a variety of reasons for this change. This may have been an attempt by landowners to reduce the chances of being left with nothing if dearth struck once more, although it gives no recognition of the restrictions placed on landowners as to the volume of livestock allowed on their land.[187] Another suggestion may be that the increase in livestock numbers is related to an increase in maritime productivity in Iceland; with a dried, storable product available for consumption during the winter months, there was no longer the same pressure to cull livestock in order to ensure there were enough foodstuffs to last all winter. This considered, there appears to have been a transition in southwestern Iceland resulting in a reduction in the marine component in people's diets. Fish consumption was declining and a proportional increase of terrestrial resources was consumed.[188] This would suggest the change in resource accessibility,[189] and that fish being caught were not solely for consumption within Iceland. A third suggestion could be the growth in *vaðmal* production, with more sheep creating a higher volume of wool. This would give an explanation for the growth in the terrestrial component in the diet of people from southern Iceland. Ultimately, with greater numbers of livestock overwintering on the landscape and greater proportions of sheep compared to other species, this may have been a factor in increasing landscape degradation, a characteristic which sees a marked increase a few centuries after first settlement on Iceland,[190] and is represented in the geoarchaeological record. Thinking along these lines, development of

[187] If landowners were recognising the impacts of deteriorating environmental conditions, they may have imposed stricter rules upon their tenants regarding livestock numbers. Evidence for this decision does yet remain unclear.

[188] Zori, *From Viking Chiefdoms to Medieval State in Iceland,* p.419.

[189] Ibid., p.419.

[190] Ólafsdóttir & Guðmundsson, 'Holocene landscape degradation'; Simpson *et al.,*'Crossing the thresholds'; Morrison, '*The Contribution of Summer Grazing'.*

an export economy around fish and *vaðmal* may be a direct causal factor in landscape change and degradation.

Whilst these negative, mainly terrestrial agencies were at work, there were also economic and political changes taking place. The zooarchaeological record at Akurvík reveals a transition around AD 1200 to a more specialist exploitation of fish, much like the Norwegians were doing at the start of the AD 1100s. This increase in marine fish is something observed both within inland and coastal zooarchaeological assemblages.[191] From this point in time onwards Akurvík had turned its attentions to the production of *klipfisk*. It had always created surplus but from this point onward, there was a greater effort made to create a particular product which would have found its way as a commercial product into the wider European market economy.[192]

The Icelandic Shark Economy

As well as *skreið*, from AD 1200 and lasting until the middle of the sixteenth century, there was a vibrant economy based around the capture of sharks. At Strandasýsla in Vestfirðir, shark liver oil was a key export item,[193] and whale meat was stocked for consumption within Iceland, as referenced in *Sturlunga Saga*.[194] Strangely, meat from whales and sharks, despite having characteristics not dissimilar to the likes of beef and mutton, were classed as cold flesh given they originate in water; this classification allowed it to be consumed during periods of religious observance. There was minimal investment required to participate in the shark trade; the same equipment to catch cod but on a larger scale, and given that the main season was between March and August,

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191 Perdikaris & McGovern, 'Cod Fish, Walrus and Chieftains'.

192 Thór, 'Icelandic Fisheries, *c*.900-1900', p.323.

193 Magnússon, & Vídalíns, '*Jarðabók'.*

194 J.H. McGrew, '*Sturlunga Saga*', (New York, 1970), p.404.

this was the off-season for catching cod.[195] As this was during the main farming season, it may be a reason it was not as widely practiced as fishing due to competition for labour. Just like their maritime counterparts, they were also susceptible to similar economic, social and environmental drivers albeit on a smaller scale.

Additional Influences on Icelandic Society

In addition to the changes observed relating to the environment, the year AD 1200 is considered to have seen a political power shift influencing the fisheries, with Icelanders apparently playing little or no part in the actual development of their fishing industry; a shortage of wood from overseas for boatbuilding is mentioned around this time which would have had a direct influence on the Icelanders' ability to fish in open water. Whether or not a lack of wood to build vessels was a cause, almost all trade by the thirteenth century was apparently in the hands of foreigners,[196] understandable given the demand coming from overseas driving productivity. Although trade was apparently in the hands of foreigners, they would have likely depended on Icelanders to still catch fish. This dominance may have not always been the case as overseas trade was said to have languished in the first half of the thirteenth century, likely fuelled by the decision of the Norwegian monarch to introduce an economic blockade and cease all trade with Iceland.[197] Håkon was making decisions, such as the one prohibiting Icelanders from leaving Norway in AD 1220, in turn tightening his political domination of Iceland. By doing so he was distancing Iceland from the 'commercial revolution' which was taking

[195] Thór, 'Icelandic Fisheries, *c*.900-1900', p.342.

[196] Gardner & Mehler, 'English and Hanseatic Trading and Fishing Sites'.

[197] Norges gamle Love, *Christiana*, Vol. 1 (1846), p.461, in Urbańczyk , Medieval Arctic Norway., p.71.

place in Europe during the thirteenth century AD.[198] Regardless of what Håkon was imposing over Iceland, it is debatable whether Iceland would have played any part in a wider European economy; despite whether the country possessed any resources, whether this be wool or fish, economic development would have been minimal with no ships allowing no trade, meaning there was nothing more than a cameo role to play in this process. If there was a growth in fishing observed in the early AD 1200s, Icelanders may have been driving progress from within the country, the ultimate preparation for when logistical capability was finally in place in later decades.

Thirteenth Century Icelandic Politics

Within Iceland politically, there was an increase in feuding in the thirteenth century AD, creating instability. In the half-century preceding the end of the Icelandic Commonwealth period in AD 1262, there was a power struggle taking place. From as early as the eleventh century AD, a new elite, referred to in modern terminology as *stórgoðar* emerged, with individual *stórgoði* seeking regional control in Iceland and overlordship of a centralised authority.[199] As the numbers of chieftains dropped through intermarriage and negotiation, the power of the remaining *stórgoðar* grew, leaving six families almost monopolising Iceland.[200] Despite the apparent shifts in power and negotiation amongst the ruling classes, there appears to be no change in the pattern of continuity in Iceland (much like parts of the Norse kingdom on the eve of *Landnám*). The 'revolution' and upheaval was not disrupting the day to day pattern of Icelanders more than it normally would, as suggested in the archaeological and selected

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198 A.J. Dugmore, C. Keller & T.H. McGovern, 'Norse Greenland Settlement: Reflections on Climate Change, Trade, and The Contrasting Fates of Human Settlements in the North Atlantic Islands'. *Arctic Anthropology*, 44 (2007), p.12-36.

199 Forte, *et al., 'Viking Empires'.*

200 The six family clans were: Ásbirningar, Haukdælir, Oddaverjar, Sturlungar, Svínfellingar, Vatnsfirðingar.

historical records.[201] This may have been due to the continued royal support this feuding was receiving. The Norwegian monarch Håkon Håkonsson, who reigned from AD 1217 to AD 1263, was playing a strategy to effectively end the chieftain-based system and bring Iceland under his direct rule. He was playing chieftains off against one another, fuelled by gift-exchange, and developing affiliations with individual chieftains.[202] In AD 1239, he appointed a Norwegian bishop to Iceland which would have gone some way to influencing decision-making within some regions of Iceland through the power ecclesiastical classes had where there was a reduced presence of *stórgoðar*. The *stórgoðar* turned to Håkon to further their ambitions, but he only agreed if he could further his own ambitions, power and most importantly, expand his kingdom.[203] This power struggle rumbled on and Håkon took his opportunity once everyone was exhausted by the civil strife. Officially, from AD 1262 onwards, Iceland was under Norwegian rule, however, given the continuity represented within the archaeological record, Scandinavian influence may have been the norm for many years given the ruling hand Norway had over Iceland, and the official status being a mere formality. Following this change were a series of changes in attitudes and laws within Iceland, possibly related to the market economy taking off as well as the effect of the Norwegian laws officially being introduced.

Icelanders were present throughout the wider North Atlantic region and in mainland Europe. At the end of the thirteenth century, for example, there was a family residing in Lübeck who went by the name of *Yslander*. This implies that there might have been an earlier connection pre-dating the Hanse trading routes, but how or when it got there is

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[201] Byock, 'The Age of the Sturlungs'.

[202] Ibid.

[203] Forte, *et al., 'Viking Empires'*. p.319.

unknown.[204] The occurrence of the *Yslander* family does not represent activity on at this particular location, however, they do go some way in reflecting the historical ancestry and trading connections of the region. This, coupled with the instance of trading falcons in Italy, shows Icelandic representation overseas.

Thirteenth Century Hardships

The hardships observed during the thirteenth century appear more significant and indeed more pronounced and numerous than the events which took place during the previous century, made more difficult by the apparent social transitions which were taking place in Iceland. The environmental conditions appear to have played a strong part in determining the outcomes of the hardships experienced, rather than the civil strife and social changes which were more prevalent prior to AD 1262. Indeed, political conflict may have been fuelled as a result of increased pressure on resources, a consequence in part of climatic deterioration. It has been observed that during the thirteenth century, stratospheric sulphate aerosol injection events were between two and ten times higher than any other century in the past millennium.[205] Events classed as moderate in size included 1228, 1268, 1275 and 1285, with a particularly large event taking place in 1259. These would have resulted in impacts on a global scale, subsequently having an effect on the climate of the North Atlantic.

With Icelandic fishing stations falling increasingly under the control of foreign interests, it may have been that Icelanders were deprived to some extent and deprived of a resource which they formerly turned to in times of need, however, the political decisions

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[204] Friedland, 'The Hanseatic League and Hanse Towns in the Early Penetration of the North'.

[205] C. Gao, A. Robock & C. Ammann, 'Volcanic forcing of climate over the past 1500 years: An improved ice core-based index for climate models, '*Journal of Geophysical Research*', *113* (2008), doi: 10.1029/2008JD010239

made in the AD 1220s would suggest that if anything, Iceland became more of an insular nation, somewhat cut off from Scandinavia and the rest of Europe. It is therefore likely that Icelanders continued to have access to fishing grounds, however, the hardships experienced as a direct result of cold temperatures would also have prevented fishing vessels from entering the sea. In July AD 1203 men walked from the mainland to the island of Flatey, around fifteen kilometres into Breiðafjörður showing the impossibility of navigating the seas when the ice was so thick and expansive.[206] With the increased pressure on the terrestrial-based economy being exacerbated by the cold climate, there was a growing pressure on nutrition-rich alternatives and substitutes. However with climatic pressures being observed, these were failing to be productive. From these widespread failures come famine and dearth throughout the human and livestock population.

Post-1260 Economic Growth

After the late- AD 1260s, the fishing economy was said to take off, attributable to the developing European market economy. Prior to this, the AD 1260s were said to have brought a surplus of cold winter months, which would have hampered development, but the climate was still said to have been cold with further reports of polar bears like in previous cold years.[207] By the thirteenth and fourteenth centuries AD, long-distance trade and exchange was said to be in place to fulfil the demands of Europe, said to have been ultimately driven by a burgeoning population.[208] Fish exports must have been significantly large over a short period that by AD 1294, after a series of climatically bad

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[206] Konungsannall (IV) in Ogilvie, 'Climatic changes in Iceland'.

[207] Dawson, personal communication.

[208] Barrett *et al.,* 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

years, Norwegian monarch King Eiríkr instructed that cod was not to be exported from Iceland whilst there was dearth in the country.[209] It was a response from a king who was experiencing the decline of Norwegian power.[210] This response was a likely reaction to several years of widespread famine recorded in the early AD 1290s,[211] and as much as it was a protection of internal resources, it may also have been Eiríkr's way of exercising control and power over neighbouring countries. Famine was also recorded in England and Europe in AD 1294,[212] which would have significantly increased the demand through increased scarcity. It also reveals that Iceland had a role to play in overseas trade and exchange at this time, and that the consumption of fish was still a necessity for Icelanders to turn to during times of hardship. Export would have had an impact on internal consumption levels.

Change in Icelandic Society

By the AD 1280s, the social norm of Iceland had completed its transition from the chieftain-led gift-giving and exchange, to an economic system orientated around investment and wealth accumulation. Attitudes to resources would have changed, although exchange for personal gain was not an unfamiliar concept.[213] The lawbooks

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209 Annals (VIII) in Ogilvie, 'Climatic changes in Iceland'. There was also a famine in England in 1294 and this may be the King's way of prohibiting exports to the country. This was the same year that Hanseatic-Norwegian treaties stipulated that trade connections with Iceland, Faeroes, northern Norway, Orkney and Shetland were limited to Norwegian merchants and that no Hanseatic trade was allowed to travel further north than Bergen. Friedland, 'The Hanseatic League and Hanse Towns in the Early Penetration of the North'. This is suggesting that in one hand the King is doing his bit to relieve poverty in Iceland, but in the other, tightening his grip on Icelandic resources.

210 Dawson, personal communication; L. Koch, 'The east Greenland ice', *Medd. Grønland* 130 (1945), p.1-374.

211 *Diplomatarium Islandicum* (2:287).

212 Dawson, personal communication; C.E. Britton, '*A meteorological chronology to AD 1450*'. Meteorological Office Geophysical Memoirs, 70 (1937).

213 *Grettir's Saga*, chapter 42 mentions the exchance of goods for dried fish.

Járnsída, introduced in AD 1271 and *Jónsbok*, introduced in AD 1281 removed the *goði* institution and introduced the Norwegian administrative and legal system.[214] This same period is seen as the end of the dual economy of fishing and farming and the end for domestic fisheries, replaced by export-orientated fishing conducted by a specialist, seasonal labour force. Examples of this investment and transition were beginning to emerge.

The Development of *Verstoð*

The growing foreign influence in Iceland brought investment in infrastructure in order to construct newer *verstoð*, replacing the existing *fiskiskálar.* These new forms of huts were constructed close to the best available fishing grounds where there were appropriate landing facilities, something which the older style of fishing huts lacked.[215] These new huts were categorised as *heimræði* (home station)*, útver* (out-station, the most common type in Vestfirðir, positioned on outlying headlands and only inhabited during the fishing season)*, viðleguver* (shared, sojourning station) and *blönduð ver* (mixed-type station).[216] The *blönduð ver* was the most common in Iceland, reflecting the need for flexibility and making the most of all terrestrial and maritime resources.[217] With the *útver* being most popular in Vestfirðir, this possibly reflects the lack of opportunity to have mixed-type stations. This era was to be the beginning of the *Age of*

[214] J.V. Sigurðsson, *Changing layers of jurisdiction and the reshaping of Icelandic Society c.1220-1350*, (Oslo, 2007).

[215] Thór, 'Icelandic Fisheries, *c*.900-1900', p.334.

[216] Kristjánsson, *Íslenskir sjávarhættir.*

[217] These categorisations, as mentioned, are due further revision from a more modern, typographical perspective.

the Fisheries.[218] It might have appeared that prospects were becoming brighter for Icelanders; unfortunately this could not have been further from the truth.

Fourteenth Century Environmental Change

With the mean annual temperature dropping to 3.2°C around AD 1300 from 4.4°C 400 years earlier,[219] conditions had been getting progressively colder from the AD 1200s onwards and worse was to follow.[220] An increase of cold Polar and Arctic water into the waters of Northern Iceland is observed in the sedimentary record, dating after AD 1300.[221] The violent and explosive Hekla eruption of AD 1300 lasted a whole year, carrying tephra to the north, destroying farms including the settlements of Skagafjörður in north Iceland and Fljót in Vestfirðir, causing famine the following winter and directly resulting in around 500 deaths.[222] This is believed to have been the second-largest eruption in Iceland during historical times.[223] Around AD 1300, Icelanders wrote to the King of Norway complaining about the level of poverty in their country.[224] This appeal either means a widespread failure of the terrestrial and maritime economies, or that there were sufficient foodstuffs to go around, but much of produce was exported and not

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[218] Thór, 'Icelandic Fisheries, *c*.900-1900', p.334.

[219] Knudsen *et al*., 'Palaeoceanographic changes off North Iceland'.

[220] J. van Hoof & F.van Dijken, 'The historical turf farms of Iceland: Architecture, building technology and the indoor environment', *Building and Environment*, 43 (2008), p.1023-1030.

[221] J. Eiríksson, K.L. Knudsen, G. Larsen, J. Olsen, J. Heinemeir, H.B. Bartels-Jónsdóttir, H. Jiang, L. Ran & L.A. Símonarson, 'Coupling of palaeoceanographic shifts and changes in marine reservoir ages off North Iceland through the last millennium', *Palaeogeography, Palaeoclimatology, Palaeoecology,* 302 (2011), p.95-108.

[222] Given the lov levels of ash found within Vestfirðir, this source may be somewhat exaggerated.

[223] Hekla <http://www.volcano.si.edu/world/volcano.cfm?vnum=1702-07=&volpage=erupt>; Annals (II, III, IV, VII, VIII) in Ogilvie, 'Climatic changes in Iceland'.

[224] Sigurðsson, 'Changing layers of jurisdiction and the reshaping of Icelandic Society'. The whereabouts of the response to this letter is unknown.

exchanged internally or made readily available to all of the population.[225] Around eighty percent of Norwegian export earnings in AD 1300 were said to have come from cod.[226] Much of this trading from Iceland was controlled by Hanseatic merchants, members of what became one of the largest trading groups in Western Europe, and key players in exposing Icelandic produce to wider markets.[227] Initially formed to protest against pirates, an activity which at this time was seen as a deterrent to trade,[228] the Hanse grew into an important mercantile organisation during the fourteenth century AD. Their strategy was about implementing monopolies, given that they excluded groups from trading at will. Until the Hanse became involved with Iceland, small amounts of dried fish were said to have been exported from the island.[229] The wider contact with European trading networks meant that Iceland not only gained a wider market potential both in exported and imported goods, but also made itself susceptible to the positive and negative economic, social and environmental fluctuations which would take place throughout Europe. Wider interaction brought a wider scope of impacts.[230] Coupling this with the difficulties Icelanders faced in their own sensitive and marginal landscape, it could create as many problems as solutions generated to Iceland's occasional periods

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[225] This argument is along the same lines of the nineteenth century Irish famine, with some believing that there were enough foodstuffs contained within the country if it were not being exported.

[226] Barrett *et al.,* 'Dark Age economics'.

[227] Gardner & Mehler, 'English and Hanseatic Trading and Fishing Sites'.

[228] W.C. Jordan, 'The Great Famine: 1315-1322 Revisited', in Bruce, S.G. '*Ecologies and Economies in Medieval and Early Modern Europe; Studies in Environmental History for Richard C. Hoffmann',* (Leiden, 2010), p.45-62.

[229] Karlsson, *Iceland's 1000 Years*, p.107. The earliest document to mention the Hanse dates to 1267, however, there is no known date from when they first became engaged in trade with Iceland. They sent Norwegian merchants to Iceland to conduct business before travelling to Iceland themselves for the first time in 1423 (Friedland, 'The Hanseatic League and Hanse Towns in the Early Penetration of the North'). Given that 'small quantities' were being exported, given the dates from Akurvík, this may have originated in Vestfirðir. Continuity in the geoarchaeological record may support this idea.

[230] J. Gribben & M. Gribben, 'Climate History and the Westvikings Saga', *New Scientist*, 1700 (1990).

of dearth. Being part of a network removes the isolation, but the downside of this is that any problems felt elsewhere reverberate much wider than they would have done previously.

Iceland and the Great European Famine

One of the impacts was felt during the fourteenth century at a time when Iceland was firmly within this wider European network. Impacts of the Great European famine were felt right across the North Atlantic. The famine is typically given as the period from AD 1315 to AD 1322,[231] (initially AD 1315 to AD 1317 was given as a result of the severity of those years, although modern revisions have extended this date).[232] The years leading up to this point were not free of crisis. Stress on resources began to increase around AD 1300.[233] From AD 1308 onwards, a succession of bad harvests and famines pushed up grain prices and reduced grain availability for a burgeoning population.[234] The cattle plague from c. AD 1315 to AD 1325 reduced the availability of meat products and increased the demand on substitutes.[235] Rains reduced salt production, doubling it in price,[236] and driving up demand for non-salt reliant products. This may have increased overseas demand for dried Icelandic fish, creating an internal pressure and been the driver of overseas demand. Thresholds and carrying capacities would have been reduced as people were pushed to their limits, but in the same vein, this may have

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231 W.C. Jordan, *The Great Famine: Northern Europe in the Early Fourteenth Century,* Princeton (1997).

232 H.S. Lucas, 'The Great European Famine of 1315, 1316 and 1317', *Speculum*, 5 (1930), p.343-77.

233 Jordan, 'The Great Famine: 1315-1322 Revisited'.

234 Dawson, *So Foul and Fair a Day,* p.101.

235 T. Newfield, 'A cattle panzootic in early fourteenth-century Europe', *Agricultural History Review*, 57 (2009), p.155-90; B.M.S. Campbell, *Land and People in Late Medieval England*, (Aldershot, 2009).

236 Jordan, 'The Great Famine: 1315-1322 Revisited'.

resulted in opportunities being created. Inclement weather was said to be the ultimate cause of this event,[237] although these impacts would have been compounded by the AD 1315 Mount Pinatubo eruption in Indonesia which had a widespread effect on global temperatures. Ocean temperatures around the beginning of the famine period may also have been higher than usual, bringing more rains.[238] After the Great Rains of AD 1315-1318, the population of Europe did dramatically reduce and farmland was abandoned.[239] The famine was said to have been a catastrophic event for Europe, but one which made it more efficient. The growth experienced prior to 1300 glutted the labour market. The famine helped cull the weaker, less productive labourers.[240] This increased efficiency allowed a quicker economic recovery, which bloomed during the more favourable environmental conditions which prevailed until the late AD 1340s.[241] Periodic famine, however, continued throughout the following decades,[242] a process which was a catalyst for seeking nutrition away from the unreliable, frequently faltering and ultimately unaffordable grain harvests. England implemented a ban on exporting grain and fish in AD 1319, which may have been a response to the dwindling availability of resources closer to Europe, however, another interpretation is that this ruling was only in place to prevent exports to its warring neighbour, Scotland.[243] As demonstrated within Iceland in the AD 1290s, the ruling classes, when called upon, used their power to

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[237] Ibid.

[238] Dawson, *So Foul and Fair a Day,* p.102.

[239] Ibid., p.101.

[240] This Malthusian-esque theory seems rather basic, going against the theories of Boserup who argues that populations respond to pressure by raising productivity and innovatively get themselves out of crisis. E. Boserup, '*Conditions of Agricultural Growth: Conditions of an Agrarian Change Under Population Pressure'*, (Chicago, 1965). The idea fails to recognise the nature of pathogens, who do not discriminate between stronger and weaker individuals.

[241] Jordan, 'The Great Famine: 1315-1322 Revisited'.

[242] Dawson, *So Foul and Fair a Day,* p.103

[243] N. Hybel, 'The Grain Trade in northern Europe before 1350', *Economic History Review*, 55 (2002), p.219-47.

protect national interests regarding resources, albeit with a dimension of personal gain added to it.

Fourteenth Century Environmental Pressures

It was not as if foreign traders could turn to Iceland and get unrestricted access to a pristine resource given the difficulties present in Iceland at this time. The poor climatic conditions experienced throughout Europe were also evident in Iceland, and to compound the misery disease amongst livestock was also rife. The lack of hay produced in AD 1312 led to the following winter being called 'Horse Death Winter',[244] and disease amongst horses in Iceland is recorded in AD 1314.[245] With a reduction in hay production and the subsequent impact this would have had on domestic livestock, there would be unprecedented pressure on the country's maritime resources. Storms were becoming more frequent and winters more severe, causing difficulties for those who decided to pursue marine resources; three times in a single decade the ice lay around Iceland until midsummer.[246] This would have had a direct impact on navigation, preventing boats from entering the water, and if they somehow managed that they would be under the constant threat of sea ice breaking their wooden hull. Secondly, with the entire island surrounded by ice, terrestrial temperatures would be cooler than normal,[247] reducing grass and biomass production, further increasing the pressure on a now difficult to get to resource. Attitudes to the environment and survival were changing; with documentary evidence in *Laurentius Saga* telling us of a bishop ordering livestock to be slaughtered as he believed the winter, thought to be sometime in the AD

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[244] Gottskálksannáll (V) in Ogilvie, 'Climatic changes in Iceland'.

[245] Newfield, 'A cattle panzootic in early fourteenth-century Europe'.

[246] Gottskálksannáll (V) in Ogilvie, 'Climatic changes in Iceland'.

[247] T.H. McGovern, 'The Archaeology of the Norse North Atlantic', *Annual Review of Anthropology,* 19 (1990), p.331-51.

1330s, would be so severe.[248] He was responding to his experiences regarding climatic variability, bracing himself in reflection of previous winters. It is this attitude of expected failure of the terrestrial resource economy, the overwhelming feeling of negativity based on previous experiences, which one would expect to be the driver towards alternatives. The options would be the expansion of an overseas export market, but there would be little terrestrial goods to trade without wool or the exploitation of the fisheries.

It would be convenient for Iceland to be somewhat isolated at this time in order to be left to its own resources. The network of trade built up prior to the Great European famine was facilitated by a labour force which no longer existed. Transportation costs made it uneconomical to trade any goods which were not high value luxury items long distances.[249] The pressures on the terrestrial landscape may have turned Icelanders to the sea more, and if this was the case, the characteristics of this development may likely be well represented by continuity within the geoarchaeological record.

As the century progressed, historical sources are littered with evidence recording widespread livestock dearth and a lack of grass, in addition to rainstorms and snowstorms.[250] Epidemics also took place, but when this coincided with episodes of favourable climate the impacts were said to be reduced.[251] Of particular significance were the events after AD 1350. Around this time, a sharp cooling is believed to have

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[248] Laurentius Saga *in* H. Björnsson, 'Sea ice conditions and the atmospheric circulation North of Iceland'. *Jökull,* 19 (1969), p.134-36. Cattle mortality was widespread in 1336 and 1341.

[249] Jordan, 'The Great Famine: 1315-1322 Revisited'.

[250] Lögmannsarnáll in Ogilvie, 'Climatic changes in Iceland'.

[251] Ogilvie, 'Climatic changes in Iceland'.

occurred in sea surface temperature,[252] and historical records mention areas of the sea encountering widespread frost and sea ice filling harbours.[253] This is the opposite of Koch, who argues for a century of reduced sea ice around Iceland's coasts.[254] By this point, dried fish became the most important resource in the Icelandic economy, taking over from *vaðmal* (woolen fabric) as the staple export article.[255] This economic transition may have taken place for a variety of reasons. The drop in temperature may have been the key factor in the *vaðmal* to dried fish transition. The colder sea temperatures would have pushed the cod 'frontier' south, and depending on where this frontier was positioned before and after the temperature shift, it could have effectively funnelled increased numbers of cod into Icelandic waters.[256] So severe was the cooling that the 'traditional' sailing route to Greenland had to be abandoned as a result of the sea ice.[257] Winter had replaced spring as the main fishing period due to the spring catches being inadequate. With more cod being in the seas, more available seasonal labour and a climate more suitable to air dry the fish,[258] it is easy to see the reasons behind this transition.

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[252] Sicre *et al.,* 'Decadal variability of sea surface temperatures'.

[253] Annálsbrot frá Skálholti, in Ogilvie, 'Climatic changes in Iceland'.

[254] Koch, 'The east Greenland ice'; Dawson, personal communication.

[255] Byock, *Viking Age Iceland*, p.44.

[256] If this was the case, it may have been that prior to *c*.1100, the waters around Iceland were not cold enough to sustain a large specialist industry and it took the shifting of the spawning grounds to facilitate this development. The desire and ability to exploit may have been there but quite simply, the fish were not. If the waters were too cold, this may also have been an impacting factor. Between the AD 1930s and AD 1960s, a warm period was experienced in the north Atlantic, and the geographical range of cod in the Iceland-Greenland ecosystem expanded greatly. The cooling which followed this episode contributed towards a decline in catch numbers. S. Agnarsson & R. Arnason, 'The Role of the Fishing Industry in the Icelandic Economy; A Historical Examination'. *Institute of Economic Studies Working Paper Series* W3 08. ISSN 1011-8888. (Reykjavík, 2003).

[257] Dawson, personal communication; Lamb, '*Climate: Present, Past and Future*', p.453.

[258] Thór, 'Icelandic Fisheries, *c*.900-1900', p.333.

From *Vaðmal* to *Skreið* – An Explanation?

The growth in the significance of exported fish could also be over-emphasised when compared against livestock. The changing environment would have created pressures on the terrestrial economy, with the reduction in biomass productivity, having a direct impact on the ability to sustain livestock. A growing population would continue to require food during the winter months, even more so as terrestrial resources dropped as a result of this reduced productivity and also the landscape degradation. There could be simply less *vaðmal* available for export. As mentioned previously, with the availability of a year round resource in fish, there were more sheep living longer with there being reduced pressure to cull them in the winter. Fewer culled brings more wool, changing the ratio of wool to fish and allowing both economies to potentially grow. Another reason behind this transition may have been that Icelanders were keeping more *vaðmal* for themselves, to transform into material and insulate themselves against progressively deteriorating environmental conditions. As exports dropped, dried fish would eventually become more significant and become a greater proportion of Icelandic commodities overseas.

Iceland as Part of the Norwegian Economy

Despite Norwegian kings trying to prevent the Icelandic *skreið* trade competing against the Norwegian market, it is documented that after AD 1340, Iceland was incorporated into the Norwegian fish market.[259] This suggests some form of unified effort in developing fish exports to mainland Europe, likely instigated by Hanseatic merchants. Norwegian fish production was said to have increased after AD 1350, bringing with it

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[259] *Diplomatarium Islandicum*, Volume 2, (1893), p.287, in Urbańczyk, Medieval Arctic Norway, p.72.

short-term collapse in the Icelandic economy as the merchants from Europe may have been favouring ports closer to their target market.[260] Fewer days at sea between landings meant more profit could be made. This statistic seems rather unusual, bucking any expected trend, given that Norway lost between thirty and fifty percent of its population around this time through plague, leading to economic collapse.[261] No ships were said to have sailed to Iceland for some years, confirming the isolation said to be experienced.[262] The lack of navigation may have been related to the afore-mentioned sea-ice which was prevalent in northern waters around this time, or a result of the effects of the plague as it made its way across Europe. The wrecking of a royal Norwegian ship off the coast of Greenland in AD 1367 echoes the growing difficulties behind the decision to suspend westward navigation.[263] Populations were dropping, both numerically and literally,[264] and as the plague only kills humans, livestock were spared albeit may have found it difficult to survive the winter without fodder. Fewer people and more livestock could have potentially created a surplus and consumption of these surpluses would have driven down the demand for fish.[265] It is unclear whether this was a temporary drop in demand, or whether there was a more permanent switch in dietary preference taking place. Reduced consumption throughout Europe and increased production in Norway meant Iceland was again pushed on to the periphery. This reduced overseas demand created a subsequent drop in trade, but the lack of

[260] This may have been a collapse in foreign trade given the growth in Norwegian exports, but if demand continued internally, continuity should be observed within the geoarchaeological record.

[261] Dugmore *et al.,* 'Norse Greenland Settlement'.

[262] E. Jones, '*The Journal of the Marigold, 1654'* (e-revision), TNA SP 18, 75 (2006), p.44.

[263] Dawson, personal communication; Koch, 'The east Greenland ice'.

[264] R. Streeter, A.J. Dugmore & O. Vésteinsson, 'Plague and landscape resilience in premodern Iceland', *Proc Natl Acad Sci USA,* 109 (2012), p.3664-69.

[265] Woolgar, 'Food and the Middle Ages'.

contact from overseas traders perhaps ensured that Iceland remained free from plague until the fifteenth century AD.

Late Fourteenth Century Decline

This reduction in demand may have been something of a 'blessing in disguise' for Icelanders and provided an opportunity for recovery and an increase in domestic consumption. The period from AD 1350 to AD 1370 was not overly bad regarding the weather, but the Öræfajökull eruption in AD 1362 may have created some difficult conditions for inhabitants living in the immediate surroundings.[266] This volcanic episode is regarded as the worst experienced in Iceland during the Middle Ages.[267] With such an event it would have been important to have additional maritime resources to turn to for domestic consumption, however, sea ice was packing out surrounding waters making navigation impossible, as reflected in the statement that in some years no ships sailed to Iceland. The year prior to the Öræfajökull eruption saw German merchants awarded a grant of monopoly of trade with Iceland, reflecting the growing influence the Hanse was getting in Icelandic trade. This was along the same lines as the one awarded to German merchants for Norwegian trading rights in AD 1341; the Hanse were widening their sphere of influence. The monopoly signalled the beginning of the end of the post-AD 1350 slump and saw Iceland become a more integral part of the European fish trade network, and once the country recovered from the hardships of the 1360s, the fisheries were allowed to grow once more with the prices rising further as the century drew to a close.[268] These favourable fish prices continued until the beginning of the sixteenth century, and were no doubt welcome as the climate became more extreme.

[266] Ogilvie, 'Climatic changes in Iceland'.

[267] Dugmore & Vesteinsson, 'Black Sun, High Flame, and Flood'.

[268] Kowaleski, 'The Seasonality of Fishing in Medieval Britain'.

This was not always the saving grace, as widespread dearth of food including fish, crops and livestock were still being reported in the AD 1390s.[269] Particularly from the AD 1370s onwards, the climate was growing increasingly harsh and in the AD 1380s, widespread rain caused landslides, an event never previously mentioned in historical sources.[270] It is unknown whether the greater extremity of weather or poor seasons can be held responsible for these landslides, or whether these are a result of land cover removal and widespread landscape degradation coupled with inclement weather conditions. Whatever the reasons, people were observing the changes which were taking place in their landscape. The destruction of German, English and Norwegian ships in AD 1392 is testament to this progressively deteriorating climate.[271]

The Age of Foreign Fisheries in Iceland

The term *The Age of Fisheries*, often found when reading the basic narrative on Icelandic fishing is a phrase which no longer tells the whole story. It would be more apt to brand the AD 1300s the *Age of Icelandic Fisheries,* and the AD 1400s the *Age of Foreign Fisheries in Iceland.* There had always been an overseas influence shaping the Icelandic fisheries, but after the AD 1400s, this appears more profound. The fifteenth century was a time of increased foreign presence in Icelandic waters, made possible by the role Iceland had in the wider European network. It is thought that by this time, fishermen from European ports began travelling greater distances to obtain their own catch, rather than trade long distances.[272] Although growth was sudden, international trading with Iceland was not new. Bristol and Scarborough merchants were said to be travelling

[269] Flateyjarannall in Ogilvie, 'Climatic changes in Iceland'.

[270] Gottskálksannáll (VIII) in Ogilvie, 'Climatic changes in Iceland'.

[271] Dawson, personal communication; Britton, '*A meteorological chronology to AD 1450'.*

[272] Barrett *et al.,* 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

north by AD 1325, more often to trade rather than fish,[273] although English fishermen from Great Yarmouth were thought to be working in Icelandic waters catching cod and other fish for commercial purposes at times during the fourteenth century AD,[274] as well as Scarborough fishermen who were setting sail to catch what they referred to as *Icelandfare*.[275] Some even suggest that fish caught in 'northern lands' were making their way into English zooarchaeological assemblages, albeit in small numbers, as early as the eleventh century.[276] The trading connection between Iceland and England was likely stimulated by the irregular trade taking place with Norway, which was cast to the side when the increasing opportunity to trade in *skreið* for grain and iron took place.[277] By the fifteenth century, significant investment had been made by the English in the Icelandic fisheries, so much so that it was viewed as England's most capitalistic maritime investment during the medieval period. Historical sources refer to the landing of a ship at Dyrhólaey in AD 1412 as the first English ship to land there,[278] which does not recognise the presence of earlier efforts suggesting that this was the first official and

[273] E.R. Cooper, 'The Dunwich Iceland Ships', *Mariner's Mirror,* 25 (1939), p.170-77.

[274] Thór, 'Icelandic Fisheries, *c*.900-1900', p.343; R. Tittler, 'The English Fishing Industry in the Sixteenth Century; the Case of Great Yarmouth'. *Albion: A Quarterly Journal Concerned with British Studies*, 9 (1977), p.40-60.

[275] Kowaleski, 'The Seasonality of Fishing in Medieval Britain'.

[276] Barrett *et al.,* 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

[277] R. Robinson, 'The Fisheries of Northwest Europe, *c*.1100-1850', in D.J. Starkey, J.T. Thór & I. Heidbrink, (eds.) *A History of the North Atlantic Fisheries Volume 1: From Early Times to the Mid-Nineteenth Century,* (Hull, 2009).

[278] D.A. Vinson, 'The Western Sea: Atlantic History Before Columbus', *The Northern Mariner*, 3 (2000), p.1-14.

regulated ship forming the beginnings of England's presence on Iceland,[279] and the beginnings of what was to be the formation of temporary shore bases.[280]

Reasons behind a Greater Foreign Involvement

There are numerous suggestions given as reasons for foreign, particularly English interest, justifying the investment to Iceland. A collapse around AD 1415 of North Sea fish stocks, the most commercialised fishery in Medieval Britain, was said to be a major factor in pushing people into seeking alternatives away from the area.[281] Scandinavian presence in Iceland was said to have weakened, perhaps opening the door for others to replace them.[282] The seas were regularly going through increasingly stormy episodes during the early fifteenth century AD,[283] and AD 1419, a year regarded as being climatically favourable,[284] saw fifteen English ships wrecked during one snowstorm.[285] By this time, Iceland was becoming an attractive prospect; the fishing season in Iceland was outside the herring season, allowing for two phases of fishing per year. Fishermen from England often travelled to Iceland during the spring and summer for the cod season.[286] Of significance from an economic perspective were customs duties; English fishermen returning with their own catch, opposed to traded goods, were exempt from

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279 Dyrhólaey is referred on some maps as Portland (or Cape Portland), which reflects the English influence on the area.

280 Thór, 'Icelandic Fisheries, *c*.900-1900', p.343.

281 Hoffmann, 'Medieval Europeans and their Aquatic Ecosystems'; Kowaleski, 'The Seasonality of Fishing in Medieval Britain'.

282 Vinson, 'The Western Sea: Atlantic History Before Columbus'.

283 Dawson, *So Foul and Fair a Day,* p.105.

284 Nýi Annáll in Ogilvie, 'Climatic changes in Iceland'.

285 Ibid., The increase in coastal erosion in Scotland during the fifteenth century is testament to the increased storminess and more dramatic episodes of weather experienced throughout the North Atlantic area, particularly after 1420.

286 J.H. Clapham, M.M Postan & E.E. Rich, '*The Cambridge Economic History of Europe'.* (Cambridge, 1941), p.139.

paying port customs.[287] Religious factors were also continuing to drive commercialisation, proven by the fact that levels were maintained even when the quality of fish, particularly herring, was of a lower standard. Cod were of a fairly consistent standard of quality, and when dried lasted up to two years, with some sources saying seven years.[288] An alternative to North Sea herring was sought after, and may have been a deciding factor in the development of a light salt cure, a popular preservative amongst English fishermen from the AD 1300s onwards.[289] A deteriorating climate in London in the AD 1280s caused a drop in resource availability as fish died in ponds as a result of the increased ice presence.[290] A product which was once turned to during times of need was now a major economic resource, and the centre of economic attention. The exploitation of this resource removes it from its role as a buffer against terrestrial failures, but at the same time the infrastructure was in place to deliver a storable product which could be turned to during times of need. The problem now arises when the status of this product turns from the storable emergency or seasonal ration to the everyday consumer product, utilised when there was no suitable alternative to turn to if the fisheries ever failed. Icelanders acknowledged the role of dried fish to be turned to during times of hardship, as revealed by archaeological excavations at Miðbær in western Iceland. The zooarchaeological assemblages here suggest fish was a buffer to climatic variation, consumed when terrestrial failures took place, a pattern more common from the seventeenth century onwards.[291] With changes

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[287] Kowaleski, 'The Seasonality of Fishing in Medieval Britain'.

[288] Edvardsson, personal communication.

[289] Kowaleski, 'The Seasonality of Fishing in Medieval Britain'.

[290] Dawson, personal communication; Britton, '*A meteorological chronology to AD 1450'.*

[291] C.P. Amundsen, 'Farming and Maritime Resources in Miðbær on Flatey in Breiðafjörður, NW Iceland', in R.A. Houseley & G. Coles, (eds.). 'Atlantic Connections and Adaptations: Economies, environments and subsistence in lands bordering the North Atlantic'. Symposia of the Association for *Environmental Archaeology,* No. 21, (Oxford, 2004).

in sea surface temperature and fish migrations, a sustained demand would have resulted in failure in the fisheries, as the pressure would be high on a resource which is no longer present.

The opportunity to develop temporary fishing bases on Iceland during the early fifteenth century may stem from the reorganisation of Icelandic society which took place after the plague of AD 1402-1404.[292] With the surplus labour force which had initially facilitated the growth of fisheries from the AD 1360s onwards no longer existing, people took the opportunity to fill the vacant farms left behind by victims of this pestilence, re-focussing their attentions from the coasts and seas to the inland areas. It was common during times of higher population for the surplus in the countryside to make their way to the 'squalid' fishing villages.[293] Population reduction removed this option. It may have been that Icelanders were still fishing but more for subsistence rather than overseas trade, an opportunity which they presented to foreign investors who looked to fill the gap left behind by Icelanders.[294]

The construction of the seasonal fishing booths in Iceland was *ad-hoc*; they were used during the summer season and left exposed in the winter, forcing their renewal on an annual basis.[295] It was not only the English and Germans who had growing associations

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[292] The arrival of the pague also coincides with a reduction in literary output from Iceland. There are some sources available, however, they are in a much reduced number compared to previous centuries. Reasons for this may be the hardships which faced the Icelanders, changing their lifestyle habits away from one which was literary-based.

[293] Karlsson, *Iceland's 1000 Years,* p.233. This terminology gives the impression that fishing was secondary to other economic activities, almost second-rate, which may be the reason behind the ease foreign fishermen had in establishing themselves in Iceland at this time; Vinson, 'The Western Sea: Atlantic History Before Columbus'.

[294] Analysis of the geoarchaeological record and whether the stratigraphies show continuous presence or prolonged abandonment will be one method adopted to answer the question of whether fishing continued to take place of whether it was abandoned outright.

[295] Gardner & Mehler, 'English and Hanseatic Trading and Fishing Sites'.

with Iceland as foreign traders from other parts of Europe also erected booths at the shore, as well as native Icelanders who also congregated there. Almost every port around Iceland had booths which were erected by overseas merchants.[296] The Hanse formed the main trading group, but there were also alternative mercantile interests, for instance Danish privateers,[297] and Basque fishermen who were documented as being in Icelandic waters as early as AD 1412.[298]

An Increased English and German Presence

The first surviving documented record of Hanseatic merchants visiting Iceland dates to AD 1423. Although the Hanse were involved in the trade and exchange of goods from Iceland, they dealt mainly through Bergen and other North Sea and Baltic ports. Trading links were so successful that the volume of exports increased between thirty and forty percent before the century was over,[299] something perhaps stimulated by the additional English and German presence in Iceland during this era. The Hanseatic presence was slightly different from the English presence; they were more likely to trade, while the English were more likely to be catching fish. From the AD 1420s onwards, it has been argued that the English were fishing in the manner of Icelanders, and through purchasing boats and renting land from Icelandic fishing station proprietors, they triggered a boom period. The town of King's Lynn had elected 'Merchants of Iceland' by

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[296] Bartering was the principal method of exchange given the lack of widespread coinage. Goods were paid for by either *skreið* or *vaðmal*, or by establishing credit. This latter method brought with it dependence, and merchants were obliged to return to Iceland the following year to redeem the debt and supply goods. It is unclear how this network sustained itself during lean years.

[297] Friedland, 'The Hanseatic League and Hanse Towns in the Early Penetration of the North'.

[298] M. Kurlansky, '*Cod: A Biography of the Fish that Changed the World*', (London, 1997), p.27.

[299] This is an estimate found in Friedland, 'The Hanseatic League and Hanse Towns in the Early Penetration of the North'.

AD 1424, for the purpose of generating tradable revenues.[300] As with any prized resource, conflict was not too far away, even within countries. The *Libel of English Policy*, dating to AD 1437, documents the rivalry between east and west English ports involved in the Icelandic fishing industry. This reflects the opposing and conflicting levels of economic interest at both sides of the same nation echoing the active competition which was present.[301] Scarborough's profits from Icelandic cod dropped in the early to mid-fifteenth century AD,[302] possibly due to increased competition not only from rival English fishermen and traders but also the Hanse. The town no longer had the advantage of exclusivity which it had enjoyed in the previous century.

Conflicting Documentary Sources

Differing historical records present pictures of varying levels of success during the fifteenth century. Some suggest that by AD 1442 the English fishery involvement in Iceland had collapsed,[303] but others see the boom of the AD 1420s being sustained until well into the following century.[304] This conflicting interpretation may be the result of sources not being viewed as a collective, and over-reliance given to few sources. Reasons supporting this perceived collapse may be related to poorer seasons prohibiting navigation in the North Atlantic, or the growth in sea ice in Icelandic waters evident between AD 1460 and AD 1600.[305] The drop in summer temperatures from the mid fifteenth century onwards was more severe than had been experienced before.[306]

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[300] H.J. Hillen, '*History of the Borough of King's Lynn, Volume 1'*, (Norwich, 1907), p.175.

[301] W.R. Mead, '*Renaissance of Iceland',* Economic Geography, (1945).

[302] Kowaleski, 'The Seasonality of Fishing in Medieval Britain'.

[303] Robinson, 'The Fisheries of Northwest Europe, c.1100-1850'.

[304] Thór, 'Icelandic Fisheries, *c*.900-1900', p.343.

[305] Dawson, *So Foul and Fair a Day,* p.106.

[306] Geirsdóttir *et al.,* 'A 2000 year record of climate'.

Despite this threat, there were still 100 English vessels visiting Icelandic waters annually,[307] both fishing and carrying goods to trade for locally caught fish.[308] Their presence was such that concern amongst economic rivals was expressed; a German agent in Iceland warned the King of Denmark of the prospect of Iceland turning into an English colony if voyages between the two countries continued to grow.[309] As the English utilised the local labour force, overseas political interest and influence on Iceland began to develop.[310] Unrest began to grow, and inappropriate behaviour by foreign fishermen disgruntled many native Icelanders.[311] This dislike of an English presence was no doubt fuelled by the rivalry between them and German merchants. The Danish kings had a strong North German heritage which may have contributed to bias and potentially favouritism, although the relationship between the Danish House of Oldenburg and the Hanseatic League were not always positive. One example of this bias and emerging conflict was when Bristol merchants were excluded from purchasing Icelandic cod by Hanseatic merchants as early as AD 1475. This prohibition reveals that English merchants were not only interested in catching and curing their own cod but in addition, purchasing stocks for trade.[312]

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[307] Thór, 'Icelandic Fisheries, *c*.900-1900', p.343. The 1460s was said to be the peak of English involvement in the Icelandic fisheries.

[308] Gardner & Mehler, 'English and Hanseatic Trading and Fishing Sites'. These items included ground corn, beer, and clothing, manufactured items such as pots and pans, needles and thread, hats, shoes, horseshoes, kettles, scissors and knives, as well as some luxury items such as haberdashery, high quality cloth and religious items.

[309] E. Carus-Wilson, 'The Medieval Trade of the Ports of The Wash', *Medieval Archaeology*, 6-7 (1962), p.182-201.

[310] Thór, 'Icelandic Fisheries, *c*.900-1900', p.344.

[311] Roberts, '*The Unnatural History of the Sea',* p.344.

[312] Kurlansky, '*Cod: A Biography of the Fish that Changed the World'*, p.27.

Post- AD 1480 Mixed Fortunes

From the AD 1480s onwards, there may have been an increased presence of fishermen in Icelandic waters. After that date, landlines were deployed by Icelanders yielding increased catch returns.[313] This technological development occurred around the same time as a phase of inclement weather which lasted through the AD 1480s and AD 1490s, bringing with it dearth years in Iceland.[314] These pressures were fuelled by the return of the plague in Iceland in AD 1494/95, with some regions being more affected than others.[315] Despite strong Anglo-Hanseatic rivalry, the period between AD 1490 and AD 1530 was said to be the main period of growth in English interest in the fishery.[316] This would have been fuelled by an Anglo-Danish Treaty of the AD 1490s. Rivalry was so fierce that English vessels had to be protected and travelled to Iceland in convoy.[317]

Even with a recorded period of growth, the Danish monarchy was financially losing out. In AD 1370, they made 3,500 Lübeck marks from fishing but in AD 1494, during the aforementioned period of growth, they only made 2,274 Lübeck marks.[318] With the English conducting the catch and trade method, fishing and doing their own processing

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[313] Longlines (definitions in Chapter 3) were traditionally used by English fishermen and more successful than the single hook method used by Icelanders. The increased returns would have gone someway to absorbing the pressures that a deteriorating climate was having on the terrestrial landscape. This appears to be a response by the population to counteract dearth, supporting the longstanding theories of Boserup.

[314] Biskupa-Annálar in J. Egilson, '*Biskupa-annálar Jóns Egilssonar með formála, athugagreinum og fylgiskjölum eptir Jón Sigurðsson in Safn til Sögu Íslands og Íslenzkra Bókmenta að Fornu og Nýju 1, Hinu Íslenzka Bókmentafélagi',* (Copenhagen, 1856), p.15-117. p44.

[315] Karlsson, *Iceland's 1000 Years*. Vestfirðir appears to have escaped this epidemic, suggesting that links between this region and the rest of Iceland were not particularly strong during this period. If a continuity is represented in the archaeological and geoarchaeological record, it would suggest that possibility that the development on the industry was not dependent on internal demand but overseas trade.

[316] Robinson, 'The Fisheries of Northwest Europe, *c.*1100-1850'.

[317] Ibid.

[318] Gardner & Mehler, 'English and Hanseatic Trading and Fishing Sites'.

and undertaking a reduced percentage of trade, the revenues were not as high as the previous century. Even with German trade involvement, revenues gained still fell short, surprising during a time of apparently unprecedented growth. Despite having a historical connection, it is easy to see why the Danes favoured the Germans; they came to Iceland with the sole intention of trading and did not themselves have the equipment to fish, forcing them to purchase from Icelandic fishermen and traders. Tensions rose further after AD 1490 as the conflict for the best fishing stations and harbours increased, culminating in the first Cod Wars. As expected, the Danes sided with German merchants, yet a decision was made in the same year to ban foreign vessels from overwintering in Iceland.[319]

Continued English Involvement

Even though Scarborough apparently withdrew from the Icelandic fisheries in the late fifteenth century, London fishermen remained heavily involved in this venture.[320] The loss of interest from Scarborough may be related to the venture undertaken by Bristol fishermen after the embargo placed on them in AD 1475, possibly because of the aforementioned reduced exclusivity and the desire to find a replacement. Existing markets were becoming increasingly competitive and their ability to suffice was decreasing. Bristol's fortunes were reduced as competition increased.[321] In the search for alternative sources of cod, Bristol merchants probed the Atlantic in search of a land called *Brasile* and continued to send two or three ships annually, well into the AD 1490s.[322] These were periods when poor climate conditions were recorded, highlighting

[319] D.E. Vasey, 'Population Regulation, Ecology and Political Economy in Preindustrial Iceland'.
[320] Robinson, 'The Fisheries of Northwest Europe, *c.*1100-1850'.
[321] Vinson, 'The Western Sea: Atlantic History Before Columbus'.
[322] Ibid.

the efforts made and the desperation to find sources away from Iceland. Herring began to decline in Europe in the late AD 1400s,[323] making alternatives to cod harder to source as demand would have been high. Causes of this may be related to a long-term change in sea temperatures. The Basques, French and Portuguese had already known about the fishing grounds of Newfoundland for a significant period of time,[324] and this information may have been somewhat neglected as English merchants were more interested in finding a lucrative spice route to the east to succeed the tedious over-land route.[325] They were eventually 'discovered' by Genoese navigator Giovanni Caboto, or John Cabot, in AD 1497 whilst he was employed by the English to find Asia and the spice routes. What he discovered was a source of cod, and he *could bring so many fish back to his Kingdom* [England] *so there would be no further need for Iceland.*[326] England nevertheless continued to have a presence in Iceland into the following century, but this additional source was much welcomed by the merchant classes.

The growth experienced during specific periods of the fifteenth century was aberrant. The changes experienced were very sudden, although international trade, as mentioned, was not new. The documentary record is peppered with references to links bringing Iceland and continental Europe together, highlighting the fact that Iceland had had something to trade with for some time. Hawks were mentioned as being traded from AD 1024, and in AD 1240 the overlord of the Hanse city of Lübeck, Emperor Frederick II, had Icelandic hawks taken to Venice and transported on to North Africa.[327] Eagles were caught at Vestfirðir, which reaped a double benefit; the removal of predators which

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[323] Kowaleski, 'The Seasonality of Fishing in Medieval Britain'.

[324] Robinson, 'The Fisheries of Northwest Europe, *c*.1100-1850'.

[325] Roberts, '*The Unnatural History of the Sea',* p.34.

[326] Kurlansky, '*Cod: A Biography of the Fish that Changed the World',* p.27.

[327] Friedland, 'The Hanseatic League and Hanse Towns in the Early Penetration of the North'.

would otherwise be preying on livestock, and also the trade in a high-value prestigious item.[328] There were several reasons for the industry expanding at the pace it did; firstly, more people became involved. Secondly, the Hanse were introduced, where they expanded and grew early in the century. They were not alone as English and other European fishermen and merchants experienced the same sort of growth. Thirdly, and most importantly from a mercantile perspective, there was an increasing demand for foodstuffs, facilitating the demand and reason for expansion at the rate it did.

Fifteenth Century – Environmental Difficulties with Economic Opportunity

Widespread famine in Europe, as experienced during the AD 1450s,[329] would have driven demand for imported foodstuffs. The way in which Icelandic society was organised would also have fuelled development. With the plague killing between fifty and sixty percent of the population, many old family lines failed and the empty farms acquired by survivors and or the Church. By AD 1450, the most valuable farms and fishing stations were owned by the Church, with few individuals acquiring the rest.[330] This process created a group of wealthy individuals who organised their fisheries much like those of the early modern period, leasing farms to tenants, both foreign and Icelandic, who operated their own boats and paid for their land rent in fish. Being put into place was a more efficient, larger scale yet economically complex system of operation to exploit the maritime resources around Iceland during the late medieval period.

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[328] A. Pálsdóttir, M.E Gorsline & T.H McGovern, '*Archaeofauna from Vatnsfjörður, Westfjords, Iceland: Interim Report 2003-2007',* NORSEC Report Number 43, (NABO, 2008).

[329] Dawson, *So Foul and Fair a Day,* p.105.

[330] Thór, 'Icelandic Fisheries, *c*.900-1900', p.331. Private ownership was more prevalent in Vestfirðir than elsewhere in Iceland.

The century was volcanically active, with the largest basaltic tephra in recorded history produced with the Veiðivötn eruption of AD 1477. Given its magnitude, it is surprising that more in the way of literature makes reference to this event. This may be a result of the reduced literary output in Iceland during the fifteenth century, although significant events do still make it into the historical record as shown above. There appears to be a change in the landscape taking place around this time, which may be directly related to the impacts of such an eruption.

As the country became part of a wider network there were an increasing number of external views of Iceland expressed in written sources. As the century drew to a close, fish was an enormously prized resource, systematically being exploited through a series of complex trading mechanisms. As with any valuable resource, fish was being increasingly fought over. However, the industry was still developing and maturing, a process which continued into the following century.

The Sixteenth Century

As much as the fifteenth century was ultimately a period of widespread success in the fishing industry, the sixteenth century was one of contrast. Widespread changes and events, which took place throughout the environment and society during this century, halted and reversed the growth which was previously experienced, bringing the economy to a standstill. From an environmental perspective, the fifteenth century, although containing some serious and dramatic events, was comparatively quiet compared to the centuries which preceded and followed it. With the turn of greater environmental impacts in conjunction with the tensions generated and changes experienced by societies associated with Iceland and desperate to gain from exploiting the maritime resources of the country, it is easy to see with hindsight that hardships were a likely event during the sixteenth century.

A Severe Economic Decline

The period between AD 1300 and AD 1550, as mentioned, has been referred to as the *Age of Fisheries*, but the start of the Iceland fishery's decline may have been around AD 1500 when *skreið* prices began to tumble in both relative and absolute terms.[331] The decline in the value of the fisheries led to falling returns,[332] coinciding with a notable rise in the failure of Icelandic fish stocks.[333] The increasing competition from elsewhere in the North Atlantic would have gone some way to driving down prices, but the failure of fisheries throughout southern Europe should have gone some way to maintaining some sort of demand. This demand was reducing given the changes in food consumption habits in Europe. More and more foodstuffs were coming from terrestrial sources.

A Rise in Environmental Pressures

Growing environmental pressures may have contributed to the actual decline in catches. Since AD 1500, Iceland's eruptions are estimated to account for a third of the total planetary outpouring of lava.[334] Hekla erupted notably three times, the episode in July AD 1510 is said to have been particularly violent,[335] but only affected a small sector of

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[331] Ibid., p.339. Thor refers to the relative and absolute terms in relation to the post-1550 price drop.

[332] Robinson, 'The Fisheries of Northwest Europe, *c*.1100-1850'.

[333] A.E.J. Ogilvie & I. Jónsdóttir, 'Sea Ice, Climate, and Icelandic Fisheries in the Eighteenth and Nineteenth Centuries', *Arctic*, 53 (2000), p. 383-94.

[334] Byock*, Viking Age Iceland*, p.61.

[335] Details of this eruption were not recorded until a century after the event took place, possibly related to the reduced literary output from Icelanders after the fifteenth century. <http://www.tephrabase.org/cgi_bin/tbase_ice_erup2.pl?eruption=4>

southern Iceland much like the Hekla eruption in AD 1947.[336] Severe winters were recorded in the AD 1520s and AD 1530s with losses of livestock and winter conditions lasting into the summer months.[337] The presence of sea ice would have prevented fishermen from reaching the fishing grounds, a direct link to annual failures and reduced returns. Not only was sea ice preventing fishermen entering the water but it was also preventing ships with cargo reaching the shore, with particular consequences in the AD 1540s as a result of this scenario.[338] Parts of Europe were also enduring the worst conditions of the century during the AD 1540s.[339] With the associated risks, it is easy to understand why overseas merchants may side with an alternative option rather than take the long and dangerous journey to Iceland where there is a strong possibility they may not even reach the shore. A growing number were making an even longer voyage to Newfoundland suggesting this may have been the case, emphasising the importance in having guaranteed landings. When the fisheries in Europe collapsed there were around fifty ships making the voyage across the Atlantic Ocean, but by the end of the century, that number had been reduced to about 150.[340]

Despite the social and environmental hardships, the link between Icelanders and the Hanse was becoming stronger at the expense of the relationship with English fishermen. A society of *Icelandfarers* was established in Hamburg around AD 1500,[341] and from this point onwards they became increasingly dominant trading partners. This bond was

336 Dugmore, Personal Communication.

337 Ogilvie, 'Climatic changes in Iceland'.

338 *Diplomatarium Islandicum* (11:203) in Ogilvie, 'The Past Climate and Sea Ice Record from Iceland, Part 1: Data to A.D. 1780'.

339 Dawson, *So Foul and Fair a Day,* p.106 refers to a particularly bad climatic conditions in Scotland from 1541 to 1551.

340 Hoffmann, 'Medieval Europeans and their Aquatic Ecosystems'.

341 Gardner & Mehler, 'English and Hanseatic Trading and Fishing Sites'.

strengthened by the capital investment made by German bankers which allowed a considerable fleet of rowing boats to be managed by Germans and operated by Icelanders to be assembled between around AD 1500 and AD 1545. These boats were mainly concentrated around the southwest of Iceland, where much of the reference to fishing activity appears to have become centred. Ever-deteriorating environmental conditions may have pushed the cod frontier even further south, something highlighted earlier in the chapter.

Changing English Involvement

English fishermen, however, were continuing to be active in Icelandic waters despite growing conflicts with rivals. The peak number of English vessels in Icelandic waters was 149 in AD 1528; this dropped sharply after the Battle of Grindavík in AD 1532 when English fishermen began to lose their foothold on mainland Iceland.[342] Legislation was passed in AD 1534 prohibiting the mercantile stockpiling and sale of fish to England, as well as the doubling of duties imposed by the Danes on English sometime in the AD 1530s.[343] This in turn made financing expeditions to Iceland very difficult. It removed most English merchants from Icelandic waters and the ones that did remain paid more. The Act was not well received, and repealed in AD 1548. By the AD 1550s, numbers of English fishermen had dropped and their focus was now on the Westman Islands, off the southern coast of Iceland, when around forty vessels were making the voyage.[344] The presence of English fishermen, albeit reduced, nevertheless continued in Iceland through the AD 1560s and AD 1570s. There is an AD 1565 record from *Broadstairs* in

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[342] Ibid.

[343] E. Jones, 'England's Icelandic Fishery in the Early Modern Period', in D Starkey, *et al.* (eds.), 'England's Sea Fisheries: The Commercial Fisheries of England and Wales Since 1300', (London, 2006).

[344] Thór, 'Icelandic Fisheries, *c.*900-1900', p344; Robinson, 'The Fisheries of Northwest Europe, *c.*1100-1850'.

Kent, of *about ninety families…chiefly employed in the Iceland cod fishery, and who make a considerable trade from the oil drawn from the livers of the fish, which are brought home hither in casks for that purpose; their residence here is on account of this harbour*.[345] This record does not state clearly if traders in Broadstairs were dealing in *skreið* or if they were dealing only in cod livers with the fish going elsewhere. This may be evidence of English traders working in conjunction with other fishermen and diversifying from what they were doing before. A letter from AD 1578 states that England was slow to develop Newfoundland links unveiled by Cabot nearly a century previous, the reason being it was still obtaining cod from Iceland.[346]

The Impact of Religious Transformation

Legislation and environmental conditions were not the only factors determining the pattern the pre-modern Icelandic fishing industry was to follow. Northern Europe in the sixteenth century was experiencing religious Reformation, part of which involved a removal of the spiritual incentive to consume fish and reducing demand on a product of which there was a growing abundance. The European fish stock collapse coincided with the beginnings of Reformation, around the AD 1520s, which may have been welcome in some areas given the pressure on a prized resource. Despite the removal of a spiritual incentive, there was still a demand for fish as a low-cost source of protein, and the growth in the Newfoundland fisheries allowed this to be fulfilled. Danish interests in the fisheries were also growing.[347] There was recognition that the fisheries had substantial

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[345] 'Parishes: St Peter (Thanet)', The History and Topographical Survey of the County of Kent: Volume 10 (1800), p.355-377. <http://www.british-history.ac.uk/report.aspx?compid=63627>, [Accessed 20/08/2008].

[346] Jones, 'England's Icelandic Fishery in the Early Modern Period'.

[347] With a drop in fishermen, the wealth accumulated by the Danish crown dropped, which may be seen as a catalyst for promoting them to manage the fisheries themselves rather than allow other organisations to do so.

potential to generate revenue, with the Danish crown introducing measures to increase its income. After AD 1540, the royal Dano-Norwegian navy began patrolling the coasts of Iceland to prevent any illegal trading, and in AD 1545 the Danish king confiscated all German property, including the Hanse boats, purchased earlier in the century, increasing the Danish presence in the Icelandic fishing grounds. This move was controversial, more so as the Danish crown had first supported German investment before confiscating the boats which were in receipt of this investment, but it was a recognition that the marine resources of Iceland were under growing Danish control, creating stability (or as some see it, stagnation) for the industry which carried through the following century and into the AD 1700s.[348]

A Response to Economic Decline

Iceland was not the only economy undergoing a transition as a result of changing consumption patterns; in an attempt to counteract the decline and boost consumption of fish, pro-fishing measures were put in place in England. Compulsory fish-eating days were imposed in an Act of Parliament in AD 1563, and by insisting on the consumption of fish on Wednesdays and Saturdays, this legislation went some way to reviving England's Icelandic interests.[349] In an attempt to encourage people to consume more, mayors reduced fish prices to unrealistically low levels, which boosted consumption but

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[348] Thór, 'Icelandic Fisheries, *c*.900-1900', p.339.

[349] Robinson, 'The Fisheries of Northwest Europe, *c*.1100-1850'; Jones, 'England's Icelandic Fishery in the Early Modern Period'. There may be a suggestion here that the push on maritime resources was to take it away from terrestrial resources, in a pre-modern form of political-led sustainability.

necessarily generated lower levels of profit. From the AD 1590s, the fruits of these efforts were being noted and a revival of fortunes took place peaking in the AD 1650s.[350]

Site Abandonment – The Archaeological Evidence

The archaeological record also reveals significant change during the sixteenth century. Specialist fishing sites at Akurvík and Gjögur, first developed around AD 1200 were abandoned by AD 1600.[351] These are just two examples of specialist fishing locations which were also economically linked, but further investigation is needed to identify what processes forced abandonment, and to establish whether these were unique sites, or representative of the pattern across Vestfirðir and Iceland. The political and economic power which had been associated with Vestfirðir is said to have left the region during the sixteenth century, leading some scholars to postulate an association between power and the marine environment in this region.[352] It appears that fishing did continue in Iceland, albeit at a reduced level, as demand dropped and processing crashed post-AD 1550, as did the shark liver oil industry; further research is required to allow understanding of this transition. Documents refer to this period as one of continuity, however, with sites in Vestfirðir not revealing the same pattern and indeed appearing to show abandonment, further investigation of fishing sites and regional diversity during the sixteenth century and into the seventeenth century AD.

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[350] Thór, 'Icelandic Fisheries, *c.*900-1900', p.344.

[351] Y. Krivogorskaya, 'Heads or Tails: The Analysis of Fish Bone Remains from NW Iceland'. (Presentation given at City University New York, 2005); C. Amundsen, S. Perdikaris, T. McGovern, Y. Krivogorskaya, M. Brown, K. Simarowski, S. Storm, S. Modugno, M. Frik & M. Koczela, 'A 15th Century Archaeofauna from Akurvík, an early Fishing Station in NW Iceland. NORSEC Laboratory Report Number 15, (2005).

[352] Edvardsson, 'Commercial and Subsistence Fishing in Vestfirðir'. See subsequent chapters of this research for a brief history of Vestfirðir.

The Danish Monopoly Years

According to Thór, the scale of the fisheries between the AD 1560s and the late AD 1700s remained constant.[353] This implies stability and a degree of uniformity across an industry and associated markets which had settled out after the collapse and fluctuations of the sixteenth century, but not necessarily other aspects of Icelandic society. The opinion that the fisheries were at a constant is likely shaped by the Danish merchant monopoly which was in place from AD 1602 until its eventual dissolution in AD 1787. This contrasts to what Jónsson proposed; that there was an increase in output from the fishing industry in the first half of the seventeenth century, and decreasing catches in the second half of the same century, something he attributed to climate change.[354] During this period Iceland was subject to the Danish Monopoly Trade System based on mercantile principles.[355] Exports continued but the economy was shackled, independent development was hindered but prices remained relatively firm. Competitive influences were removed which subsequently removed initiative, reaffirmed by the lack of contemporary, innovative ideas emerging from Iceland. New trading venues on previously unoccupied sites, such as that at Kúvíkur in Vestfirðir were established after the monopoly commenced, [356] which would have gone some way to promoting and boosting trade. The aim of the monopoly was to subsidise the export of

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[353] Thór, 'Icelandic Fisheries, *c.*900-1900', p.340.

[354] Jónsson, 'Fisheries off Iceland, 1600-1900'. Here, more detailed observations of what proved to be one of the harshest centuries on record allows more detailed understanding of how climate helped determine activity in particular regions of Iceland, and the simple rise and fall in temperature suggested by Jónsson is in the present context a simplistic way of interpreting a complex economic observation.

[355] R. Arnason, '*The Icelandic Fisheries: Evolution and Management of a Fishing Industry',* (Oxford, 1995), p.11.

[356] B. Lárusdóttir, G Lucas, L.B Pálsdóttir & S Ólafsson. 'Kúvíkur. An Abandoned trading Site'. *Archaeologia Islandica*, 5 (2005), p.103-18. There is evidence of trading sites being abandoned *c.*1600 at Gásir and Gautavík. Theories behind this abandonment range from increased sea ice, increased silting or that ships were becoming larger and requiring a larger draft. The emergence of new trading sites may have been replacements for the ones that were lost.

farm products. It would appear that on the back of failure in the fisheries, there was more effort to develop the terrestrial economy. An increase in sediment influx and soil accumulation rates is observed within the geoarchaeological record representing the seventeenth and eighteenth centuries AD, much like the same as what is observed during the record from the twelfth and thirteenth centuries AD.[357] Just like before, these also correlate with a surge in production of the fisheries, supporting Holm's theory. Soil accumulation and erosion were closely correlated with increased pressure and degradation of the landscape, a process which appears accelerated when there was greater intensity in land use in an ever more marginal and progressively degrading post-medieval environment.

It would be easy to suggest that the increase in degradation observed throughout Iceland during the seventeenth and eighteenth centuries was a direct consequence of human interaction. As much as this may have been a significant causal factor, the role which the climate and weather played is also significant. This was a society said to be focussing its attentions more on the terrestrial environment,[358] which, over the course of the century, endured some of the worst conditions ever recorded. The key to livestock success is estimating biomass productivity and ensuring the correct numbers of livestock were utilising the land; with climatic conditions deteriorating, productivity was further reduced and over-stocking the landscape exceeded available biomass levels, with the same numbers of livestock requiring higher levels of nutrition in an ever-harsher environment.

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[357] Sigurbjarnarson, 'The loessal soil formation and the soil erosion in Haukadalsheidi'; I.T Lawson, K.B Milek, W.P Adderley, A.F Casely, M.J Church, L Duarte, A.J Dugmore, K.J Edwards, F.J Gathorne-Hardy, G Guðmundsson, S Morrison, A.J Newton, I.A Simpson, 'The Palaeoenvironment of Mývatnssveit during the Viking Age and Early Medieval Period' in G. Lucas, '*Hofstaðir; Excavations of a Viking Age Feasting Hall in North-Eastern Iceland',* (Reykjavík, 2009).

[358] Lawson, I.T. *et al.,* 'The Palaeoenvironment of Mývatnssveit during the Viking Age and Early Medieval Period'.

The Seventeenth Century AD

Despite the Danish monopoly, the influence of Dutch mariners also grew in the AD 1600s, investing not only in the Icelandic fisheries but also in whaling and falcons. European population growth in conjunction with shipping developments and the end of the Anglo-Spanish war in AD 1604, which opened up shipping lanes, boosted prices and demand.[359] At the start of the AD 1600s, the English fisheries in Iceland were still important, and Icelandic fish was the second-highest import into King's Lynn after Scottish coal.[360] With attention turning to the terrestrial environment, it may have been the case that Iceland was happy for foreign fishermen and merchants to fish in their waters, yet the fact that a trade monopoly was supposedly operating makes this an unusual set of circumstances. Coastal sea ice between the AD 1600s and AD 1630s may have been keeping Icelanders on their shores, however, fishermen travelling from Europe would not have been subject to the same conditions, providing they kept some distance between themselves and the Icelandic shoreline. Fish catch figures quoted by Jonsson show a dramatic drop in landings in the AD 1630s, recognised as one of the coldest decades of the century.[361] This drop may, however, be linked in some way to the tax and duty increase imposed by England on English fishermen in the AD 1630s,[362] although the collapse of the Faeroese fisheries in the 1620s tells a story of changing and progressively difficult maritime conditions. The Thirty Years War would have further

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[359] Robinson, 'The Fisheries of Northwest Europe, *c.*1100-1850'; Jones, 'England's Icelandic Fishery in the Early Modern Period'.

[360] J.M. Barney, 'Shipping in the Port of King's Lynn, 1702 – 1800', *The Journal of Transport History*, 20 (1999), p.126-40.

[361] Jónsson, 'Fisheries off Iceland, 1600-1900'. In 1625, 38, 610 tonnes of un-gutted fish were landed. This drops to 9,885 tonnes in 1630, and rises again in 1655 to 34,055 tonnes, a period which is described as 'ice-free'.

[362] Jones, 'England's Icelandic Fishery in the Early Modern Period'. The English were said to have left the Icelandic fisheries at this time, but returned after the 1650s.

increased grain prices, complicating matters further in the sense that demand for maritime produce would have likely increased.

An Ever-Changing Climate

The poor climatic conditions of the AD 1630s were somewhat compounded by eruptions of Hekla in AD 1636, some of which lasted for over a year, damaging properties and livestock. As the climate improved over the following decades, the catastrophic events which took place were found in isolation, ultimately reducing their widespread impacts.[363] Between the AD 1650s and AD 1680s when the weather was comparatively favourable, there were only four seasons of high grain prices in Europe, and only occasional mentions of stormy weather destroying infrastructure.[364] From the late AD 1600s, however, records indicate that haddock numbers were in decline in the North Sea, driving fishermen back to Icelandic waters for their maritime produce.[365] There was a change of climate experienced during this period, which may have contributed to the collapse of the haddock fisheries through a change in the 'fish frontier', but it also made conditions more favourable for fishing in Icelandic waters. Competition was fierce, and it was common for English fishing vessels to have continued naval protection in foreign waters just like in centuries previous.

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363 S. Þórarinsson, '*The Eruption of Hekla 1947-1948',* Vísindafélag Íslendinga, (Reykjavík, 1967), p.85.

364 Dawson, *So Foul and Fair a Day,* p.117; There appears a contradiction on the historical record regarding weather during the 1650s; Ogilvie (1984) comments that the decade was ice-free, however, Jones (2006), using a source from The Marigold's logbook, states that sea ice is present round Vestfirðir and navigation at times was impossible. This shows the inter-regional variability which needs to be considered when using such sources. This variability is acknowledged by Ogilvie once higher resolution records become more readily available from the 1680s onwards, with inter-regional data available from 1700, Ogilvie (2010). Jones, '*The Journal of the Marigold.*

365 Holm, 'Fishing Down the North Sea'.

The resurgence of foreign fishing in Iceland may have contributed to and compounded economic stagnation in Norway.[366] This re-introduction of foreign fishermen may have been having an impact on Icelanders, who reported their own economic stagnation, and some regions were reporting poor fisheries all round.[367] The cod fisheries off Greenland ended around AD 1675 when the cod shoals migrated south; the winters between AD 1676 and AD 1684 were said to have been persistently cold, and the sea temperatures of less than two degrees centigrade resulted in the kidneys of cod not being able to tolerate temperatures so low.[368] The same thing happened in Shetland waters in AD 1696 as polar water shifted south; sea ice was even reported in the waters off southern England and northern France.[369] The Faeroese fisheries underwent a period of collapse during this century, continuing into the eighteenth century AD, caused by the shifting polar front and changing migration and spawning patterns.[370] The rapid changes meant almost overnight shifts in success and failure. The historical record details the hardships between AD 1676 and AD 1684, but the winter of AD 1684, which was more favourable, was called the 'winter of the big lots' on the back of the successful yields returned.[371]

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[366] P. Christensen & A.R. Nielssen, 'Norwegian Fisheries 1100-1970 Main Developments' in P. Holm, D.J. Starkey & J.T. Thór, 'The North Atlantic Fisheries, 1100-1976: National Perspectives on a Common Resource', (Esbjerg, 1996).

[367] One example of this would be from Barðastrond, as referenced in Ogilvie & Jónsdóttir, 'Sea Ice, Climate, and Icelandic Fisheries'.

[368] Dawson, *So Foul and Fair a Day,* p.121.

[369] Ibid., p.123.

[370] Ogilvie & Jónsdóttir, 'Sea Ice, Climate, and Icelandic Fisheries'.

[371] Jónsson, 'Fisheries off Iceland, 1600-1900'.

King William III's 'Ill' Years

The AD 1690s were a period almost universally associated with hardship throughout Europe. Cold continental air temperatures were said to have dislocated society through population decline and farm abandonment.[372] Summers were wet, winters were freezing, and in Iceland these benefactors were compounded by the eruption of Hekla in AD 1693, the largest eruption of the century, which lasted between seven and ten months. Tephra and volcanic ejecta was mainly carried to the west and northwest of Iceland, ninety percent of the total emitted within the first hour, causing widespread damage to fish, livestock and birds through associated fluorosis, as well as lahars and tsunamis.[373] A total of fifty-five farms were apparently destroyed as a direct consequence of the eruption, with more simply abandoned as the landscape became overwhelmed and the livestock destroyed. The impacts of the eruptions and the hardships would have been significant and caused a moderate level of disruption to Icelandic society, but the cessation of Hekla was only a brief respite; an episode which has been termed 'King William's Ill Years' saw the first of seven years of famine in Europe take place in AD 1694, caused by cold winds from the east and sulphurous fog,[374] likely derived from Hekla. Temperatures plummeted, and Iceland was surrounded by sea ice as far as the eye could see.[375] This meant the seas were not navigable and ships could not reach harbour.[376] Governments in Europe had to intervene to prevent starvation. Harvests were failing as storms were becoming more violent and erratic as

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[372] Dawson, *So Foul and Fair a Day,* p.122.

[373] Þórarinsson, *The Eruption of Hekla 1947-1948,* p.88.

[374] Dawson, *So Foul and Fair a Day,* p.122.

[375] Jones, '*The Journal of the Marigold*'; Ogilvie, 'Climatic changes in Iceland'.

[376] Dawson, *So Foul and Fair a Day,* p.123.

the century drew to a close.[377] Demand for food remained high, but with ships finding it difficult to get to Iceland to obtain fish, trade could not be undertaken. Regardless of whether the ships could get to Iceland, catching the fish was a problem, with the polar front moving, fluoride poisoning affecting environments, fish migrating elsewhere in an environment difficult to navigate around, the cards were firmly stacked against the European population of the late seventeenth century. European society in the seventeenth century AD was said to be eating more meat than before; increasing demand in a European landscape which was suffering the impacts of poor environmental conditions.[378]

The Impact of *Skreið* Price Decline

Some fishing communities in northern Norway ceased to exist after the seventeenth century, much like the site at Akurvík. The drop in *skreið* prices may have been a causal factor in this process,[379] although a reorganisation of the economy away from a maritime basis at the time was perhaps a contributing factor. With the main European markets being flooded with fish from the New World, and catching fish around Iceland becoming more difficult through increased storminess and unpredictable through shifting polar fronts, it is understandable why these communities ceased producing fish. Their abandonment may have been compounded as there was no longer a product with a long shelf-life which Icelanders could turn to in times of hardship. Failure to be economically competitive created a bigger loss in the long-term. One example of this

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[377] Ibid., p.125.

[378] Robinson, 'The Fisheries of Northwest Europe, *c.*1100-1850', states that people were eating more meat at the expense of fish in the AD 1600s, causing decline in the fisheries. It may have been that the rising population were eating more meat products yet the consumption level of fish remained the same, albeit taking up a reduced proportion of consumed foods over the course of the century.

[379] Thór, '*Sjósóku og svávarfang: Saga Sjávarútvegs á Íslandi'.*

would be the collapse of the Newfoundland fisheries in AD 1719 and AD 1726,[380] which forced European traders to find their produce elsewhere.

The Eighteenth Century

When viewed alongside the eighteenth century, it is understandable why there was no perception of apparent economic continuity experienced in Icelandic society during the seventeenth century. The eighteenth century AD continued from the previous century; climatically very poor and the weather more erratic.[381] During this century, it has been calculated that Icelanders experienced forty-three years of distress through cold winters, ice floes, failure of the fisheries, shipwrecks, inundations, volcanic eruptions, earthquakes, epidemics and contagious diseases.[382] These events were so numerous and significant that it is easy to call this a century shaped by crisis like no other. Periodically, death tolls took a significant drop,[383] as this volcanic activity, inclement weather, and pestilence arrived, compounding their impact as they arrived in quick succession, increasing their impacts much more severely than if they were to happen on an individual basis. Climatically, the first half of the century was cool, with the AD 1740s and AD 1750s being particularly poor, more so in the west of Iceland.[384] The coldest years on record swiftly followed a period of rapid warming.[385] There were numerous examples of this collection of circumstances; a weakened population, feeling the impacts

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[380] O.U. Janzen, '"They are not such great Rogues as some of their neighbours": A Scottish Supercargo in the Newfoundland Fish Trade, 1726', *Newfoundland Studies*, 17(2001), p.294-309.

[381] D. Wheeler, R. Garcia-Herrera, C.W. Wilkinson & C. Ward, 'Atmospheric circulation and storminess derived from Royal Navy logbooks: 1685 to 1750', *Climatic Change,* 101(2010), p.257-80.

[382] M. Stephensen, '*Eftirmæli átjándu aldar eptir Krists hingaðburð, frá ey-konunni Íslandi'*, Leirárgörðum, (1806); Tomasson, 'A Millennium of Misery: The Demography of the Icelanders'

[383] Death tolls in Ísafjarðarsýsla were said to have jumped significantly after 1784.

[384] Ogilvie & Jónsdóttir, 'Sea Ice, Climate, and Icelandic Fisheries'; Wheeler, *et al.,* 'Atmospheric circulation and storminess derived from Royal Navy logbooks'.

[385] Wheeler, *et al.,* 'Atmospheric circulation and storminess derived from Royal Navy logbooks'.

of inclement weather, faced with a smallpox epidemic which coincided with the Bárðarbunga volcanic eruptions. The same environmental conditions would be creating problems of hunger and dearth (a problem which remained significant throughout the eighteenth century), and on another occasion, coincided with the Mývatn Fires, a low-energy but sustained episode (after the initial explosion) of volcanic activity at the Krafla fissure, lasting from AD 1724 until AD 1729. Öræfajökull erupted over the course of ten months from August AD 1727, causing *jökulhlaups*. The episode were severe given the contrasting conditions experienced compared with the relative calmness of the AD 1730s, thought to be driven by changes in the characteristics of the North Atlantic oceanic circulation, but the fact this area was previously destroyed in the fourteenth century somewhat minimised the direct impacts.

Decline in the Fisheries

Fishing grounds were closed in the AD 1750s, the Katla volcano erupted a significant explosion in October AD 1755, and the great famine of AD 1756-58 swiftly followed. This was said to have been triggered by poor climate, volcanic activity and the subsequent increase in acidity, and a lack of returns from the fisheries. However, it is not entirely clear whether the fishing grounds were closed before the famine as a direct result of acidification of the rivers and seas, or after it had commenced. Regardless of their exact commencement, these events compounded the misery, reducing the population by an estimated 6,000 people.[386] This is a significant proportion of the population, enough to make an impact on the labour force required to undertake seasonal operations in a fishing industry which was at times fluctuating and unreliable, hinting that the closure of the grounds was a post-famine event. Poor catches were

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[386] Karlsson, *Iceland's 1000 Years*, p.177.

reported in the AD 1740s and AD 1750s;[387] the lower rates of return, however, may be more to do with the reduced labour force rather than all-round poor stocking levels of the fishing grounds.

Changes Stemming from Denmark

Fortunes changed around the AD 1760s, along with a new Danish reforming mentality. Regulations passed in AD 1763 allowing foreigners into Icelandic waters; they, however, were not allowed to employ Icelanders.[388] This decision, likely made in Copenhagen, may have been fuelled by the hardship experienced in Europe from the early AD 1760s. Good fisheries were reported between AD 1766 and AD 1779. This change was timely; the Hekla eruption of AD 1766 proved to be the longest eruption in historical times, initially violent but calming down and lasting until AD 1768.[389]

In respect of the above-mentioned question of availability of labour to catch fish, it may have been the case that more people were focussing on the fisheries after AD 1766. Adam Smith in his book *The Wealth of Nations* noted a trend of investment into developing maritime societies when his book was published in AD 1776.[390] The increased effort and investment may explain the higher returns recorded. The increase in numbers involved in fishing might reflect elements of the population being driven

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[387] Ogilvie & Jónsdóttir, 'Sea Ice, Climate, and Icelandic Fisheries'.

[388] Eggertsson, 'No experiments, monumental disasters: Why it took a thousand years to develop a specialized fishing industry in Iceland'.

[389] Dawson, *So Foul and Fair a Day,* p.138, mentions that this year in Scotland was referred to as the 'Year of the Black Snow'.

[390] A. Smith, *The Wealth of Nations: Books I-III*, (London, 1776), p.342. Smith may have been influenced in this observation by the investment by the British Fisheries Society which was attempting to stem the flow of migrating individuals from Scotland to the New World. It is also worth noting that Smith recognised the role the environment had to play, that natural factors could determine whether you were successful in the fisheries as much as the influence of technological advancement.

into that occupation by the impact of the volcanic activity on the landscape, but market demand spurred by the hunger and hardship which was being experienced in parts of Europe might also have provided an economic stimulus.[391] Resources would be sought from greater distances as the population of Europe continued to grow.[392]

The strength of this theory that tephra deposition influenced the catches and economic behaviour in Vestfirðir is questionable, as the tephra was mainly deposited in a southerly direction, yet since it was the second-highest volume of volcanic output in historical times its impacts would typically be more widespread. A more likely suggestion would be landscape pressures, such as the heavy rainfall which was experienced in AD 1768 and generated high returns in the fisheries,[393] or the twenty year sheep epidemic which lasted until AD 1780.[394] These pressures and terrestrial failures were being recognised and had been for some time. Twenty years after the idea was first proposed, reindeer were imported to Iceland as a hardy animal and a replacement for the ever-dwindling sheep population which dropped sixty percent during the AD 1760s as a result of disease. Ultimately, the reindeer's heavy grazing on increasingly degraded landscapes simply compounded the problem so much that calls were made for a cull.[395] Interestingly, according to the schematic presented by Oslund, it appears that no reindeer were released in Vestfirðir. There are numerous theories why this was; it may have been that the region was never originally populated by sheep therefore did not require a replacement. It may have also been an area requiring no sort of investment and that economic conditions were generally better than elsewhere in

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391 Dawson, *So Foul and Fair a Day,* p.138.

392 Smith, *The Wealth of Nations: Books I-III*, p.342.

393 Jónsson, 'Fisheries off Iceland, 1600-1900'. Rainfall on a degraded landscape may have increased sediment influx, further supporting Holm's theory.

394 Oslund, 'Nature in league with man'. Others reveal the disease lasting until around 1770.

395 Ibid.

Iceland, or that the region at this point was not part of any forward-thinking developments in Iceland.

A Return to Growth

This growth in the fisheries would have been assisted by the temperatures which, depending on their starting position, warmed and cooled, shifting the polar front in the direction of Iceland. This narrow window of opportunity made it important that oceanographic conditions for fishing were ideal – too warm and the fish would spawn too far north and beyond a days sail away; too cold, there would be too much ice and the polar front would shift south. The boom in the AD 1770s was caused by the polar front shifting southwards,[396] peaking around AD 1780 and continuing right through the decade. However the swift drop in temperatures early on in the decade may have contributed towards a return to poor fishery returns through an inundation of sea ice closing the fishing grounds, and with the epidemic still present, high death rates were recorded. Despite these poor returns and the cessation of English involvement in the Icelandic fisheries, it was still attractive to foreigners. Dutch activity in Icelandic waters peaked in AD 1770.[397] Key to this success was a change in the technology; decked vessels were now being adopted in Icelandic waters, allowing fishermen to cure their catches offshore. By the AD 1790s such vessels were acquired by Icelanders, mainly in Vestfirðir and south Iceland.[398] Barrelling of catches was also being phased out in the late seventeenth century, with a salt-cure in the holds of vessels being the new favoured storage technique. These methods were generally used by foreign fishermen who had access to salt, although Icelanders began adopting this method after AD 1760 when

[396] Dawson, *So Foul and Fair a Day,* p.139.

[397] Robinson, 'The Fisheries of Northwest Europe, *c*.1100-1850', p.142.

[398] This was the first major change to boats as open rowing boats had been in use since *Landnám*.

Spanish merchants were bringing solar-dried salt and exchanging it for pre-salted fish. Air drying was not favoured by summer fishermen as catches tended to be spoiled by blowflies,[399] something which was not a problem to early Icelanders as their fishing season was predominantly winter. The first Icelander practiced salting in 1766, and by AD 1790 it was practiced at all major fishing stations, undertaken at purpose-built salt houses constructed by merchants.[400] By this time, sun-dried *saltfish* had replaced *skreið* as Iceland's main export article.

Changing Economic Conditions

Aside from the slowly increasing favourable environmental conditions, there were market opportunities outside Iceland driving these developments. The Mediterranean market was opening up once more, and the American market, which took merchants away from Iceland in previous centuries, was closing up. The American population was growing and, rather than shipping foodstuffs across the Atlantic for European populations to consume, they were being consumed by the growing number of inhabitants within the American continent. Given that Spain was one of the biggest consumers of North American cod, it is not surprising that the Spanish turned to Iceland for supplies.

The Laki Eruption of 1783

These developments happened against the backdrop of one of the greatest environmental disasters to happen in Iceland, the Laki volcanic eruption, beginning in June AD 1783. The impact of the eruption is at such a scale and took place at such a time

[399] Jones, 'England's Icelandic Fishery in the Early Modern Period'.
[400] Thór, 'Icelandic Fisheries, *c*.900-1900', p.330.

that it is one of the best-documented episodes in the history of pre-modern Iceland. Over a period of eight months, clouds of hydrofluoric acid and over 120 million tons of sulphur dioxide entered the atmosphere. The result was a prolonged episode of widespread dearth.[401] Fluoride ingestion caused bone formations and changes in bone shape in both humans and livestock, with many people dying through the ingestion of toxins. Skeletal remains dating from this period clearly show these deformities.[402] Estimates as to how many humans and livestock died during this episode vary; livestock numbers range from fifty to eighty percent, with human death rates being between twenty and twenty-five percent.[403] Immediately following the eruption, thirty-seven farms were destroyed leaving 400 people without shelter.[404] Subsequent food shortages and disease was said to have killed over 9,300 people during AD 1784-85.[405]

From an environmental perspective, the Laki eruptions were enormously significant. The precipitation which followed the eruption was highly acidic, destroying the inland fisheries, with the coastal fisheries not recovering until spring AD 1784.[406] Acid pulses in the water would lead to greater fish mortality.[407] Impacts were not only witnessed in Iceland; this was an eruption on a never-before seen scale, taking place in historical times, and found its way into contemporary written records. Unusual weather events and experiences were recorded in diaries and journals of the AD 1780s, many people

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[401] The 120 million tons of sulphur dioxide was three times the European industrial output for 2006, putting the eruption into a modern context.

[402] Fornleifastofnun Íslands, 'Annual Report', (Reykjavík, 2004).

[403] Dawson, *So Foul and Fair a Day,* p.146. The figure of 9,336 deaths from famine and disease is reported in Stephensen, M., '*Island i det Attende Aarhundrede'*, (Copenhagen, 1808).

[404] Tomasson, 'A Millennium of Misery: The Demography of the Icelanders'.

[405] Karlsson, *Iceland's 1000 Years*, p.180.

[406] D.E. Vasey, 'Population Regulation, Ecology and Political Economy in Preindustrial Iceland'.

[407] J.P. Grattan & F.B. Pyatt, 'Acid damage to vegetation following the Laki fissure eruption in 1783 – an historical review', *Science of the Total Environment*, 151 (1994), p.241-47.

documenting the same event from a multitude of perspectives. This period is often referred to as the *Móðuharðindin* (Mist Hardships) or the 'Laki Haze'. Crops and trees in eastern England and northern Germany were damaged through acid pollution in the atmosphere, and there was increased fish mortality witnessed in Scotland.[408] Those hit hardest by the hardships ate shellfish from the shore, a resource not typically consumed.[409] The gasses, which found their way into the atmosphere, caused an almost immediate cooling effect in the northern hemisphere.[410] This had a profound impact on the climate, with the winter of AD 1784 being exceptionally cold and subsequent seasons across Europe being erratic.

Vestfirðir's Good Fortune

The predominantly southerly direction of the tephra and pollution cloud meant that Vestfirðir was one of the least affected regions.[411] This reflects the significance of knowing the wind direction and weather patterns during times of eruption in understanding the impacts of the volcano and associated tephra on the surrounding landscape.[412] Mortality rates were the lowest in the country, although the colder weather in following years did cause a jump in death tolls in the Ísafjarðarsýsla hreppur. Aside from the acid pulses in the rivers and seas, the availability of a seasonal labour force would have been significantly disrupted. The Laki eruptions brought widespread change in Icelandic society and this was one of them; although the Vestfirðir region was spared from the direct impact of the eruption, the economic framework which was in

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408 Ibid.

409 Dawson, *So Foul and Fair a Day,* p.143.

410 Ibid.

411 Vasey, 'Population, Agriculture and Famine'.

412 S.M, Davies, G, Larsen, S, Wastegård, C.S.M, Turney, V.A. Hall, L. Coyle, T. Thordarson, 'Widespread dispersal of Icelandic tephra: how does the Eyjafjöll eruption of 2010 compare to past Icelandic events?' *Journal of Quaternary Science*, 25 (2010), p.605-11.

place incorporating other regions of Iceland would have been dramatically altered. There were plans originating from Copenhagen to evacuate Icelanders,[413] but with only parts of the country suffering during what was otherwise a successful time for the fisheries, the plans were shelved.[414] Farm bonds were introduced in Iceland in AD 1783, an attempt to encourage people to remain working on the farms rather than jumping aboard the fisheries bandwagon and migrating to coastal regions. It is likely that this political decision matured over the course of several years, fuelled by the innovation and ambitions from the mid-AD 1700s to make fishing a year-round economy. Its timing, however, has made some observers think that it was introduced in the immediate aftermath of the Laki eruption. In terms of making this incentive work, the timing could not have been any worse, with the terrestrial landscape under enormous pressure and bringing reduced returns in the aftermath of volcanic eruption and inclement environmental conditions.

Relaxation of the Danish Monopoly

Iceland's sub-standard living conditions in the context of Enlightenment Europe may have fuelled the ambition of Icelanders to develop economically. Such ambitions may have been the main contributing factor to the Danish decision to relax the trading monopoly with Iceland in AD 1788, a recommendation contained within a letter sent from Danish land commission officials.[415] The external perception of Iceland was that it lagged behind other provinces of the Danish kingdom. Efforts were made to modernise, and anything away from the modern was disregarded as inefficient and sub-standard.

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[413] Dawson, *So Foul and Fair a Day,* p.147.

[414] Oslund, 'Nature in league with man'. A motive behind this decision was for Icelanders to re-populate the Danish region of Jutland, which had dramatically depopulated during the eighteenth century as a result of sand storms and soil erosion.

[415] Oslund, 'Nature in league with man'.

After AD 1788, there was a surge in numbers of an Icelandic merchant class and subsequent widespread transition within the fisheries. The new demand, both from the Mediterranean market and also the burgeoning European population in conjunction with periodic dearth,[416] helped force up the price of fish, but this time it was in an era where enterprise was allowed to flourish. Investments could now be made, as mentioned previously with the successful introduction of decked vessels and widespread use of salt. Developments also took place at fishing stations; catches would now be processed on board and taken to trading ports rather than landing and being processed on shore. Despite this growing industry, between AD 1750 and AD 1775, sixty-three percent of the fish caught was said to have remained within Iceland for domestic consumption.[417] This figure does not, however, give any indication of fluctuations in catch sizes, nor indicate distribution patterns, or provide details on which areas of Iceland exported the majority of their fish stocks. This figure probably refers to landed catch figures and not all the fish caught, processed at sea and taken back to the markets of mainland Europe without ever reaching Icelandic shores.

By the end of the century, the fisheries had undergone complete transformation in Iceland, fuelled by demand, given the opportunity to flourish by the removal of restrictions, yet still shaped and determined by the greater environmental forces on the landscape and the population. Despite Iceland not being given the full benefit of free trade until the AD 1850s, it was still allowed to invest and modernise. This transition can be expected to reveal itself in the archaeological record; with the processing of fish

[416] Dawson, *So Foul and Fair a Day,* p.153. Famine was more of a causal factor in pushing up the price of fish in the early nineteenth century when persistent rain reduced food productivity.

[417] Thór, 'Icelandic Fisheries, *c*.900-1900', p.339. Somewhere between 3,000 and 4,000 tonnes were consumed by Icelanders out of a total catch of somewhere between 4,000 and 5,500 tonnes.

being conducted elsewhere, less activity would be taking place at fishing stations making them essential as a base, yet more peripheral as a working area.

An Industry Transformed

Entering the nineteenth century AD, the modernisation process continued. The most striking development was the construction of larger and more comfortable huts at major fishing stations. No longer were they seasonal and haphazard, but more permanent and made of stone, built on top of smaller, abandoned turf structures.[418] These substantial constructions show the investment that this industry was receiving and the wealth it was generating to make the construction worthwhile.[419] This investment, however, did not change the fact that Iceland was a country on the margins and disaster was never too far away. A strong El Niño event in AD 1803 brought persistent rains throughout the seasons and increased storminess throughout the North Atlantic.[420] Food shortages were widespread and it is suggested by some that it was the last famine ever experienced in Iceland;[421] around 450 people died from hunger and hunger-related illnesses. Although perhaps the last Icelandic 'famine' event, hardship remained prevalent in Iceland right up to the modern era like it had throughout history, instigated by events such as inclement climatic conditions, volcanic activity and epidemic. To say there were no episodes of widespread starvation in Iceland after AD 1803 does not reflect the true conditions within the country, nor give recognition of the periods of dearth which took place late on in the nineteenth century.[422] A growth in sea ice was

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418 Amundsen *et al.*, 'A 15th Century Archaeofauna from Akurvík'.

419 Thór, 'Icelandic Fisheries, *c*.900-1900', p.336.

420 Dawson, *So Foul and Fair a Day,* p.155. Dawson also suggests that more lives were lost in storms than in some conflicts (p.156).

421 Karlsson, *Iceland's 1000 Years*, p.251.

422 Ogilvie, 'Historical Ecology, Climate Change'.

also witnessed before AD 1820, a likely result of the AD 1815 eruption of Mount Tambora in the Philippines, after which sunlight was obscured for many months.[423] Heavy storms may have been the deciding factor in the construction of stone booths, to withstand the force of North Atlantic weather patterns where before they may have been forced to renew on an annual basis. In the AD 1860s, potato blight was said to have hit Iceland twice causing five percent of the population to die as a direct result, and despite this figure being less than in Europe it was still a sizable proportion of the population.

Fisheries continued to benefit from investment; there was a rise in *saltfish* production, pointing towards an overall growth in activity after the AD 1820s. Salt excise was abolished in AD 1825 which would have contributed to this growth. Free trade and growing urbanisation in Europe reinvigorated the shark trade, which had collapsed around AD 1550, as a result of the high prices being paid for train oil.[424] Ísafjörður in Vestfirðir emerged in the AD 1830s as the centre of the shark fleet, and added an additional dimension to the maritime economy. This was a wasteful industry; only the desired parts (such as livers) were brought ashore and the rest of the carcass left at sea.[425] It collapsed around the AD 1880s after the widespread introduction of gas as well as kerosene (paraffin) which forced down prices making shark-fishing for oil uneconomical.[426] The collapse was softened by the opening up of the Mediterranean saltfish market, with Spain being a significant consumer of Icelandic cod. These changes

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[423] Dawson, *So Foul and Fair a Day,* p.157.

[424] Train oil is defined as the blubber of any marine mammal, particularly (but not exclusively limited to) whales.

[425] Despite *hákarl* (shark meat) being a national dish it was still not the most favoured meat.

[426] Production was conducted on a small scale, mainly in the north and Vestfirðir.

occurred in a still changing environment, with severe storms remaining commonplace throughout Europe.

Mass-Migration Westwards: A Millennium Later

A series of volcanic eruptions took place in Iceland during the nineteenth century which had socio-economic implications on a never before seen scale. The temptation of a life in the New World was taken up by many Icelanders throughout this time, but a notable surge in numbers happened after the Askja eruption of AD 1875. Iceland was finding itself in the same position as Scandinavia a millennium earlier; the opportunity to emigrate presented itself and people moved *en masse*. Free trade was permitted in Iceland after AD 1855, possibly as a means of encouraging growth and stemming the exodus from the country. Similar schemes were put in place in Scotland early in the nineteenth century to promote economic growth.[427] Counter-balancing this population shift were advances in technology which ensured that catches could be obtained all year round, making the process of catching fish more efficient and making the process more resilient to environmental processes which would have an impact on them. The transition into a fully mechanised society was just around the corner. Ísafjörður in Vestfirðir was one of the first areas to fully embrace mechanisation of the fisheries and the shark trade, potentially following the same pattern as a millennium earlier as Icelanders took to the northwestern seas to meet the demand for fish.

Chapter Conclusions

This chapter has provided a historiographical chronology encompassing a period of 1,100 years, highlighting the processes and circumstances which went some way in

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[427] The creation of the British Fisheries Society was one of these ventures. For further reading see J. Dunlop, '*The British Fisheries Society, 1786 – 1893*', (Edinburgh,1978).

shaping the Iceland's historical narrative, particularly relating to its fisheries. The episodes determining various outcomes have been imposed at a range of levels, some taking place during times of stability and comparative environmental calm, others during times where vulnerability has been fluctuating and changes widespread.

The chapter reveals the broader pattern outlining the way in which fisheries have changed, how change has either been forced upon them or naturally evolved, how societies have responded to these transitions and whether the outcome can be viewed as successful in the full light of history. Contained within the historiographical chronology are episodes so significant that they almost undoubtedly helped shape Icelandic society. Episodes of this magnitude would without a doubt have left a mark within the cultural landscape. Despite this significance, the information still remains at a generalised and often nationalistic level; there is now a necessity to understand the variance and historiography on a regional scale. Often in the past, single events were interpreted as representing universal activities as a whole. Fisheries, within the historiography, present themselves as very linear, with regions either having positive or negative results. What the narrative lacks is a level of detail and resolution at a regional and site specific level which involves a more complex interplay of Iceland's maritime economy. The generation of information on a broader level is essential to provide a context, however, a successful interpretation from a heritage and cultural perspective depends on the ability to construct a narrative on a more specific and detailed scale, which can be linked across various sites before building back up towards a regional perspective. It is also important to be able to compare and contrast varying narratives, something which is a limiting factor in the historiography.

By applying geoarchaeological techniques and synthesising it with the historiography, new knowledge can be created from which an understanding of the past can be formed and the desired scale. It is the aim of the following chapters to develop the chronologies contained within the soil and sediment records, before integrating them back into this broader historical and environmental framework in order to construct original investigations and provide an explanation to the changes and responses witnessed in the Icelandic fisheries over time at a never-before explored site and regional level. The strength of this study will lie in its potential to show the differences within the Icelandic landscape over a comparatively small scale in reference to the existing narrative, as well as being able to triangulate and cross-reference various sources of information to weave together a complex and in-depth narrative.

Chapter Three – Field Sites, Geoarchaeological Overview & Methodology[428]

This chapter aims to provide a detailed overview of the study area, outline the role geoarchaeological investigations will play in enhancing the existing historiography, and demonstrate how the various parts of the methodology integrate with one another – from a macro to micro scale – to achieve the aims and objectives set out in chapter one. The research has been designed to take the general overview of the historiography and develop a more detailed, region-specific narrative applicable to Vestfirðir. It is by having a wider narrative that an understanding can begin to be developed, from which differences in the regional narrative can begin to be explored, permitting questions regarding specific economic activities and intensive occupational periods to be answered.

The discussion of the field sites will provide a detailed context of each area under investigation and allow the unique nature of each location to be understood, before discussing the advantages of implementing a chronological framework in generating a region-specific narrative, coupled with a series of geoarchaeological techniques. The rationale behind the selection of methods is discussed, before setting out how the results will be analysed. The research framework is designed as such to make the most of the integrated methodology and understand the interaction environmental and social processes which have helped generate the cultural material now retained within each stratigraphy.

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428 The reason for the geoarchaeological overview being contained in this chapter (opposed to chapter two) is that the higher resolution of detail would take away from the thematic and chronological narrative of the previous chapter. Given the importance of geoarchaeology and thin section micromorphology to this research, a more detailed overview of research and themes is required.

Field Sites

The triangular-shaped region of Vestfirðir possesses the poorest quality land of any of Iceland's perimeter landscapes. It is peninsular, with only a ten-kilometre land link to the southeast joining it with the rest of Iceland. Located between sixty-five and sixty-six degrees north, this is a region mainly consisting of coastal and highland ecology. The steep oceanic shelves are close to the continual band of mountainous cliffs, which wind their way round the perimeter of the peninsula, forming fifty-two deep fjords, increasing the richness of maritime resources.

These are comparatively sheltered areas which offer the best protection against the North Atlantic Ocean and the Denmark Strait despite facing the open sea.[429] The fjords and coastal waters are the basic areas where the larvae mature and the young fish feed. The greatest amounts of quality fish, however, came not from the fjords but from the seas and the deep water fishing grounds not far off the northwest tip of the peninsula.[430] The marine catchment circle, the radius from the fishing base in which fish were generally caught, was on average twenty kilometres for a six-oared boat. In Vestfirðir, boats varied from two to eight oars, but the six-oared boat was most common.[431] The location of the Polar Front, where the warm waters from the Gulf Stream meet the cold Arctic waters and the melting ice caps during the summer months, determines the distribution of the feeding grounds, creating a very specific hydrographic character that brings with it a greater number of maritime species. Most of the fresh water entering

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[429] T. Tulinius, 'The Westfjords', *Archaeologia Islandica,* 4 (2005), p.9-15; Gardner & Mehler, 'English and Hanseatic Trading and Fishing Sites'.

[430] P. Urbańczyk, *Medieval Arctic Norway,* (Warsaw, 1992), p.30.

[431] R. Edvardsson, S. Perdikaris, T.H. McGovern, N. Zagor & M. Waxman, 'Coping with hard times in NW Iceland: Zooarchaeology, history, and landscape archaeology at Finnbogastaðir in the 18th century', *Archaeologia Islandica*, 3 (2004), p.20-47.

the fjords occurs during the summer months when meltwaters from the mountains increases riverine flow.

With this topographical extremity comes the interpretation and assumption that good quality pastoral land would be largely absent. There were nevertheless some fertile valleys present within Vestfirðir. The shelter provided by the near-vertical cliffs allowed hay to be grown to feed a limited livestock population during the winter months, however, this hay-yield was not significant enough to go beyond a subsistence level. In the southeast of the region, some farmers were able to take advantage of being close to the vast numbers of sea birds nesting on the steep cliffs, and of course there was the importance of fishing; it was said that fishing boats in Vestfirðir rowed out of almost every bay and cove.[432] Topographically, the region appears isolated, but the coastal areas were connected to the rest of Iceland by a series of mountain passes which criss-cross and connect where the peninsula narrows. This route system would have provided connections through which an overland distribution network could be created, providing an opportunity for prosperity.

The question of Vestfirðir's prosperity in the earlier Middle Ages is currently a subject of debate. Through findings in the archaeological record, such as beads associated with Viking Age burial as well as the uncovering of a longhouse, wealth and power is said to have developed soon after *Landnám* in the Vestfirðir region. The origin of this wealth is not fully understood; with there being two probable sources. It may have been inherited wealth from the Norse homeland,[433] or accumulated wealth through control,

[432] Thór, '*Sjósóku og svávarfang: Saga Sjávarútvegs á Íslandi.'*

[433] Byock, *Viking Age Iceland.*

exploitation and distribution of maritime resources,[434] or even a combination of both. Other parts of Iceland accumulated wealth through the trade and exchange of terrestrial-based surpluses from a pastoral economy,[435] but this was not an option for people residing in Vestfirðir due to the fact the area was agriculturally poor in comparison to the rest of Iceland.[436]

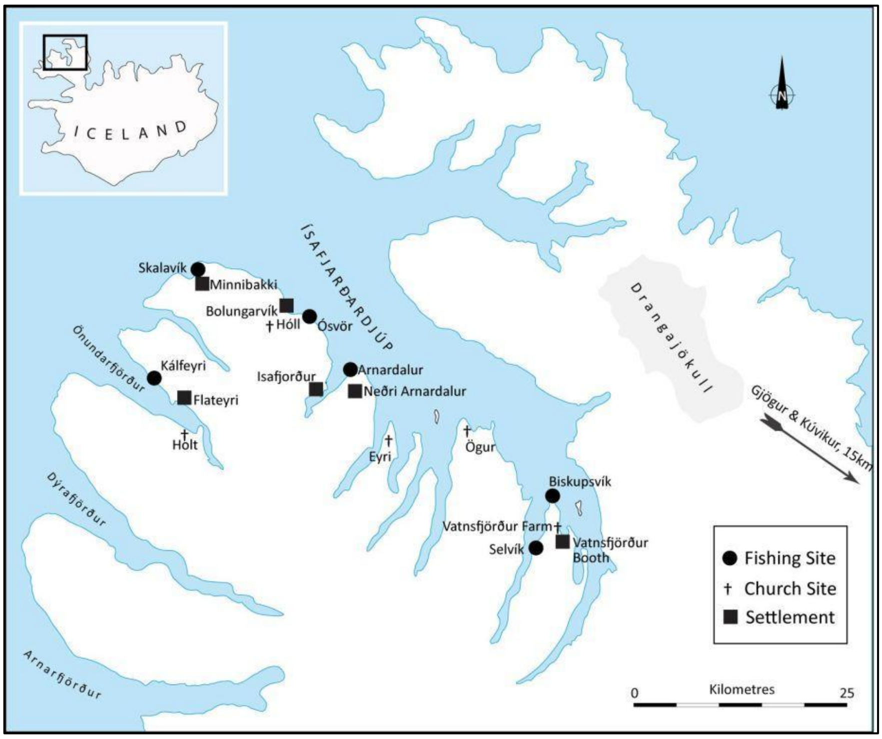

Figure 11: Field Sites within Vestfirðir, Iceland

The sites that form the core of this research are concentrated within the Ísafjarðardjúp and Önundarfjörður fjords (Figure 11), with the former extending right from the heart of the region. Numerous sites relating specifically to fishing activity can be found around the peninsula.[437] Almost directly at the centre of the triangular-shaped region is Vatnsfjörður, the farm which apparently served as a power centre from the ninth to

[434] Edvardsson, 'Commercial and Subsistence Fishing in Vestfirðir'.

[435] Edvardsson & McGovern, 'Archaeological Investigations at Vatnsfjörður 2003-2004'.

[436] Ibid.

[437] Aldred, 'Landscape Research in the Northwest'.

fifteenth centuries.[438] The farm occupies a location which brings together the Ísafjarðardjúp fjord with the mountain passes which provide overland access throughout Vestfirðir.

Seven sites were identified for field-based investigation and sampling, each one being selected to give a representation of inner fjord and outer fjord areas with the selection criteria being based on variables such as accessibility and existing site knowledge as well as reference in historical records, such as *Jarðabók*.[439] Sea level around the time of *Landnám* was estimated to be around two metres higher than it is today,[440] slightly modifying the spatial relationship we see today between the fishing booths and where the occupants entered the sea. Vatnsfjörður Farm was selected to give a terrestrial comparison on the basis that it was known to have been a site of early power and unlikely to have been used as a base for a specialist fishing community. Many sites, where specialist fisheries were located and have been documented in the historical record, have since vanished as a result of coastal erosion or modern-day road construction.[441] Both of these widely differing processes express little consideration for the preservation of historical remnants relating to Iceland's cultural past.[442] The selection of fishing sites was chosen for analysis loosely using Ísafjarðardjúp as a

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[438] Tulinius, 'The Westfjords'. The term 'power centre' refers to the individuals or families who would inhabit the farm, exercising their control over their immediate vicinity and beyond. Historically, figures who have been associated with power and control in Vestfirðir have been associated with Vatnsfjörður, some of whom will be detailed below.

[439] Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland'.*

[440] Ł. Mikołajczyk & L. Gardeła 'GPS survey in the coastal area of Vatnsfjörður', in K. Milek, (ed.) 'Vatnsfjörður 2009: Interim Reports', Fornleifastofnun Íslands FS499-03099, (Reykjavík, 2010).

[441] With the sea level in Ísafjarðardjúp during the Viking Age being around two metres higher than it is today, this may be regarded as some sort of buffer against coastal erosion, ibid. If the sea level had remained around the same level as centuries previous, the impact of erosion around the coast might be considerably different.

[442] A fishing station near Bolungarvík, Ósvör, was lost due to road construction in the twentieth century. A reconstruction has since been assembled allowing visitors to experience an interpretation of nineteenth century stone fishing booths.

transect line, with the farm positioned at the heart of the fjord and fishing stations identified in a progression in a northwesterly direction out towards the open sea.

At each coastal site, a pit was inserted, positioned close to the front of the structure, categorised as the side facing the open water. Focus was on this immediate area, as it is likely to have represented a concentration of activity which would have deposited wastes relating to daily life. These wastes generate a sheet midden, from which samples can subsequently be obtained from. Sheet middens are archaeological artefacts which contain discarded materials found on the soil surface opposed to stratified heaps.[443] These are regarded as representing the remnants generated from daily activity on the site through daily discard behaviour rather than specific patterns of dumping,[444] a reason justifying their selection in this research. Some dismiss sheet middens and their contents in favour of midden heaps, however, sheet middens have been identified as having high analytical potential containing a rich volume of information relating to on-site behaviours.[445] It can be argued that with wastes being so valuable to other parts of the economic unit, a concentration of midden material in a spoil heap would contain select materials of lesser value to the contemporary society, giving weight to a sheet midden which would be in receipt of all activity and wastes which were to come into direct contact with the site. Areas of the Icelandic landscape, including field systems associated with upland structures have been used to represent occupational activity associated with relevant structures, allowing for a non-invasive approach which still

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443 Arizona State Museum – Definitions <http://www.statemuseum.arizona.edu/crservices/azsite/featerms.shtml> [Accessed 13/12/2011]

444 N.M. Versaggi, 'Decoding the message in the midden: what can nineteenth-century sheet refuse tell us?' in J.P. Hart & C.L. Fisher (eds.), 'Nineteenth- and Early Twentieth-Century Domestic Site Archaeology in New York State'. New York State Museum Bulletin, 495 (2000).

445 Ibid.

retains a high level of detail.[446] This method does not require the disruption of any structure, allowing the preservation of the site and structures for any potential excavation in the future. The inside area of abandoned structural remains were often used as dumping grounds for domestic refuse, as demonstrated in the early twenty-first century excavations at Skálavík,[447] which can make interpretation increasingly difficult.

Vatnsfjörður Farm was different from the coastal locations, in that the farm mound rather than the sheet midden was sampled to give a terrestrial comparison. Once excavation of each site had bottomed out the pit (determined by bedrock or the water table), the stratigraphic horizons were subsequently identified. The stratigraphic profile was drawn up at a 1:10 scale using standard archaeological equipment (spirit level, string, galvanised nails, centimetre foot rule), with the colours of each stratigraphic horizon recorded in accordance with the internationally standard Munsell® Soil Colour Chart.[448]

Once recorded, samples suitable for determining radiocarbon ages within the stratigraphy were sought (predominantly *Betula* charcoal), with the key sample coming from as low as possible in the stratigraphy to determine the oldest age. Kubiëna tins, aluminium boxes measuring eight by five by four centimetres, were then inserted into the stratigraphy at positions aimed at providing as much representation of undisturbed stratigraphic variance as possible, generally between two or more horizons. Once their position was recorded, they were removed and sealed. From the remaining, now uneven and partially sampled from stratigraphy, bulk soil samples were taken from each

[446] Simpson, personal communication.

[447] Edvardsson, 'Commercial and Subsistence Fishing in Vestfirðir'.

[448] Munsell Soil Color Chart. www.munsell.com

identified stratigraphic horizon (where possible) for subsequent analysis at the University of Stirling laboratories.

Vatnsfjörður Farm Site

The farm at Vatnsfjörður (Figure 12) is located around 100 metres from the shore on a peninsula between Reykjafjörður and Mjóifjörður fjords, and in the southwestern corner of Vatnsfjörður fjord. Vatnsfjörður is mentioned in *Landnámabók,*[449] which dates from the twelfth to thirteenth centuries but which purports to record life in Iceland around the time of the first settlement of the island. Through historical document and archaeological interpretations, its excavators Ragnar Edvardsson and Thomas McGovern have contributed significantly to the wider debate on early Icelandic society.[450] It was previously thought that Vestfirðir was settled later than other parts of Iceland and by people of poorer social standing. The region was also regarded as physically and culturally isolated, and considered to have played only a passive role in the Icelandic economy. As mentioned in chapter two, overseas visitors since the seventeenth century produced an often fictitious interpretation of Icelandic history, which has helped to distort modern perceptions of Iceland and its regional economies. By the time the likes of Ólafsson and Pálsson became familiar with the region, its economic and power base had gone and the terrestrial resources which remained were scant, giving the perception perennial poverty and a false impression of continuity at this level.

Within Vatnsfjörður's excavated archaeological record, cultural remains dating to the tenth century were thought to be representative of accumulated wealth, attributed to

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[449] *Landnámabók,* Chapter 51.

[450] Edvardsson & McGovern, 'Archaeological Investigations at Vatnsfjörður 2003-2004'.

the systematic and organised exploitation of the area's natural resources in a period shortly after *Landnám.* These findings alone revolutionise the early economic history of Iceland as well as raising questions of trading systems in this isolated region. The economic power contained within the region is thought to be parallel to that of nationally important ecclesiastical sites at Skálholt and Hólar.[451] Historical evidence, which emerges from the sagas, suggests that Vatnsfjörður was one of the largest seats in Vestfirðir and the farm of the most important chieftains from AD 1000 to AD 1300. Sagas such as *Hrafns Saga Sveinbjarnarsonar* details Vatnsfjörður chieftains at the beginning of the Sturlung Age.

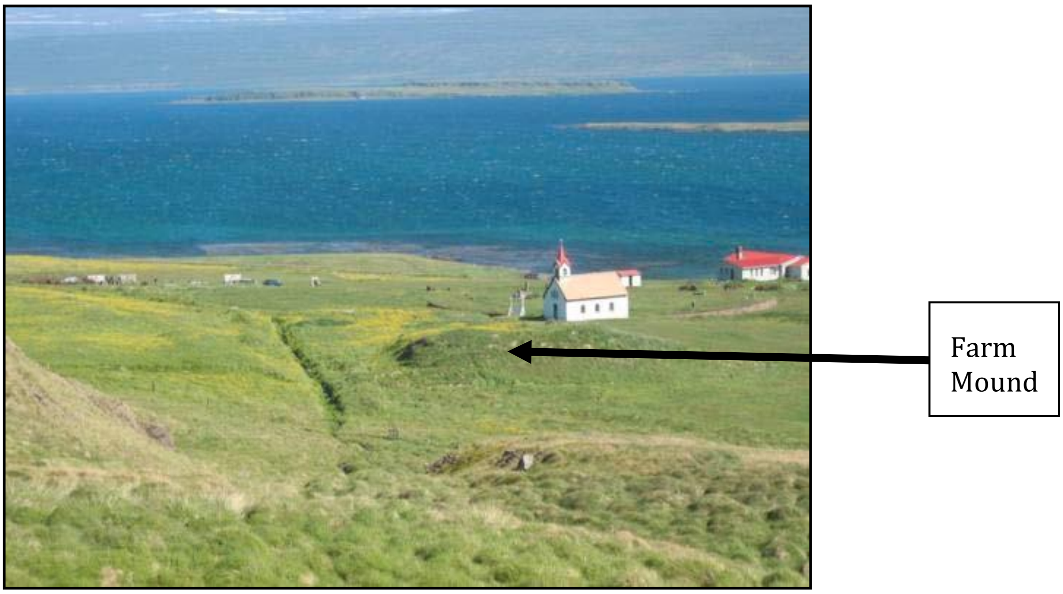

Figure 12: Vatnsfjörður Farm, looking northeast

One such example is that of Þorvaldur Snorrason, chieftain of the Ísafjörður area who resided there from AD 1160 to AD 1228. Þorvaldur was a rich magnate who also served as head of the *Hriðstjóri*, the Norwegian Court, for the north and west of Iceland, a

[451] Ibid.

position which without doubt came with advantages in respect of trade. His direct descendants continued to control Vestfirðir well into the sixteenth century AD.[452]

The efforts of Þorvaldur and his descendants were apparently successful, given that during the time when *The Sagas of Icelanders* was being composed in the thirteenth or fourteenth century, Vatnsfjörður was one of the richest farms in Iceland. It was, moreover, the seat of the Vatnsfirðingar clan, one of the most powerful families in Iceland. Björn Þorleifsson, one of the wealthiest and most powerful individuals in fifteenth century Iceland bought Vatnsfjörður and some other properties within the region in AD 1433. Their acquisitions extended right across the Vestfirðir region of Iceland. From these acquisitions, further economic and political power grew allowing Björn to rule over a large number of farms in Vestfirðir, obtaining rents in the form of marine produce[453] This power remained until AD 1467 when he was killed along with his men by English fishermen.[454]

Not only does this event confirm that there was contact between Vestfirðir and England by the mid-fifteenth century AD, it also underscores that there was conflict between

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[452] Tulinius, 'The Westfjords'.

[453] A. Sigurjónsson, 'Vestfirðingasaga 1390-1540', (Reykjavík, 1975), p.114-16; J. Hjaltason, '*Frá Djúpi og Ströndum, Ísafoldarprentsmiðja'*, (Reykjavík, No Date). Citation in Edvardsson & McGovern, 'Archaeological Investigations at Vatnsfjörður 2003-2004'.

[454] Genealogical Record: Björn Þorleifsson < http://poslfit.homeip.net/cgi-bin/genea.pl?60165> [Accessed 16/11/2010]. This site is a family tree. The death of Björn was a result of conflict over marine resources. His role was to enforce Danish regulation over Icelandic resources and ensure revenues were collected as a way of re-strengthening the rule of the Danish crown which had lost some of its power over Iceland during the century. Being honoured by the Danish nobility a decade previous and effectively having rule over Icelandic resources did not hold him in the highest regard from native Icelanders who did not seem overly concerned regarding his death. Resources were the most important factor, and they dealt with the English fishermen in their own manner, but by allowing the conflict to take place, they (temporarily) removed the ruling hand of Denmark from their prized resources. See K.A. Seaver, '*The Frozen Echo: Greenland and the Exploration of North America, ca AD 1000-1500',* (Stanford, 1996), p.318 for a more in-depth interpretation. This opinion, referenced from the saga literature, may have been conditioned by the underlying nationalistic opinion from the nineteenth century onwards and the overall negative perception of Danes.

Icelanders and Englishmen most likely to do with the control and distribution of resources. It appears there were two very different welcomes for overseas visitors; traders were very much welcomed, but fishermen were seen as a threat, something which stems back to earlier in the fifteenth century.[455] There also appears to have been strong ties between this region and Denmark. Björn Þorleifsson's grandfather, Björn Einarsson, was the governor of Vatnsfjörður and had enough wealth to travel to Jerusalem.[456] In his entourage, he had poets, signifying his wealth and culture and perhaps signalling control of an apparently affluent region, something that is very much at odds with the negative post-medieval view of Vatnsfjörður's place within Icelandic society. His father had been the knight governor of Vatnsfjörður before his death in AD 1342, and his great-great-grandfather was the celebrated saga-writer Snorri Sturluson.[457] The surge of culture and verse, music and painting right up until the end of the seventeenth century has been claimed to have been facilitated by favourable economic conditions.[458] A shift of power away from Vatnsfjörður, however, had perhaps already begun during the sixteenth century as Ögur, a neighbouring farm on the peninsula to the west, grew in importance. Vatnsfjörður nevertheless did hold significance until around AD 1700.

In the eighteenth century land-register known as *Jarðabók*, Vatnsfjörður is of unknown value but registered as a church farm and 'beneficium'.[459] It was compiled in AD 1712 when economic and social power was believed to have moved away from Vestfirðir. Its

[455] Seaver, '*The Frozen Echo',* p.318.

[456] Genealogical Record: Björn Þorleifsson <http://poslfit.homeip.net/cgi-bin/genea.pl?60165> [Accessed 16/11/2010]

[457] Genealogical Record: Einar Eiríksson <http://poslfit.homeip.net/cgi-bin/genea.pl?60177> [Accessed 16/11/2010]

[458] Tulinius, 'The Westfjords'.

[459] These benefices were free from all tithes, making actual values uncertain.

account of Vatnsfjörður may provide an accurate, contemporary interpretation, skewing perceptions of the historical reality of the location. At the time of writing early in the eighteenth century, *the church farm owned two boat places at the fishing station in the farmland of Hóll in Bolungarvík*,[460] an example of outer fjord fishing stations at considerable distances from the home farm but closer to the deepwater fishing grounds. The inner fjord location, somewhere *in Vatnsfjarðarnes, had long since been abandoned given that fish had long since migrated so far into the fjord*. Up to five sites in the area have been recognised by modern landscape archaeologists as potential fishing stations, although more detailed specifics regarding the location of the site referenced in *Jarðabók* remain absent.[461] Reference to the depleted fish stocks contributed to the increasingly grim picture of Vatnsfjörður and its environs during the eighteenth century; *outfields were waterlogged and hay meagre for use, turfcutting was bad, there was little birch to burn, and little in the way of freshwater fish such as trout and few seagulls eggs*.[462] The fishing booths at distant Bolungarvík appear to have been a lifeline. When recovery from this depression did take place in the nineteenth century, innovative techniques to exploit the maritime resources, including whales, shark and fish, became established in Vestfirðir, leading the way in the development of modern fishing that we can see today.

Vatnsfjörður has for a long time also been historically significant from an ecclesiastical perspective. The farm was classed as a Church Farm, and was a property controlled by

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460 Magnússon, & Vídalíns, '*Jarðabók'*.

461 Aldred, 'Landscape Research in the Northwest', Taken from the map in Magnússon, & Vídalíns, '*Jarðabók',* p.22, details that it was used by one or two boats during the spring and autumn fishing seasons, but there had been no fishing since the plague. What plague the author is referring to is questionable.

462 *Jarðabók* translations provided by Ragnar Edvardsson, taken from the Land Registry of Árni Magnússon. Magnússon, & Vídalíns, '*Jarðabók'.*

the church under the diocese of Skálholt in the south of Iceland.[463] A church was constructed in AD 1150 although it was likely that a chapel was constructed on this site not long after the Christianisation of Iceland around AD 1000.[464] It was where the greatest chieftains of Iceland were said to have had their base from the eleventh to thirteenth centuries.[465] The influence of bishoprics grew *c.* AD 1300, around a time when chieftain power was diminishing and they began to accumulate fishing farms and fishing stations through gifts and confiscations. Two priests and one deacon were said to have been in residence there.[466] They were not alone in growing their power base as this practice was also followed by leading families.[467] A parish church, in place since the Reformation, remained at Vatnsfjörður until being moved to Súðavík in the twentieth century.[468] The church became a *staðir* sometime shortly after AD 1500 (Figure 13).[469]

Returning to the archaeological evidence, the radiocarbon assay obtained by Edvardsson and McGovern's AD 2003-04 excavations at Vatnsfjörður dates the longhouse unearthed in that season to between AD 900 and AD 950.[470] This early date directly contradicts the opinion that the farm here was less significant and settled much later than the rest of Iceland.

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[463] S. Júlíusdóttir, '*The Major Churches in Iceland and Norway; A Study into the Major Churches in Skálholt Diocese and Bergen Diocese in the 11th to the 15th Centuries',* (Bergen, 2006).

[464] Vésteinsson, '*The Christianisation of Iceland*'; Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland'.*

[465] Jónsson, G. (ed.) *Íslendinga Sögur I*., (Reykjavík, 1968); Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland'.*

[466] Júlíusdóttir, '*The Major Churches in Iceland and Norway'.*

[467] Karlsson, *Iceland's 1000 Years*, p.107.

[468] Edvardsson & McGovern, 'Archaeological Excavations at Vatnsfjörður 2003-04'.

[469] Júlíusdóttir, '*The Major Churches in Iceland and Norway'.*

[470] Edvardsson & McGovern, 'Archaeological Excavations at Vatnsfjörður 2003-04'.

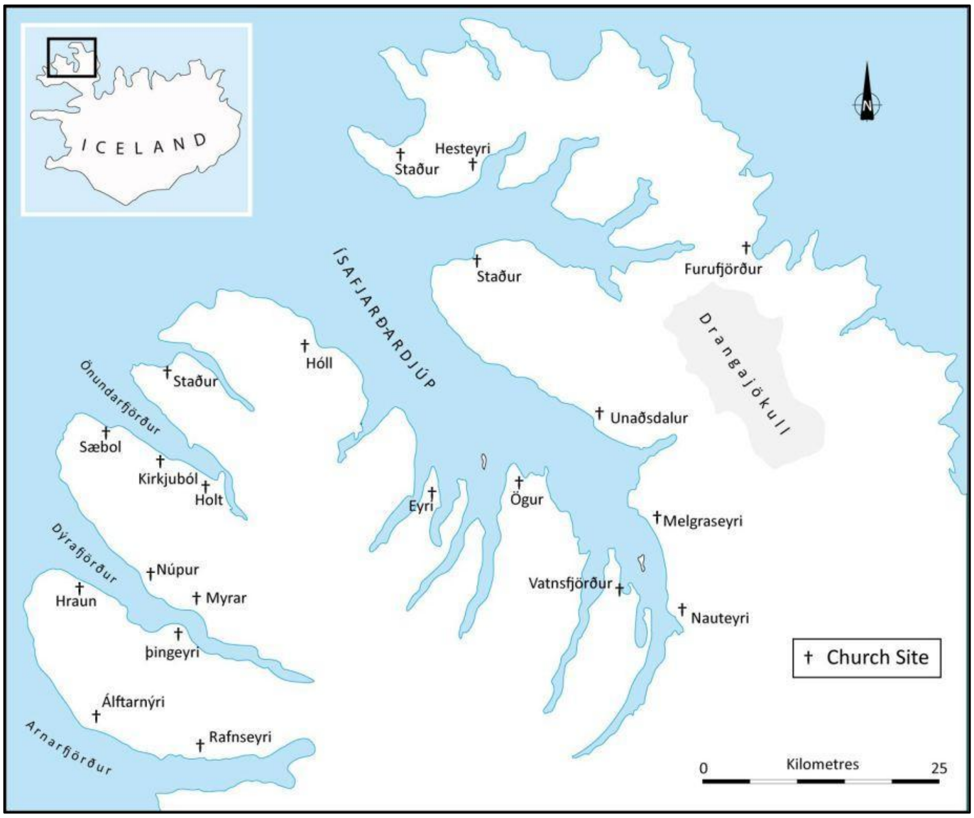

Figure 13: Church Sites in Vestfirðir

Little in the way of preserved fish bones has been identified amongst the early archaeofauna, giving rise to the suggestion that the site was associated with leadership and high-status residence and not with basic resource processing and manufacture. This has prompted excavations elsewhere on the farm mound, which will form a terrestrial and baseline component of this research. By interpreting and understanding the baseline, interpretation of wastes relating to everyday activities can be conducted with greater confidence. Changes observable in the midden stratigraphy can potentially reflect the wider social and environmental changes which perhaps took place throughout the region and indeed the country. The farm mound itself measures ninety by sixty metres. It is located to the southwest of the present day church and graveyard, and is composed of structure remains, household refuse and small-industrial wastes. A smithy was found nearby in AD 2005, and artefacts identified as originating in Ireland were found in AD 2006.[471]

Figure 14: Vatnsfjörður Farm Mound Stratigraphy

The mound was known to have been abandoned only in the AD 1950s and there had been some disturbance in the uppermost parts of the farm mound stratigraphy. This disturbance was related to the insertion or cleaning up of a drainage channel which was re-routed less than 100 years ago.[472] This channel has assisted in improved drainage in the areas around the farm, facilitating reconfiguration and field levelling during the

[471] Fornleifastofnun Íslands, Annual Report, (Reykjavík, 2004).

[472] Edvardsson, personal communication.

twentieth century.[473] Despite this relatively recent intervention in the upper levels, the lower parts of the mound remained relatively undisturbed. Three test trenches were dug into the farm mound (Figure 14), exposing the accretional stratified deposits of domestic refuse, one of which was selected for sampling.[474] From this stratigraphy, twenty-six bulk samples, three radiocarbon dates and eight soil thin sections were acquired.

Selvík

The fishing booth site at Selvík is likely to have had its catching grounds in the inner fjord areas of Mjóifjörður and the southern waters of Ísafjarðardjúp. Place name evidence is rather opaque. *Sel* is the Icelandic word for a shieling, but the term *skali* is also used in describing shielings or temporary huts.[475] The description of these non-permanent structures fits in with the depiction of early fishing communities, of seasonal migration and annual reconstruction efforts.[476] With the inner fjord location and being close to a home farm, *sel* may be referring to the secondary, terrestrial function of dwellings which may have been on the site. Additionally, some place names with the prefix *sel-* derive from the Norse word *selr* (seal). This too would fit in with any maritime role the site may have had. It is almost universally agreed that the suffix –*vík* is interpreted as a small bay or an inlet. *Jarðabók* mentions a fishing location somewhere in Vatnsfjarðarnes, not inhabited since the plague.[477] It may be possible, although doubtful, that this site is the location being referred to, something which a

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473 Fornleifastofnun Íslands, Annual Report, (Reykjavík, 2004).

474 Two of the three trenches experienced flooding as a result of the positioning of the stream.

475 Place-Names in *Landnámabók* <http://my.stratos.net/~bmscott/Landnamabok_Place-Names.html> [Accessed 16/11/2010]

476 Edvardsson, 'Commercial and Subsistence Fishing in Vestfirðir'.

477 Magnússon, & Vídalíns, '*Jarðabók'.*

secure radiocarbon chronology can assist with. No fishing station is identified here in the eighteenth century, which suggests that if there is a maritime history at this location it belongs to a much earlier period.

Figure 15: Selvík Shell Midden Stratigraphy

The bay at Selvík contains three structures which face a northwesterly direction, all adjacent to each other and in a line parallel to the shoreline around twenty metres away. The rocky foreshore would have provided suitable landing places. Around seven metres to the north of the structures there is a free-flowing stream which cuts through the steep hillside. It would have been an ideal source of clean, fresh water, and would have taken processing residues out into Mjóifjörður. This series of booths is located on the land of a nearby farm called Skálavík.[478] It may have been that this was classified as a *haemraeði* on land belonging to Skálavík, used by a farmer-fisherman, and a few farm hands. Half of the Skálavík farm was owned by the church at Vatnsfjörður.[479]

Six pilot trenches were dug around the structures (Figure 15), which revealed that the surrounding soils were organic and shallow with depths no greater than twenty centimetres being achieved. During occupation, it may have been that the buildings stood on a rocky foreshore and the organic, peaty accumulation has been a more recent phenomenon. At the southern edge of the largest of the three structures, interpreted as the main structure on the basis of its size, was a significant shell midden deposit. The sheet midden stratigraphy was recorded and sampled for laboratory analysis with material obtained for radiocarbon dating.

Biskupsvík

The fishing booths at Biskupsvík are located on the eastern edge of *Langamyri* bog,[480] close to the northernmost point of the Vatnsfjörður peninsula, Vatnsfjarðarnes. It is highly probable that the site mentioned above, noted in *Jarðabók*, is this site. The place name translates simply as Bishop's bay, cove or inlet. Despite being in a cove, the site is still exposed to winds driving down the length of the fjord. Present are the remains of two detached structures accompanied by a nearby cairn, sheltered to the south by a short but steep hill. A crescent-shaped shell-rich shoreline is located around twenty metres from the structures (Figure 16). With the shoreline being of a finer material consistency, some sort of shoreline construction may have been required to make

[478] This is not to be confused with the fishing station of the same name northwest of Bolungarvík.
[479] Edvardsson, personal communication.
[480] This translates as long bog, or long swamp.

landings safer in the absence of a rocky foreshore. The landscape to the south of the structures is an elevated marshland, with runoff streams providing a source of water although these are not found in great quantities. These fishing booths perhaps would have been owned by farmers, and housed no more than two boats. Tolls were paid to Vatnsfjörður farm, and what was landed here was more for subsistence and said to be of little commercial value.[481] Construction probably dates from no earlier than AD 1700, which when cross-referenced with the information from *Jarðabók* means that these were not the mentioned Vatnsfjarðarnes fishing booths (as they have not returned fish since the plague). It may be that *Jarðabók* was referring to the commercial operation of the location, thereby not acknowledging any subsistence returns which were obtained. Although unlikely, it may also have been that the owners of Vatnsfjörður declared that the sites were returning no catches so as to evade any taxation or payment. The most likely possibility is that the site was constructed around the time *Jarðabók* was produced, and therefore was not included in any reference to the area. This would, in turn, mean that the sites mentioned in *Jarðabók* were located elsewhere in Vatnsfjarðarnes.

Four sample pits trenches were dug in the area surrounding the structures, with samples for radiocarbon, laboratory and thin section micromorphology analysis obtained from the stratigraphy of an area directly to the north of the largest fishing booth, which was also the closest one to the foreshore.

[481] Edvardsson, personal communication.

Figure 16: Biskupsvík Bay, looking northeast towards Drangajökull

Vatnsfjörður Booth

Positioned around 100 metres to the northeast of Vatnsfjörður farm is a *þurrabuð* (cottage) where poor people resided.[482] These were said to be common on church lands in Iceland between the eighteenth and twentieth centuries AD, and totally dependent on the main farm.[483] Knowledge of the *þurrabuð* is limited; but it may have functioned as a fishing station prior to becoming a *þurrabuð.* It is known that the inhabitants of *þurrabuð* would have lived mainly on fish, signifying its importance as a source of protein amongst the wider and more peripheral Icelandic community. There is one structure found at this location, and an absence of features which would point towards it functioning as a fishing booth. It is the closest archaeological structure to the boathouse, positioned on the shoreline close to the farm. The boathouse appears to have been built for a larger vessel rather than the standard size of fishing boats which were found at

[482] Ibid.

[483] Ibid.

Vatnsfjörður prior to the twentieth century AD. This larger scale would seem to imply that it is a later construction, or that its function was to house a cargo boat for the transportation of materials and merchandise falling under the control of Vatnsfjörður. Given the potential absence of industrial activity on this site, it is possible for it to be used as a control against other sites.

Figure 17: Calcareous Deposit overlain by a rich organic layer, Vatnsfjörður Booth

Two sample trenches were dug to the southwest and northwest of the structural remains, with samples for analysis taken from the stratigraphy of the southwest trench Figure 17). Excavation was not possible at the front (northeast) of the structure as there was no soil or sediment present with it butting right on to the rocky foreshore. The building may have been built against the rocky foreshore, or the coastline here may have been eroding away. The sample pit provided a unique stratigraphy, with a thick horizon of weathered beach and broken shell material underlying a thick horizon of peaty material. This may be representative of a continuous period of abandonment, or a single unique weather event which has taken place, providing a sizable deposit as one distinct and complete horizon.

Arnardalur

This site is positioned on the eastern shore of Skutulsfjörður[484] (Figure 18). The place name translates as the dale or valley belonging to Arnar. Historical sources first mention the site in the eighteenth century, but no earlier sources exist.[485] Here is the site of former fishing booths, some of which have been expanded and modernised and are still being used as storage sheds and lock-ups today. Despite this being the only site interpreted as a fishing booth location still in use, it echoes an age old practice of Icelanders and Nordic cultures that have a tendency to build upon the remnants and structures associated with former land use.[486] The habit of rebuilding goes back a long way. Some view this as a way of associating with past generations; others see it as a more practical decision. A good location is of paramount importance, and building on top of wastes and middens provided additional heat and insulation, something highly valued in such colder landscapes.

Historically, the fishing station was a property of the privately-owned farm, Arnardalur-Neðri, who paid nothing to the church other than tithes.[487] Tolls obtained from the fishing station were paid to the main farm. Nearby is *Fremri-Arnardalur*, a place-name

[484] Skutulsfjörður translates as harpoon's Fjord, after Helgi Hrólfs' son is said to have found a harpoon at the water's edge.

[485] Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland',* p.170.

[486] Reference the building on farm mounds and anthropogenic accumulations.

[487] Edvardsson, personal communication.

which translates as 'foreign exchange', indicating that at some point this area may have had a wider trading function. Despite the presence of modern structures, some pre-modern remnants are still evident, providing the opportunity for field surveying, trench excavation and sampling. Twelve identifiable structures and other remains line up side-by-side facing the open water, with entranced orientated in a northwesterly direction. Running through the northern end of the site is the Arnardalur stream, which would have provided fresh running water.

Two test trenches were excavated to the southeast and northwest of the largest ruined structure, with samples being obtained from the stratigraphy of the northwest pit location half a metre to the north of the main entrance to the structure. This was the structure positioned third from the left as facing the Skutulsfjörður fjord.

Kálfeyri

The fishing station at Kálfeyri is one of the best preserved examples of a nineteenth-century fishing station in Iceland.[488] Presently occupying the site is a series of detached structures, built over earlier turf constructions which have been relatively undisturbed since abandonment of the site in the early twentieth century. The place name translations have several meanings, which add to confusion; *kálf* translates as calf, which raises the possibility that this site may have had a pastoral function, a hypothesis which could be tested using thin section micromorphology.

[488] Thanks go to Ragnar Edvardsson for undertaking the differential GPS survey and developing the survey maps.

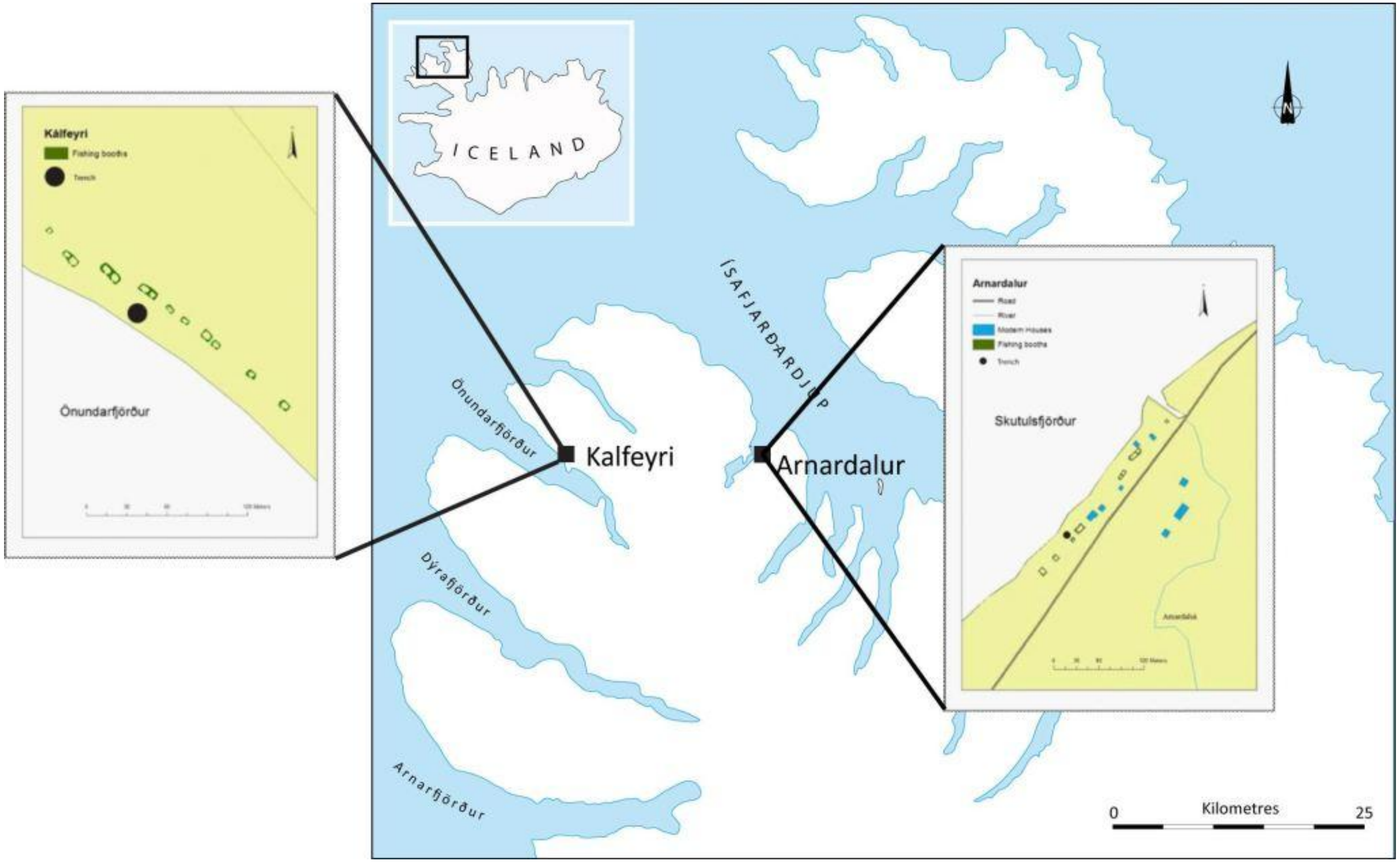

Figure 18: Kálfeyri and Arnardalur Site Maps

Eýri in modern Icelandic translates as foreign exchange, and also spit of sand. If the site was important as a specialist fishing community, it could realistically also function as a trading location. The spit of sand is not entirely topographically accurate, but this name could relate to the association of the fishing stations with nearby Flateyri which is built on a spit of sand entering the fjord, or given its relationship with Eýri it could symbolise the distant relationship between the sites, possibly a satellite site associated with the 'parent' site. Flateyri became important as a trading post during the late eighteenth century as shark hunting and whaling grew, so it may well be that the names of these locations have changed over time until the abandonment of Kálfeyri in the twentieth century. The fishing station belonged to the farm at Eýri, located around twenty-five kilometres away,[489] and was privately owned. The station was used by all farmers in the district during the fishing season. Tolls were paid directly to Eýri, and the site was said to have a high commercial value.[490]

Figure 19: Kálfeyri Coastline, April 2006

[489] Site-to-site in a line is just over 25 kilometres, but routes would have been much larger to negotiate the fjords. Access from the sea may have been the favoured method of connection.

[490] Edvardsson, personal communication.

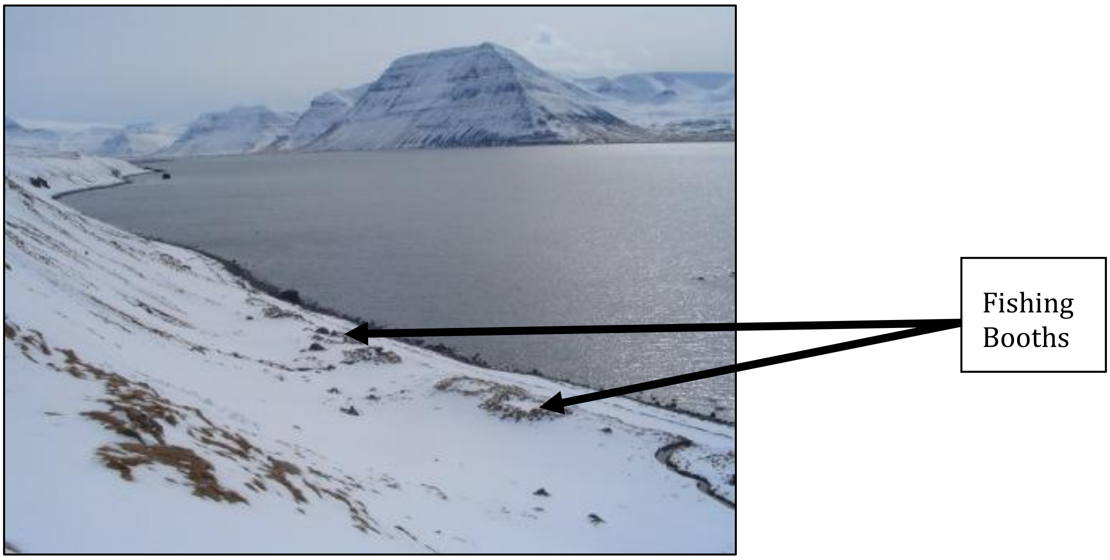

Figure 20: Kálfeyri Fishing Booths facing into the Fjord, April 2006

Located in the Flateyrarhreppur administration district these nine structures face in a southwesterly direction on the shores of the Önundarfjörður fjord (Figure 18). The most modern structures are a mix of single and double-celled construction, measuring around five by five metres per cell, and generally positioned between ten and fifteen metres apart (Figure 19 and Figure 20). These booths are sheltered by a series of steep cliffs to the northeast, and very close to the cod-rich deepwater fishing grounds. All booths show entrances facing the sea, and the stone constructions were finished to an unexpectedly high quality given that they were seasonally occupied structures, a feature perhaps evident of a later time when investment was significant. A stream runs through the Klofningsdalur valley at the rear of the structures, cutting between booths 3 and 4, which would have provided the site with fresh water. The topography dictates that any terrestrial activities in the vicinity of this site would be very limited.

A circular stone platform stands at the northwestern end of the structures, most likely forming the base of a winch contemporary with the stone built structures on the site, for pulling the heavier boats from the sea to the shore. Similar stone platforms have been found at other fishing sites throughout Vestfirðir.[491] The outstandingly preserved remnants of the fishing booths can be attributed to the restricted access to the area nowadays, and that the booths were utilised within the last one hundred years which would have assisted in the structures retaining their original shapes. Up to fifty people would have occupied this site at any one time during the winter fishing season.[492] Three test trenches were excavated around a centrally positioned booth, with samples obtained from the southwest of the main entrance of what is modern booth number four.

Skálavík

The pre-modern fishing station at Skálavík (Figure 21) is the largest known in Vestfirðir, with twelve booths identified at present, some of which are contiguous (Figure 23 and Figure 24). The site at Slétta also has twelve; but those are of a smaller size.[493] The booths were regarded as having evolved over time, and date from a variety of periods as a range of sizes are found on the site. It is thought that the larger structures represent a more recent phase of habitation and were likely built on top of the remnants of older structures. The name Skálavík is thought to derive from *skali-* (shieling or hut used on a temporary basis), and *–vík* meaning bay, inlet or cove.[494] Skálavík was in operation as a fishing station until the early decades of the twentieth century, with the surviving booths being stone built and relatively well preserved. The oldest record mentioning

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491 Edvardsson, 'Commercial and Subsistence Fishing in Vestfirðir'.

492 Edvardsson, personal communication, April 2006.

493 Edvardsson, 'Commercial and Subsistence Fishing in Vestfirðir'.

494 Place-Names in *Landnámabók,* <http://my.stratos.net/~bmscott/Landnamabok_Place-Names.html>

Skálavík dates to AD 1363, with a church deed dating to AD 1509 revealing a direct association between Skálavík and the church at Vatnsfjörður.[495]

The farmer at Hóll had absolute control over the fishing stations. Fishermen paid their toll to the farm at Minnibakki, an independent farm, but the lord at Hóll took his dues from the farm,[496] much like a pyramid system (Figure 22). The booths are positioned adjacent to the rocky foreshore, strategically placed between a steep cliff face to the north and a sandy beach to the south. There appears to be no stream present, but this may be a consequence of agricultural improvements which took place and the insertion of drainage channels taking water away from the direction of the booths. The neighbouring farms of Minnibakki and Meiribakki, found in the same cove as Skálavík, are presently occupied only during the summer months as holiday homes. The decline and the eventual abandonment of Skálavík as a fishing site can be attributed to the introduction of a mechanised fishing industry, and the comparative success of Bolungarvík twelve kilometres away which, unlike Skálavík, was one of only a handful of locations in Iceland where the fishing grounds could be accessed all year round.

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[495] Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland'.*

[496] Edvardsson, personal communication.

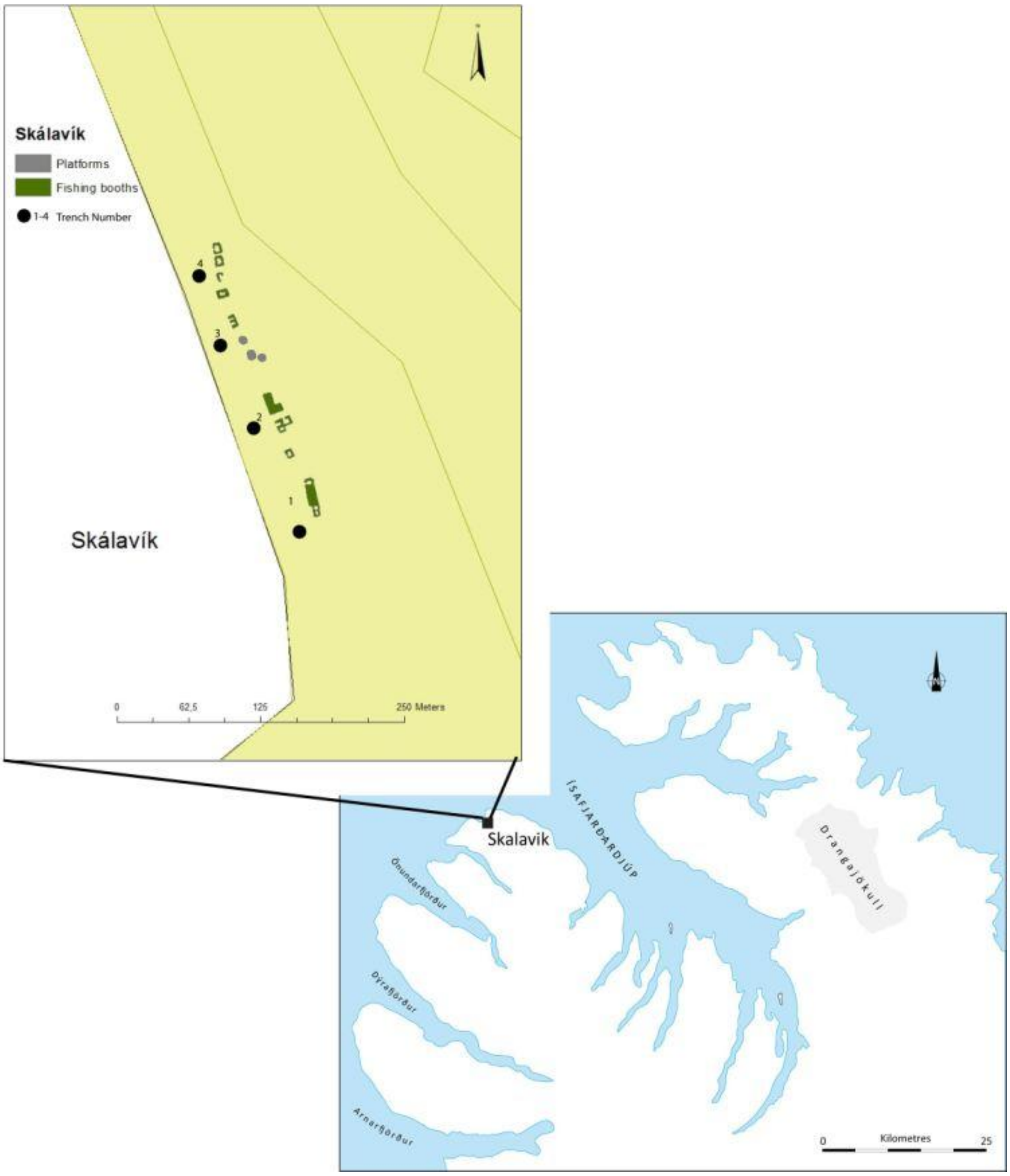

Figure 21: Skálavík Survey Map

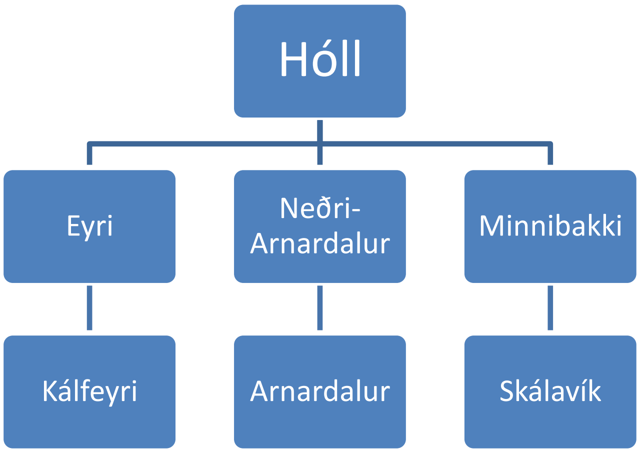

Figure 22: Potential site hierarchy and illustration of control and ownership

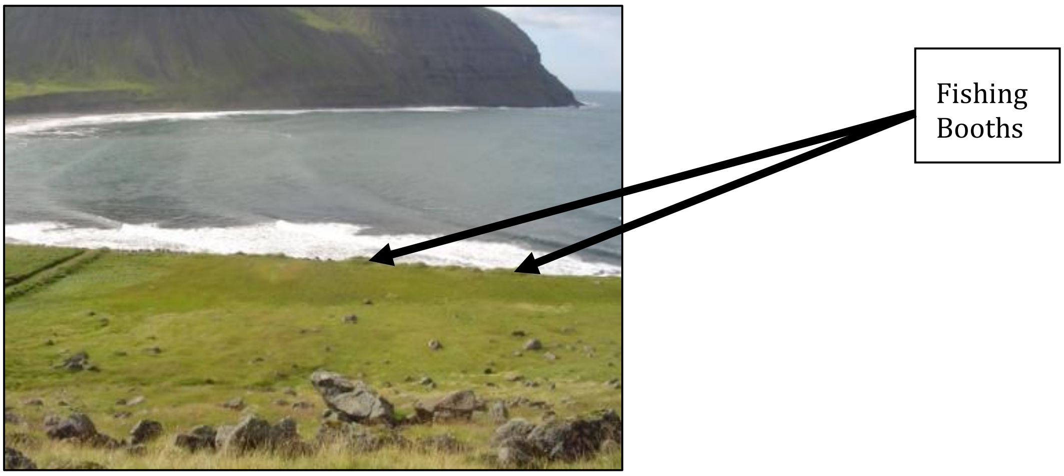

Figure 23: Skálavík Bay and Fishing Booths, August 2008

Figure 24: Pre-Modern Industrial Remnants – Boat Winch at Skálavík, August 2008

Four trenches were dug and bottomed out, with the stratigraphic faces of each being sampled and subsequently named Skálavík 1-4 (Figure 25 and Figure 26). These provided a range of depths and samples from across the site. The surrounding topography is not as steep as Kálfeyri, but the site is still comparatively isolated with a flat bog area positioned inland from the shore. The flat area vegetation cover is potentially capable of supporting livestock. The encroaching bog does, however, pose a threat to the preservation of the structural remains, as much as coastal erosion and development does elsewhere in the region. It is only a matter of time before this site is subsumed under the encroaching landscape.

Figure 25: Skálavík 1 Stratigraphy with Kubiëna Tin Positions

Figure 26: Skálavík 4 Stratigraphy with Rounded Gravel Lenses

A pilot excavation was conducted at Skálavík in the early twenty-first century. Clay pipes and domestic wastes were relatively dated on stylistic grounds to the eighteenth and nineteenth centuries.[497] On the basis of these finds and the awareness that some material pre-dated these, the site chronology is thought to extend from the early fifteenth century, with a resurgence taking place in the seventeenth century, and lasting

497 Edvardsson, 'Commercial and Subsistence Fishing in Vestfirðir'.

through until the twentieth century AD.[498] These dates closely link to what the historical record has to say, but in the absence of a thorough on-site investigation and reliable radiometric dating, these findings may be subject to revision.

Geoarchaeological Overview

In simplest terms, geoarchaeological investigations are ways of applying earth science principals and techniques to solve archaeological problems and understand the archaeological record.[499] Geoarchaeological analyses by their very nature are semi-subjective, using a variety of sources to interpret past landscapes.[500] Being a multi-disciplinary technique, it uses a wide variety of strategies and methods which permits it to address a wide range of research questions, many of which would struggle to be answered using a single-method approach. It differs from archaeology as more focus is given on site formation processes and, as demonstrated within this thesis, investigating the cultural record contained within them. The terminology came to prominence in the 1970s, although there is still what some view as an unnecessary debate concerning the etymology and definition of the subject.[501]

The approach to be taken in this thesis is to firstly establish a site-based chronological framework at selected sites using chronometric dating techniques. Integrating this with thin section micromorphology and soil chemical analysis, signatures and characteristics contained within the landscape can begin to be interpreted. With radiocarbon dates

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[498] Edvardsson, personal communication.

[499] SASSA, *Geoarchaeology*, <http://www.sassa.org.uk/index.php/Geoarchaeology:Home> [Accessed 30/10/2009]; D.M. Jones, '*Geoarchaeology; Using Earth Sciences to Understand the Archaeological Record',* (Swindon, 2007).

[500] K, Boulden, 'Interpretative geoarchaeologies? A relationship between archaeological soil scientists and theory'. *Archaeology Review from Cambridge*, (Forthcoming).

[501] A summary of this can be found in: P. Goldberg & R.I. Macphail, '*Practical and Theoretical Geoarchaeology',* Blackwell Publishing, (Oxford, 2006), p.2.

taken from selected points throughout site stratigraphies, the opportunity is also presented to understand the changes in the landscape over time. Given that sediments in archaeological sites reflect the environment in which they have been formed, the potential is there to identify and interpret sediment properties and offer more refined understanding of the cultural activities associated with site formation, in turn reflecting the broader environmental and social processes.[502] The findings obtained will be supplemented with the historical documentary research found in chapter two, as well as current research, in order to establish it firmly within the wider North Atlantic context, ultimately providing greater insight into the development of maritime environments.

The adoption of bulk soil analysis in the geoarchaeological component of this research is regarded as an important area of the methodology. Organic matter, pH, particle size distribution, soil magnetism and total phosphorus are all key features which represent environmental and cultural processes impacting the soil. The last two in particular are particularly useful in determining the presence and absence of intense cultural activity relating to waste disposal and the burning of fuels for domestic and industrial purposes, processes which, in this thesis, can be attributed to fishing activity.

Radiocarbon Dating

A reliable, chronological framework is one of the fundamental components underpinning this research. For this, the method of radiocarbon dating was chosen ahead of other methods used in the North Atlantic region such as tephrochronology and optically stimulated luminescence dating (OSL). The reasons behind this are geographical; the local geology does not contain sufficient levels of quartz or feldspar,

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[502] I.A. Simpson & W.P. Adderley, 'A micromorphological perspective on archaeological site formation processes', in J.H. Larsen and P. Rolfsen (Eds.) '*Halvdanshaugen - Arkeologi, Historie og Naturvitenskap',* Occasional Papers vol. 3, (Oslo, 2004), p.329-40.

minerals required for OSL dating to take place. Tephrochronology is a method used throughout the majority of Iceland, however, in Vestfirðir tephra rarely falls due to the source of prevailing winds. The Vatnsfjörður area has one identified historical tephra layer, tentatively identified as the ejecta from the Hekla AD 1693 eruption.[503] A stratigraphic face containing a series of tephra horizons allows its identification and association to a particular volcanic eruption. As each temporal marker is different in its composition, they are unique to eruptions taking place at different times. Given the frequency of volcanic activity in Iceland, this is a popular and very cost-effective method applied to pretty much every region away from Vestfirðir. The recognition of an olive and white tephra dating from AD 871 ± 2, known as the *Landnám* tephra is used as a settlement base marker in Iceland as first permanent occupation took place shortly after its deposition. Little or no archaeology is found beneath this layer. Unfortunately, little of Vestfirðir appears to be covered.

Developed in the mid-twentieth century by a team headed by Willard Frank Libby, radiocarbon dating is a method which can allow dating estimations to be made on materials which have carbon present in their structure, mainly organic materials. This technique has revolutionised archaeology since its development allowing absolute dates to be attributed to organic materials found within archaeological sites. Radiocarbon dating can be carried out on a variety of materials such as wood, charcoal, shell, bone, peat and organic-bearing sediments, carbonate deposits and carbonates in oceans and lakes,[504] with modern methods requiring very little material to work with. When

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[503] M. Sigurgeirsson, '*Short Account on the Discovery of the Hekla 1693 Tephra in Vatnsfjörður, NW Iceland*', (2005).

[504] Minnesota State University, *Radiocarbon Dating*, <http://www.mnsu.edu/emuseum/archaeology/dating/radio_carbon.html>, [Accessed 24/04/2007].

radiocarbon dating was developed, it was tested on samples with known ages such as Dead Sea Scrolls and wood from an Egyptian tomb.

Radioactive carbon is produced when nitrogen-14 isotope is bombarded by cosmic rays in the earth's atmosphere, drifts down to earth and is absorbed from the air by plants through the process of photosynthesis. Humans absorb this into their bodies by eating plants and also by eating animals who obtain their carbon from eating plants. At the point where living organisms die, they cease to absorb carbon-14 isotopes and begin to disintegrate reverting the disintegrating carbon-14 back into nitrogen-14. The measurement of how much carbon has disintegrated and what remains allows scientists to calculate known ages by the fact they know carbon-14 has a half-life of 5,730 years, meaning that half of the organic matter present will disappear after 5,730 years, and half of that will disappear after another 5,730 years, and so on. The quantity of carbon-14 continues to half until none remains after around 50,000 years. The development of atomic mass spectrometry (AMS) has reduced the size of sample required for radiocarbon dating to be reduced significantly, increasing the reliability of this dating method.

The method of radiocarbon dating has known strengths and weaknesses, however, as long as these are recognised, the findings can be viewed in their appropriate context. A relevant and contemporary issue is that of marine reservoir effects, which yields a variance in radiocarbon ages depending on the sample origin, such as marine and terrestrial environments. Given the mobility of material carrying the potential for radiocarbon dating, it is essential to consider any activities which may have modified the sample in any way, such as the influence of geothermal groundwater, or the proportion of marine produce in an individual's diet, identifiable through the measurement of bone collagen. A framework has been established for the North Atlantic to make any adjustment to relevant samples.[505] The samples obtained for this research were predominantly Betula species of terrestrial origin, and the samples analysed in conjunction with the Scottish Universities Environmental Research Centre. Research is still ongoing, and progress being made to ensure progressive levels of accuracy and confidence in the measurement of samples for radiocarbon dating in the North Atlantic.[506]

Laboratory Preparation Methodology

Bulk samples from each recorded soil horizon were transported to the soil laboratory at the University of Stirling, where they were air dried for two weeks. Undisturbed soil samples, taken in Kubiëna tins, were also taken from selected stratigraphic faces for preparation at the Thin Section Laboratory at the University of Stirling (see later section on thin section micromorphology). The dried bulk samples were then sieved to less than two millimetres, prior to the commencement of a range of standard laboratory tests. These were testing for pH, measuring the percentage organic matter, measurement and calculation of magnetic susceptibility, measuring particle size distribution using laser diffraction, and analysis of total phosphorus content within the soil. These methods allowed the assessment of key anthropogenic indicators (total phosphorus and magnetic susceptibility) and also more general soil and sediment characteristics (pH, organic matter and particle size distribution). Replicate samples were produced to assess the reliability of the findings. As part of the analysis the results were integrated with the findings from the thin section micromorphological analysis.

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[505] P.L. Ascough, G.T. Cook, M.J. Church, A.J. Dugmore, S.V. Arge & T.H. McGovern, 'Variability in North Atlantic marine radiocarbon reservoir effects at *c.* AD 1000', *The Holocene*, 16 (2006), p.131-36.

[506] P.L. Ascough, G.T. Cook, H. Hastie, E. Dunbar, M.J. Church, Á. Einarsson, T.H. McGovern & A.J. Dugmore, 'An Icelandic freshwater radiocarbon reservoir effect: Implications for lacustrine 14C chronologies', *The Holocene*, 21 (2011), p.1073-80.

Soil pH

Analysis of soil pH measures the comparative H and OH ions in the soil. Values less than seven, the neutral value, are referred to as acidic, with values higher than seven being designated alkaline or base. The level of pH in a soil or sediment affects a variety of characteristics. It can affect the retention and mobility of phosphates, which, as mentioned, is a key indicator of an anthropogenic presence. Soils in a more acidic environment have a negative and corrosive impact on the preservation of archaeological relics such as bone, shell and wood which are also key anthropogenic indicators.[507] Variance in the pH value may reflect changes taking place as a result of varying deposition patterns.

The method undertaken in this research adhered to the standard method of Bascomb,[508] with samples made into a solution using a ten gram sub-sample of soil sieved to less than two millimetres. Added to this was twenty-five millilitres of distilled water, with the suspension stirred and allowed to stand for thirty minutes. Where ten grams of soil was not available, the volume of distilled water was proportionally reduced in order to achieve results consistent with the remainder of the samples. The solution was measured using a glass electrode pH meter, calibrated to pH 4 and pH 7, calibrated one hour prior to the commencement of sample measurement.

A variety of differing factors can have an over-riding impact on soil pH, such as climatic conditions, geological background and various levels of anthropogenic influence. These

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507 How aerobic or anaerobic the soil is can be viewed as just as important as pH; there have been a significant number of well-preserved finds obtained from peat bogs, which are acidic environments but the anaerobic conditions limit degradation.

508 C.L. Bascomb, 'Physical and Chemical Analyses of <2mm samples', in B.W. Avery & C.L. Bascomb (eds.), '*Soil Survey Laboratory Methods*', (Harpenden, 1974), p.14-41.

uncontrolled additional factors need to be considered when analysing results in order to make an appropriate and more accurate attempt at landscape interpretation.

Loss-on-Ignition

The application of loss-on-ignition to soils and sediments provides a cost-effective proxy which allows the percentage estimation of organic matter present within them. Samples with higher levels indicate greater proportions of organic material present. In the context of this research, elevated levels of organic material contained within the stratigraphy can be expected to originate from two sources: anthropogenic inclusions or through site abandonment and the rapid encroachment of peat often which takes place in these wet Icelandic environments. Integrating this method with total phosphorus and thin section micromorphology will clarify the source and origin of where elevated levels are observed.

The samples were subject to the standard method of Ball.[509] Air dried soil sieved to less than two millimetres was put in an oven at 105˚C for four hours and stored in a desiccator to remove moisture. Dry porcelain crucibles were weighed, and sample added to the crucible and weighed again prior to being put in the furnace for sixteen hours at 375˚C. The lower ignition temperature was chosen to preserve any clay minerals which may be lost or broken down at high temperatures. Once completed, the samples were removed from the furnace and placed in a desiccator to cool and remain moisture-free. The loss-on-ignition is calculated by subtracting the burnt soil from the pre-burnt sample divided by the pre-burnt sample minus the weight of the crucible,

[509] D.F. Ball, 'Loss-on-Ignition as an Estimate of Organic Matter and Organic Carbon in non-calcareous soils', *Journal of Soil Science,* 15 (1964), p. 84-92.

multiplied by 100 giving a percentage of organic matter lost through the application of this process, as demonstrated in the following calculation,

% Loss on ignition = ((W2 - W3) ÷ (W2 - W1)) x 100

where W1 is the empty crucible, W2 is an unburnt soil-filled crucible and W3 is a burnt soil-filled crucible.[510]

Magnetic Susceptibility

All materials have an intrinsic magnetic susceptibility.[511] Changes in magnetic susceptibility occur when magnetic grains become concentrated or diluted through the addition or removal of materials, and also through the transformation of minerals.[512] This can be measured and quantified allowing the identifying of the associated formation processes and components. Magnetic susceptibility is dependent on concentrations of ferromagnetic minerals and largely controlled by the nature and abundance if iron oxides. Anthropogenic activities are known to enhance magnetic susceptibility of soils and burning can result in ferromagnetic materials forming, making this an ideal method for use on occupational surfaces and stratified material.[513]

Samples of a known volume were numbered and weighed and measured using a Bartington MS2 Magnetic Susceptibility System with the MS2B sensor at a low and high

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[510] SASSA, *Loss on Ignition Methodology,* <http://www.sassa.org.uk/index.php/Analytical_Methods:LOI >

[511] R.S. Sternberg, 'Magnetic properties and Archaeomagnetism', in D.R. Bothwell & A.M. Pollard, (eds.), *Handbook of Archaeological Sciences,* (Chichester, 2001).

[512] B. Marwick, 'Element Concentrations of Magnetic Susceptibility of Anthrosols: Indicators of Prehistoric Human Occupation in the Inland Pilbara, Western Australia', *Journal of Archaeological Science*, 32(2005), p.1357-368.

[513] J. Crowther, 'Potential magnetic susceptibility and fractional conversion studies of archaeological soils and sediments', *Archaeometry,* 45 (2003), p.685-701.

frequency. A formula was applied to the results to determine the mass specific susceptibility,

$$\boldsymbol{\chi\ 10^{-6}\ m^3\ kg^{-1} = (\kappa\ /\ Mass)\ /\ 10}$$

where κ is the corrected value and Mass is the weight of soil in grams.[514]

Particle Size Distribution

Analysis of the mineral fraction of the sizes of particles in a sample can give an indication of the origins and development of particular archaeological contexts, characterising the nature of deposition regarding the soils and sediments at their particular location.[515] A mixture of materials and sizes may suggest variances in the nature of deposition related to an anthropogenic influence, albeit depending on the context of the observed samples.

Samples with a greater than five percent organic matter were treated firstly with hydrogen peroxide, rinsed, and treated with hydrochloric acid to eliminate organic and calcareous content respectively. The mineral soils which remain were made up into a solution containing ten millilitres of distilled water and five millilitres of sodium hexametaphosphate, also known as Calgon. Samples were agitated for an hour prior to analysis using laser diffraction in order to break down the aggregates and larger particulates. The analysis was undertaken using a Beckman Coulter LS230 laser diffraction particle size analyser, known as a Coulter Counter, with three volume analyses recorded and results averaged and presented in a log graph showing the

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[514] SASSA, *Magnetic Susceptibility Methods,* <http://www.sassa.org.uk/index.php/Analytical_Methods:Lab_Mag_Sus>

[515] Laboratory Methods for Soil Science, <http://www.lamp.ac.uk/uwlas/pdf/uwlas_soil_methods.pdf> [Accessed 02/04/2007]

standard deviation curve. The Coulter Counter operates by adding samples to a tank which keeps water in motion, retaining the sample in a state of suspension. Sample extracts were piped from the tank across lasers, recording the particle sizes. Those attributes measured include mean particle size of the sample, median particle size, skewness, kurtosis, as well as the percentage volume of different class sizes. Skewness is the degree of distortion from symmetrical in a distribution, with zero values indicating perfect symmetry of a distribution either side of a mean. Positive values are when the coarse particles pull the mean to the right of the mode, with negative values indicating the opposite. Kurtosis describes the peaked-ness of a distribution; values greater than zero are leptokurtic with most particle sizes close to the mean and the sediment well sorted, and platykurtic distributions, those less than zero, are more widespread and the sediment more poorly sorted.[516]

Total Phosphorus

Phosphates are present in all organic materials. General sources of phosphorus among pre-industrial era peoples include human waste, organic discard derived from bone, tissue, fish and plants, as well as burials and ash from fires.[517] These materials can all be directly associated with human habitation, leaving a permanent signature within the archaeological landscape which can only be removed by erosion itself.[518] Many forms of human activity lead to phosphate enrichment, and under favourable conditions, remain

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516 R. Tipping, L. Verrill, S. Morrison, M. Burns & .J Bunting, '*Later Prehistoric Landscape Dynamics',* in A. Jones, *Understanding Rock Art in its Context,* (Oxford, In Press).

517 V.T. Holliday, & W.G. Gartner, 'Methods of Soil P Analysis in Archaeology', *Journal of Archaeological Science*, 34 (2007), p.301-33.

518 R.E. Terry, P.J. Hardin, S.D. Houston, S.D. Nelson, M. W Jackson, J Carr, J. J Parnell, 'Quantitative phosphorus measurement: A field test procedure for archaeological site analysis at Piedras Negras, Guatemala', *Geoarchaeology,* 15(2000), p.151–66.

detectable for thousands of years.[519] This is due to its ability to bind strongly on to particle surfaces, particularly clays and silts,[520] and that it is largely resistant to leaching.[521] This factor makes it a good method to use on tightly packed midden horizons and stratigraphic deposits. It can be assayed as one of a range of elements enhancing the possibility of recognising a cultural signal.[522] Typically, the higher the phosphorus value, the higher the level of anthropogenic enrichment. Variance in the levels of phosphorus can give indication to the nature and level of wastes present, a reason why this technique is widely used in archaeological science. This analysis can provide insight into spatial and in this case, temporal sequences of activity allowing direct comparisons to be made between various horizons within deposited sequences. This use of this method is continually increasing in popularity as it is a good presence and absence indicator of human habitation, although does not allow analysts to determine the actual source of the phosphorus.[523] This can be assisted by assessing other elements and properties within the soil stratigraphy, and in the case of this research, the application of thin section micromorphology.

The procedure used to determine total phosphorus in soils and sediments is by sodium hydroxide fusion, following the standard procedures at the School of Biological and Environmental Sciences, University of Stirling. The air dried soils were sieved to ninety µm, and treated with 0.5 molar hydrochloric acid solution to eliminate calcareous

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519 Laboratory Methods for Soil Science <http://www.lamp.ac.uk/uwlas/pdf/uwlas_soil_methods.pdf> [Accessed 24/06/2008]

520 D.L. Rowell, '*Soil Science: Methods and Applications*', (Essex, 1994), p.200; J. Crowther, 'Soil phosphate surveys: critical approaches to sampling, analysis and interpretation', *Archaeological Prospection*, 4 (1997), p.93-102

521 Jones, '*Geoarchaeology'.*

522 Bascomb, 'Physical and Chemical Analyses of <2mm samples'.

523 K.J. Knudson & L. Frink, 'Ethnoarchaeological analysis of Arctic fish processing: chemical characterization of soils on Nelson Island, Alaska', *Journal of Archaeological Science*, 37(2010), p.769-83.

content. Excess acid is removed using distilled water, and the 0.1 grams of the treated soil is heated singularly with one gram of sodium hydroxide pellets until a colourless liquid is formed. The solution is made up to fifty millilitres and after the process of centrifugation, the supernatant is transferred into a sealed container prior to colourimetry. The solutions were then placed in a spectrophotometer at 880 nm to measure the colour of absorbance of light passing through the blue solution within the optical cell. Once passed through this cell, the beam falls upon a photoelectric cell, converting light energy into electrical energy and measured with an ammeter.[524] The result from this final measurement allows the micrograms of phosphorus for each sample to be determined.

Statistical Analysis

It is important to study, analyse and interpret the numerical values obtained through the laboratory research in a manner that is understandable and relevant to the research questions being asked. By observing trends, patterns and correlations, a wider picture can be generated as regards to on-site activity as well as periodic phases of abandonment. These can then be integrated into the larger scale historiography and finer scale micromorphology.

In this research, a basic statistical approach is adopted to differentiate values within the stratigraphy. Correlations were undertaken to establish the strengths of association between different techniques, and a correlation diagram constructed. In order to understand the differences found within individual stratigraphies, standard deviations and z-scores were calculated based on the fishing site group as a collective, and the sites on their own. The values generated will be ranked according to their number of

[524] Rowell, '*Soil Science: Methods and Applications*'.

standard deviations from the mean,[525] from positive three to minus three, and graphical images formed for each stratigraphy based on this ranking to assist in the interpretation of the findings.

Given the strong association between magnetic susceptibility and total P,[526] an additional category will be formed merging the results of these two rankings together. Each variable will be analysed in their own right, until the end of the process when they will be integrated. The aim is to identify the areas of each stratigraphy where anthropogenic influence is potentially at its highest. There are other values which will influence the figures associated with magnetic susceptibility and total P (such as pH and associated soil preservation conditions), however, this method will be used in conjunction with a variety of techniques and not be interpreted and presented in a standalone manner. In addition to this, the standard error values will also be generated to assess the variance of the soil material and any errors which may have been picked up during laboratory processes.

Thin Section Micromorphology

Micromorphology as a technique applied in soil science is one which is widely regarded as being developed by Walter Kubiëna, best known for his book *The Soils of Europe,*[527] with significant developments being made by Brewer and Sleeman,[528] FitzPatrick,[529] and

[525] C.P. Wheater & P.A. Cook, '*Using Statistics to Understand the Environment',* Routledge, (London, 2000), p.89.

[526] See Goldberg & Macphail, '*Practical and Theoretical Geoarchaeology',* for case studies outlining the association between the two.

[527] W.L. Kubiëna, '*The Soils of Europe',* (London, 1953).

[528] R. Brewer & J.R. Sleeman, *Soil Structure and Fabric,* (East Melbourne, 1988).

[529] E.A. FitzPatrick, *Soil Microscopy and Micromorphology,* (Chichester, 1993).

Bullock *et al.*[530] in terms of advancing the way in how micromorphology and soil formation processes are understood.[531] Recently, a volume has attempted to bring together the most recent and up-to-date research on thin section micromorphology, making the method more easy to understand for students and researchers alike.[532]

Greater understanding of the characteristics of soil formation, structure, visual properties and accumulation patterns can be achieved through the adoption of thin section micromorphology as a method of analysis. Accurate understanding and control of natural processes of formation, disturbance, alteration and destruction of a given archaeological site must be understood before we can begin to understand past human behaviours reflected in its soils and sediments.[533]

Thin section micromorphology of undisturbed sediments has been increasingly applied to the understanding of archaeological units throughout the North Atlantic.[534] This has facilitated detailed, microscope-based consideration of sediment source, variability of composition, post-depositional processes and the physical relationship between organic,

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530 P. Bullock, N. Fedoroff, A. Jongerius, G. Stoops, T. Tursina & U. Babel, '*Handbook for Soil Thin Section Description',* (Wolverhampton, 1985).

531 D.A. Davidson & I.A. Simpson, 'Archaeology and Soil Micromorphology', in D.R. Bothwell & A.M. Pollard, (eds.), *Handbook of Archaeological Sciences,* (Chichester, 2001).

532 G. Stoops, V. Marcileno & F. Mees (Eds.), '*Interpretation of Micromorphological Features of Soils and Regoliths',* (Ghent, 2009).

533 Harvard University, Soil Analysis Methods, <http://www.fas.harvard.edu> [Accessed 20/06/2006]

534 Simpson & Barrett, 'Interpretation of Midden Formation Processes at Robert's Haven'; Simpson *et al., '*Cultural sediment analyses and transitions'; I.A. Simpson, J.H Barrett & K.B Milek 'Interpreting the Viking age to Medieval period transition in Norse Orkney through cultural soil and sediment analyses', *Geoarchaeology,* 20 (2005), p.357-79; I.A. Simpson, R.G. Bryant & U. Tveraabak, 'Relict Soils and Early Land Management in Loföten, Norway', *Journal of Archaeological Science*, 25 (1998), p.1185-198; I.A. Simpson, K. Milek & G. Guðmundsson, 'A Reinterpretation of the Great Pit at Hofstaðir, Iceland Using Thin Section Micromorphology', *Geoarchaeology*, 14 (1999), p.511-30; I.A. Simpson, O. Vésteinsson, W.P. Adderley & T.H. McGovern, 'Fuel Resource Utilisation in Landscapes of Settlement', *Journal of Archaeological Science*, 30 (2003), p.1401-420; I.A. Simpson, G. Guðmundsson, A.M. Thomson & J. Cluett, 'Assessing the role of winter grazing in historic land degradation, Mývatnssveit, north-east Iceland', *Geoarchaeology,* 19 (2004), p.471-503.

mineral and anthropogenic components.[535] Further work has been done using more novel techniques to supplement findings from semi-quantitive thin-section analysis, for example the use of x-ray analysis to obtain a more detailed elemental observation of degraded bone composition.[536]

Geoarchaeological focus has been on both the terrestrial and maritime environments, but there has yet to be a thorough study of maritime environments in Iceland using this approach. Over the past two decades, various sites have been investigated, furthering the knowledge and understanding of coastal communities. At Robert's Haven in Caithness, Scotland, midden deposits were investigated in order to understand the medieval palaeoeconomy of the region.[537] Thin section micromorphology was used to observe differences in deposition patterns, noting continuous and sporadic deposits which were interpreted respectively as seasonal and temporary settlement. The rapid accumulation was associated with the emergence of an export fishery, or the failure of terrestrial harvests. Site absence was represented by post-depositional processes such as the mobilisation of iron, accumulation of wind-blown deposits as well as evidence of exposed surfaces. These exposed surfaces are indicators that a significant period of time has passed in which the site was not being occupied or disturbed in any way. Conclusions as to the specific nature of this site were left open; it could not be established whether it was a seasonal or permanent fishing location, but what was established was that it was part of an economically diverse settlement.

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535 Davidson & Simpson, 'Archaeology and Soil Micromorphology'.

536 W.P. Adderley, I.L. Alberts, I.A. Simpson & T.J. Wess, 'Calcium-iron-phosphate features in archaeological sediments: characterisation through microfocus synchrotron X-ray scattering analyses', *Journal of Archaeological Science,* 31 (2004), p.1215-224.

537 Simpson & Barrett, 'Interpretation of Midden Formation Processes at Robert's Haven'.

The initial research in Scotland led to a similar methodology being used in northern Norway. Studies at Langenesværet in the Vesterålen region set out with the aim of comparing two competing hypotheses.[538] Was the site first established around the AD 1300s, or did it have an existing history before evolving into a *fiskevær* sometime between AD 1100 and AD 1300? *Fiskevær* were specialist fishing stations, with one or two livestock kept by most households for wool, milk and meat. Two sites at Vollen and Været were excavated, with the former displaying characteristics of *fiskevær* in earlier deposits, and the latter a site with turf structures dating to the early first millennium and used as a specialist fishing site. These were maritime systems which evolved over time, showing a subsistence to specialist pattern.

Within the Scottish and Norwegian sites, thin section micromorphology was able to identify characteristics within the cultural record of the soil relating, at times, to intensive and specialist fishing communities. Little in the way was found to identify these areas with other land uses, such as farming. The long histories which have been established and associated with these sites somehow make it more difficult to interpret clear origins. This present research, however, allows a different angle to be taken; given that there is no indigenous population on Iceland, the opportunity is presented to understand the nature and development of specialist fishing communities on a pristine landscape, whilst reflecting on the previous studies which have been carried out in the North Atlantic region.

The process of thin section micromorphology begins with the collection of an undisturbed soil sample from a stratigraphic face within the archaeological trench in the field in a stainless steel tin measuring eighty by fifty by forty millimetres, called a

[538] Simpson *et al.,* 'Cultural sediment analyses and transitions'.

Kubiëna tin. The collected thin sections were then prepared following internationally standard procedures,[539] at the University of Stirling Thin Section Micromorphology Laboratory.[540] The procedure consisted of acetone exchange to remove water content within the sample, confirmed by specific gravity measurement. This step was completed prior to the impregnation of the sample with a polyester resin and the catalyst 'Q17447'. This composition was thinned with acetone and a standard composition of 180 millilitres of resin, 1.8 millilitres catalyst and twenty-five millilitres acetone. This standard was used for every Kubiëna tin processed. During the process of preparation, no accelerator was used, but the soils were impregnated under vacuum to ensure the outgassing of the soil. The curing period was completed over a period of three to four weeks and samples at the end of that period placed in an oven for ninety-six hours at forty degrees centigrade. The blocks were sliced, bonded to a glass slide and lapped to a uniform thickness of thirty μm. Cover slipping of the slides using a plastic cover completed the manufacture of the thin sections, enabling the microscope analysis of the prepared thin sections to commence.

Visual descriptions of the thin sections were carried out under an Olympus BX50 petrological microscope, and initially described in accordance with internationally standard terminology found in the *Handbook for Soil Thin Section Description,*[541] and *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*.[542] The adoption of these standard methods allows the description of mineral materials, organic materials, microstructure and b-fabric to a standard used by micromorphologists. The

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539 C.P. Murphy, *Thin Section Preparation of Soils and Sediments,* (Berkhempstead, 1986).

540 Thin Section Micromorphology Laboratory, University of Stirling <http://www.thin.stir.ac.uk>

541 Bullock *et al., Handbook for Soil Thin Section Description'.*

542 G. Stoops, *Guidelines for Analysis and Description of Soil and Regolith Thin Sections,* (Wisconsin, 2003).

descriptions were carried out under a range of magnifications (10x to 400x), under different light sources (plain polarised, cross polarised and oblique incident light) and recorded in semi-quantitive tables. Given the sizable variety in anthropogenic features observed under thin section, there lacks a universal directory resulting in the need to establish a list of features and characteristics by going through published and unpublished literature relating to other cultural landscape studies.[543] Thin section micromorphology was first used in an Icelandic context in the late AD 1990s,[544] and since then has become an invaluable tool adding an additional dimension to environmental-based research, helping to interpret site formation processes and its contents at a microscopic scale.

Chapter Summary

This chapter outlines the varying component parts which will address the research questions outlined in chapter one. There is a deliberate movement in this methodology which permits the repeated triangulation of data from macro to micro scales, which will assist in creating a multi-resolution narrative where the historiographical record falls short. This helps develop the narratives which are applicable to both regional and site-based discussions, and perpetuate the movement of information from one scale to the next. In turn, this builds up a highly detailed picture.

These techniques are adaptations of methods applied elsewhere or in a similar geoarchaeological context, carefully selected in order to maximise the opportunity to gain information. It is an opportunity to bring these methodologies together for the first time in the context of Iceland, giving greater value to individual techniques in

[543] Further details of this can be found in Chapter 4.

[544] Simpson *et al.,* 'A Reinterpretation of the Great Pit at Hofstaðir'.

comparison to them being used within a single context. The radiocarbon ages within each stratigraphy provide a detailed framework of site-based information, with the soil chemistry (and subsequent statistical analysis) alongside thin section micromorphology providing finer levels of detail regarding each observed temporal phase. Repeating this process for each site helps compose a comparative regional picture, where the variance and similarities can be understood within the broader historiographical record. It is with this free-flowing movement through a variety of scales that these complex and in-depth narratives can begin to be assembled, something which is essential when dealing with an array of field sites encompassing several centuries and displaying such a wide variety of characteristics.

Chapter Four – Results

This chapter begins with the establishment of a chronological framework serving as a baseline for the geoarchaeological and micromorphological results. This is done for all fishing sites, and also the farm site at Vatnsfjörður farm which is used as a terrestrial-based reference. From here, soil contexts and associated micromorphological features were systematically identified and discussed on a site-by-site basis, analysing each site in the context of its own stratigraphy. Each stratigraphy follows the key and scale shown in Figure 27. The results aim to provide a broad-to-fine level of detail, focussing on patterns across the site as well as individual episodes and characteristics which can enhance the detail and context of the narrative. This will create a multiple resolution study of the each site, which can in turn, compliment the historiographical element of chapter two. Information within the chapter begins with site-level stratigraphic interpretation, moving to an integrated interpretation of the soil chemistry and micromorphological analysis.

Field Stratigraphies

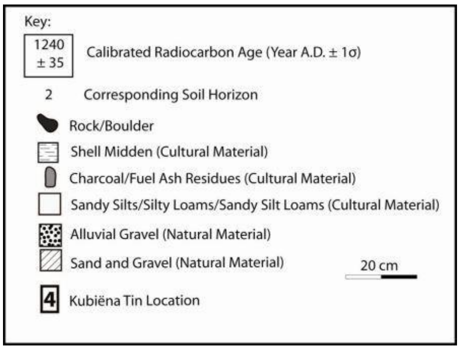


Figure 27: Field Stratigraphy Key (For Figure 28 to Figure 37)

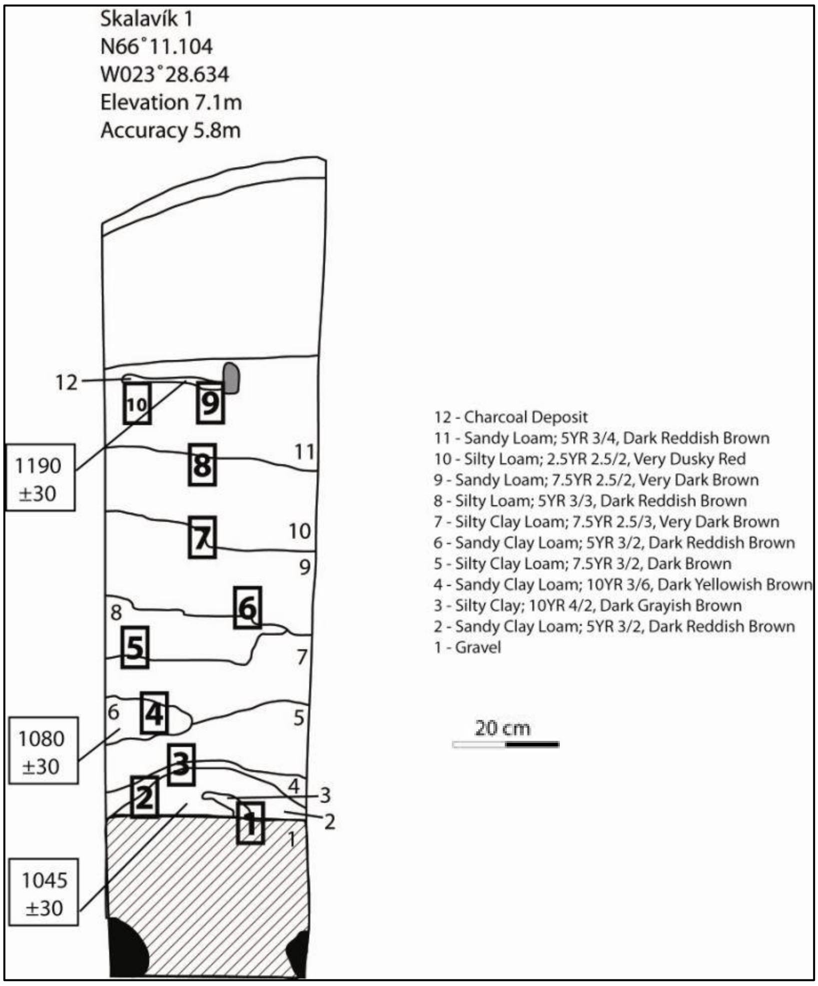


Figure 28: Field Stratigraphy with AMS Radiocarbon Dates, Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Skálavík 1

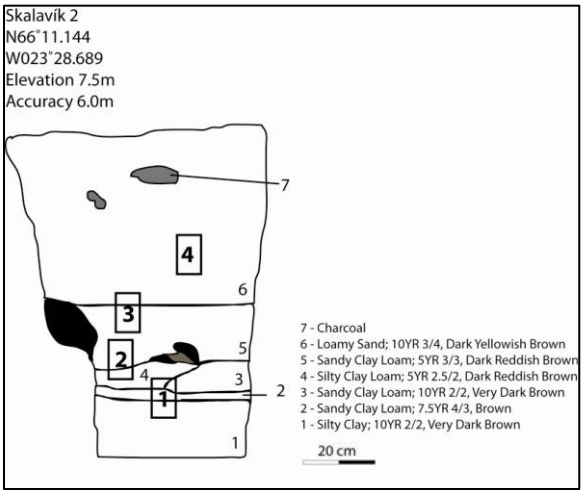


Figure 29: Field Stratigraphy with Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Skálavík 2

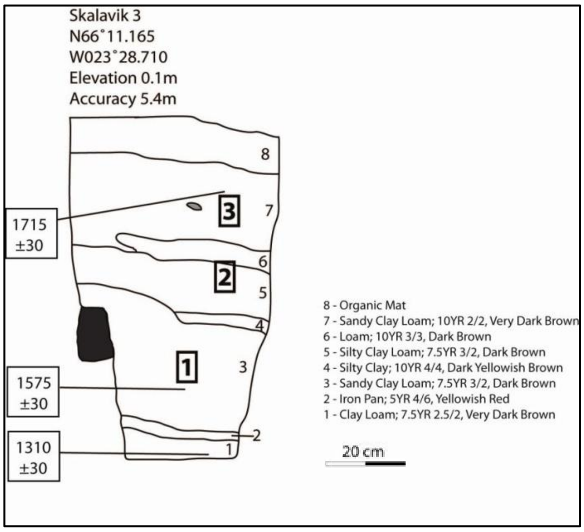


Figure 30: Field Stratigraphy with AMS Radiocarbon Dates, Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Skálavík 3

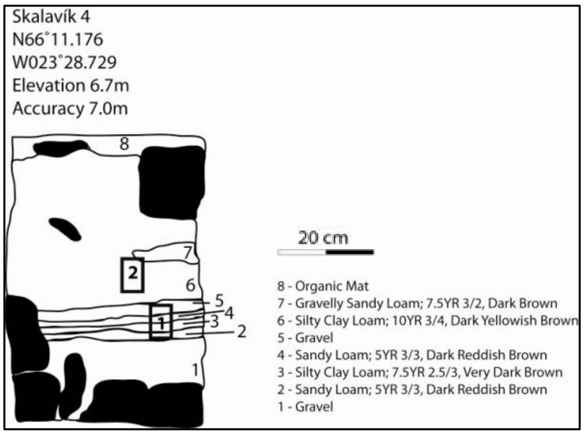


Figure 31: Field Stratigraphy with Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Skálavík 4

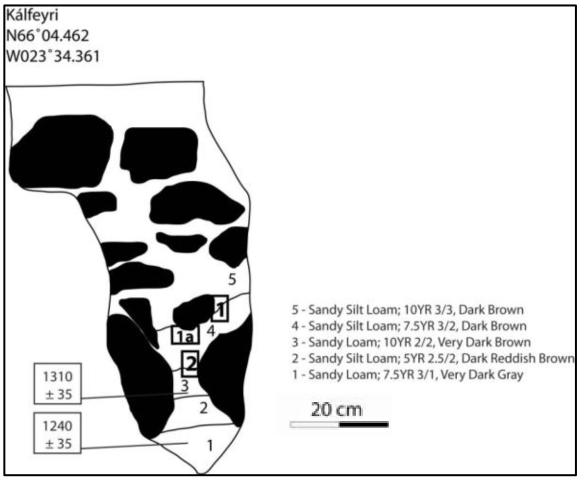


Figure 32: Field Stratigraphy with AMS Radiocarbon Dates, Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Kálfeyri

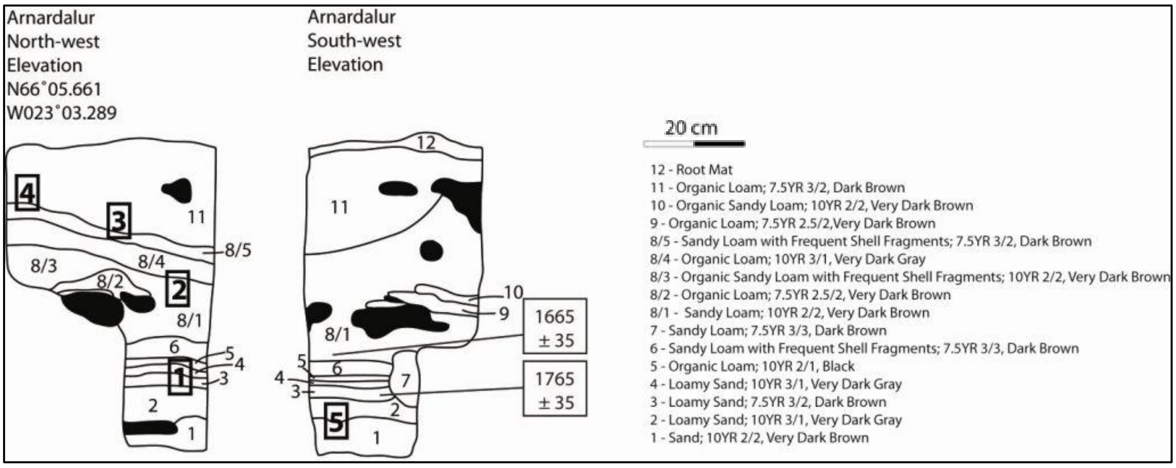


Figure 33: Field Stratigraphy with AMS Radiocarbon Dates, Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Arnardalur

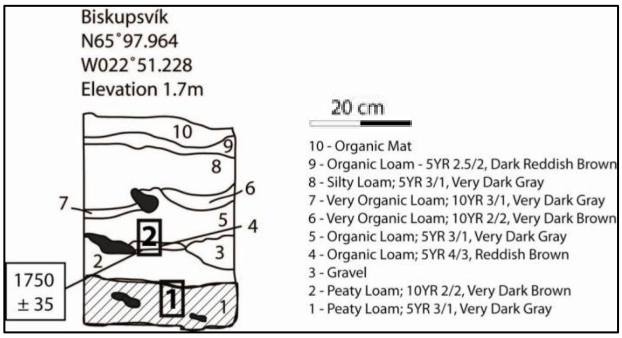


Figure 34: Field Stratigraphy with AMS Radiocarbon Date, Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Biskupsvík

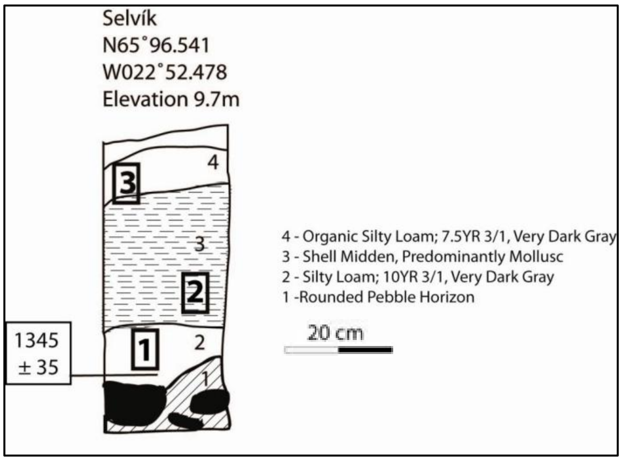


Figure 35: Field Stratigraphy with AMS Radiocarbon Date, Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Selvík

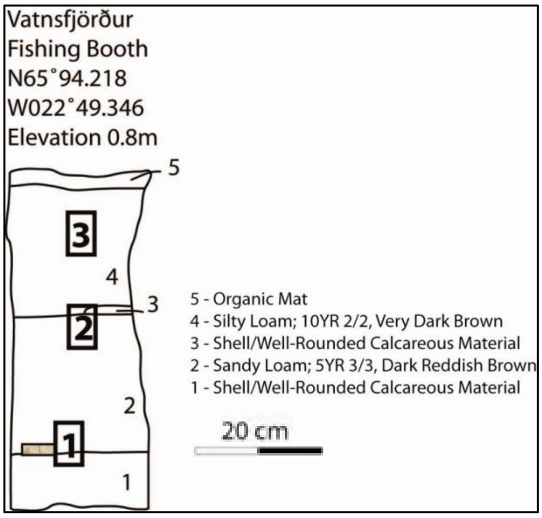


Figure 36: Field Stratigraphy with Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Vatnsfjörður Booth

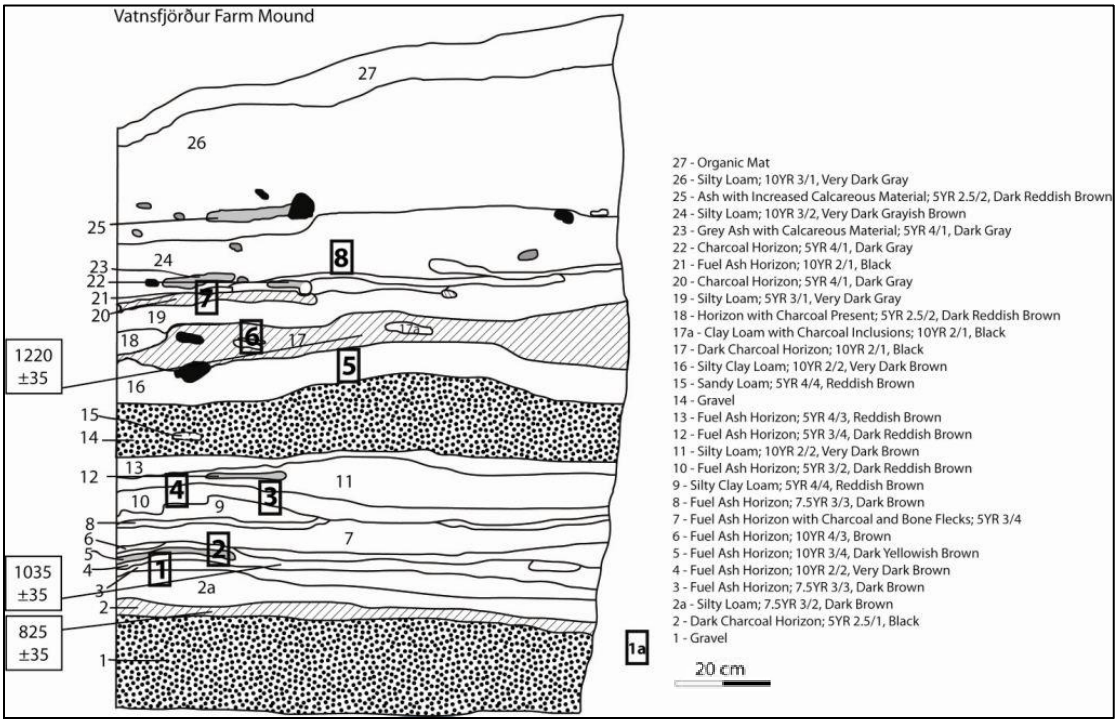


Figure 37: Field Stratigraphy with AMS Radiocarbon Dates, Kubiëna Tin Locations, Field Descriptions and Munsell Colours, Vatnsfjörður Farm Mound

As detailed in chapter three, the process of obtaining samples from the stratigraphies followed an identical sequence across all sites, undertaken by hand. Once the soil pit was inserted the stratigraphy was drawn up to scale on waterproof tracing paper, the next step was to obtain suitable material from relevant horizons for radiocarbon dating.

Following this the colours and textures detailed in accordance with international standard guidelines. After this process, the location of Kubiëna tins was determined and inserted into the stratigraphy. On numerous occasions, the material within a stratigraphy proved impenetrable and alternative areas were sought. The final sampling process was to obtain bulk samples (where possible) from each recorded horizon. Due to the nature of archaeological soils, the quantity of soil was not sufficient to conduct a full suite of laboratory tests, but the most was made of the sample. Varying sites did display different degrees of depth and complexity, from the multiple fuel residue layers at Vatnsfjörður farm site, to the highly organic and thick horizons found at Biskupsvík. Once recorded and sampled, the pit was backfilled and left in as close to the condition as it was found. The subsequent analysis of these samples can be found later in this chapter.

Radiocarbon Chronology

Samples for radiocarbon dating were obtained from, where possible, the lowest and most key points within each sheet midden stratigraphy. These were predominantly *Betula* charcoal, however, there were also mussel shell and non-coniferous wood present (Table 1). *Betula* charcoal and the inherent age of charcoal chronologies are considered as indicative and representative. These samples were typically small (with exception of the shell), weighing only a few micrograms, and were identified to species level by Glasgow University Archaeological Research Division (GUARD). The atomic mass spectrometer (AMS) radiocarbon measurements and calibrations were undertaken at the Scottish Universities Environment Research Centre (SUERC) radiocarbon laboratory.

Table 1: Radiocarbon measurements from sheet middens around Fishing Booths and from the Vatnsfjörður farm mound, Vestfirðir, Iceland

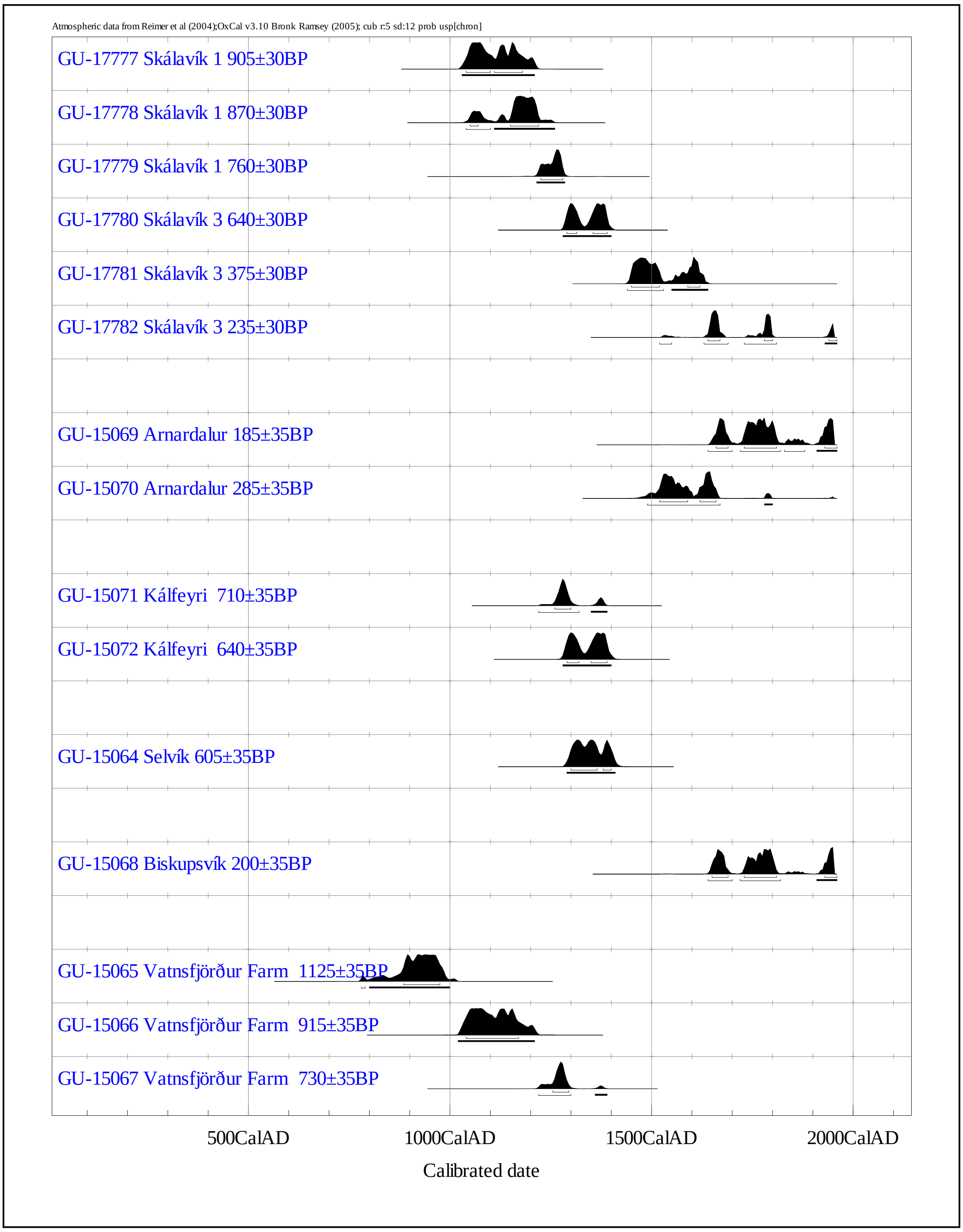
Location	Sample Type	Depth in Profile	Lab Code No.	Measu-rement	14C Age (yr B.P. ± 1σ)	δ 13C ‰	Calibrated Age Ranges (yr A.D. to 2 σ)[545]
Vatnsfjörður Farm Mound	*Betula*	Horizon 2	GU-15065	AMS	1125 ± 35	-25.8	790-860
Vatnsfjörður Farm Mound	*Betula*	Horizon 3	GU-15066	AMS	915 ± 35	-27.4	1000-1070
Vatnsfjörður Farm Mound	*Betula*	Horizon 17	GU-15067	AMS	730 ± 35	-27.4	1185-1255
Selvík	*Mytilus edulis* (Mussel) Shell	Horizon 2	GU-15064	AMS	605 ± 35	1.4	1310-1380
Biskupsvík	*Betula*	Horizon 4	GU-15068	AMS	200 ± 35	-27.4	1715-1785
Arnardalur	Non-coniferous wood	Horizon 3	GU-15069	AMS	185 ± 35	-25.9	1730-1800
Arnardalur	*Betula*	Horizon 8	GU-15070	AMS	285 ± 35	-25.9	1630-1700
Kálfeyri	*Betula*	Horizon 1	GU-15071	AMS	710 ± 35	-28.0	1205-1275
Kálfeyri	*Betula*	Horizon 3	GU-15072	AMS	640 ± 35	-27.4	1275-1345
Skálavík 1	*Betula*	Horizon 2	GU-17777	AMS	905 ± 30	-27.2	1015-1075
Skálavík 1	*Betula*	Horizon 6	GU-17778	AMS	870 ± 30	-27.0	1050-1110
Skálavík 1	*Betula*	Horizon 12	GU-17779	AMS	760 ± 30	-25.6	1160-1220
Skálavík 3	*Betula*	Horizon 1	GU-17780	AMS	640 ± 30	-27.2	1280-1340
Skálavík 3	*Betula*	Horizon 3	GU-17781	AMS	375 ± 30	-27.6	1545-1605
Skálavík 3	*Betula*	Horizon 7	GU-17782	AMS	235 ± 30	-26.2	1685-1745

Radiocarbon measurements are also presented in Figure 38. Measurements from Vatnsfjörður farm mound (Figure 37) reveal calibrated ages of AD 790-860 (Horizon 2), AD 1000-1070 (Horizon 3) and AD 1185-1255 (Horizon 17). The earliest radiocarbon measurement from any of the interpreted specialist fishing locations is from the outer fjord site at Skálavík 1 (Figure 28), dating from AD 1015-1075 (Horizon 2), with two horizons further up the stratigraphy yielding dates of AD 1050-1110 (Horizon 6) and AD 1160-1220 (Horizon 12). The trench at Kálfeyri (Figure 32), another outer fjord site this time on the Önundarfjörður fjord, has an earliest date of AD 1205-1275 (Horizon 1), with a date of AD 1275-1345 being obtained from further up the stratigraphy. Skálavík 3 (Figure 30) yields a radiocarbon date of AD 1280-1340 at the lowest point in its stratigraphy (Horizon 1), with dates of AD 1545-1605 (Horizon 3) and AD 1685-1745

[545] P.J. Reimer, M.G.L. Baillie, E. Bard, A. Bayliss, J.W. Beck, C.J.H. Bertrand, P.G. Blackwell, C.E. Buck, G.S. Burr, K.B. Cutler, P.E. Damon, R.L. Edwards, R.G. Fairbanks, M. Friedrich, T.P. Guilderson, A.G. Hogg, K.A. Hughen, B. Kromer, G. McCormac, S. Manning, C. Bronk Ramsey, R.W. Reimer, S. Remmele, J.R. Southon, M. Stuiver, S. Talamo, F.W. Taylor, J. van der Plicht, C.E. Weyhenmeyer, 'IntCal04 terrestrial radiocarbon age calibration, 0–26 cal kyr BP', *Radiocarbon,* 46 (2004), p.1029–58.

(Horizon 7) further up the profile. The outer fjord site at Arnardalur (Figure 33) yields an earliest date of AD 1630-1700 (Horizon 8), with a horizon below yielding a younger age of AD 1730-1800 (Horizon 3).

Figure 38: AMS Radiocarbon Results



The earliest radiocarbon age from the identified inner fjord sites comes from Selvík (Figure 35), dating from AD 1310-1380 (Horizon 2). This date is derived from a thick horizon of shell midden material which contains fine fish bones, sandwiched between a layer of well-rounded stones and a horizon of culturally-influenced organic soil. The inner fjord site at Biskupsvík (Figure 34) yields a sole radiocarbon age of AD 1715-1785 (Horizon 4).

Sediment Analysis – Soil Chemistry – Correlations and Z-Scores

In order to maximise the interpretation potential regarding the soil chemistry data, a variety of different parameters was used. The main aim was to obtain a more generic overview and observe trends and differences at the sites as two collective groups, and also within their individual context. Firstly, all fishing sites were considered on an individual basis to identify the inter-horizon variances, before broadening the approach and being considered as a collective to establish wider trends tying in with individual site characteristics. Vatnsfjörður farm mound was analysed as a separate entity for a variety of reasons. Firstly, it represents more terrestrial activities opposed to maritime activities at the fishing sites, and secondly, what was sampled was taken from a midden heap, opposed to a sheet midden. This is a completely different method of deposition; wastes piled upon wastes, opposed to what is found at fishing stations, mainly occupational surfaces which would have accumulated debris as part of an everyday working environment. Most importantly, the site can be used as a terrestrial control from which to base the maritime sites against.

SPSS version 18 (later PASW statistics 18) and Microsoft Excel were used to establish means, medians, maximums and minimums. Standard errors were also calculated to test the robustness of the data (Table 2 and Table 3). Pearson's Correlation was used to identify any on-site statistical relationships between a variety of variables; pH, soil magnetism, total phosphorus and percentage organic matter. Particle size analysis was also included, involving mean, median skewness and kurtosis. Hierarchical groupings were created to assist in the interpretation, however, at some sites there was insufficient data to undertake correlations with any degree of accuracy. These groups do form part of the broader collective, however, sample size was very much limited at specific sites. Standard deviations of pH, soil magnetism, total phosphorus and organic matter were obtained, with z-scores calculated and rankings assigned based on one, two and three standard deviations from the mean.[546] This assisted in the interpretation of stratigraphic differences which in turn, linked with the micromorphological analysis.

Table 2: Descriptive Statistics, Vatnsfjörður Farm

	N	Minimum	Maximum	Mean	Std. Deviation	Standard Error
mgP_100g_soil	28	160.79	817.71	448.55	185.56	35.06
Mag_sus	26	112.03	1186.86	417.96	362.33	71.06
Organic_matter	25	11.02	59.81	25.80	12.03	2.41
pH	28	5.60	6.50	6.03	.23	0.044
Valid N (listwise)	25					

Table 3: Descriptive Statistics, Fishing Sites

	N	Minimum	Maximum	Mean	Std. Deviation	Standard Error
mgP_100g_soil	61	77.34	1840.28	533.75	375.25	48.05
Mag_sus	53	4.36	1083.60	394.37	259.90	35.70
organic_matter	59	1.16	85.56	20.57	14.60	1.90
pH	61	4.00	7.60	5.63	.98	0.125
Valid N (listwise)	53					

The use of correlations can provide insight into activities which have been undertaken on occupational surfaces resulting in what ends up within the stratigraphy. One such key variable is phosphorus. Studies have been undertaken looking at soil phosphorus

[546] Statistical consultation undertaken with D. Pearson, University of Stirling, Autumn 2010 and Autumn 2011.

and its relationship with other variables, which provide a suitable baseline for this investigation. One example would be a site in Orkney which shows a direct correlation between soil phosphorus and organic matter.[547] If levels of this element were raised, the question is what the cause of this elemental increase is, and is this in any way related to other on-site activities.

Table 4: Vatnsfjörður Farm – All Stats (Correlations)

		Org_mat	Mag_sus	pH	mean	median	skewness	kurtosis
P	Pearson Correlation	.125	.653**	-.082	-.051	-.099	.325	.287
	Sig. (2-tailed)	.553	.000	.677	.797	.616	.091	.139
	N	25	26	28	28	28	28	28
Org_mat	Pearson Correlation		.084	-.039	.631**	.549**	.241	.156
	Sig. (2-tailed)		.688	.852	.001	.005	.245	.456
	N		25	25	25	25	25	25
Mag_sus	Pearson Correlation			.239	-.224	-.124	.442*	.492*
	Sig. (2-tailed)			.240	.271	.547	.024	.011
	N			26	26	26	26	26
pH	Pearson Correlation				-.125	-.146	.059	.106
	Sig. (2-tailed)				.528	.458	.764	.591
	N				28	28	28	28
mean	Pearson Correlation					.784**	.195	.040
	Sig. (2-tailed)					.000	.319	.838
	N					28	28	28
median	Pearson Correlation						.316	.225
	Sig. (2-tailed)						.101	.249
	N						28	28
skewness	Pearson Correlation							.967**
	Sig. (2-tailed)							.000
	N							28

At Vatnsfjörður farm (Table 4; Figure 39), there were strong positive correlations between total phosphorus and magnetic susceptibility (N=26, r=0.653, p<.001), and organic matter and median particle size (N=25, r=0.549, p=.005). Moderate positive correlations were found between magnetic susceptibility and skewness (N=26, r=0.442, p=.024), as well as magnetic susceptibility and kurtosis (N=26, r=0.492, p=.011). The total phosphorus and magnetic susceptibility association shows that these two variables, strongly linked with anthropogenic activity, were very well related; as material such as fuel residues were being deposited, they were simultaneously influencing and increasing the value of phosphorus found within the stratigraphy. This

[547] S.J.L. Morrison & I.A. Simpson, 'Nessbreck, Corrigall, Harray, Orkney: Soil Chemical Analysis of spot samples from Souterrain', (Unpublished Report, 2008).

observation is understandable, given that fuel wastes have been used to amend soils and increase fertility for many years, and increases in phosphorus is an element which increases the growth of vegetation.

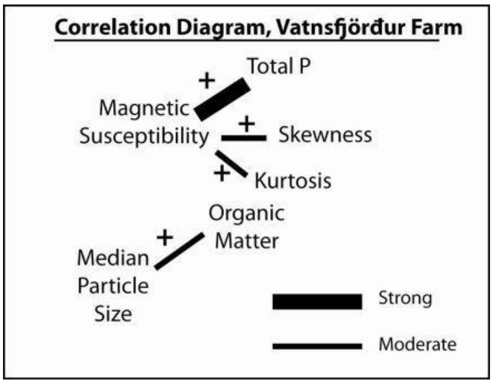


Figure 39: Correlation Diagram, Vatnsfjörður Farm

There were a significant number of correlations observed when looking at all fishing sites as a collective (Table 5; Figure 40). A strong positive correlations is observed again between total phosphorus and magnetic susceptibility (N=53, r=0.579, p<.001). Strong negative correlations were observed between total phosphorus and soil pH (N=61, r=-0.773, p<.001), as well as median particle size and skewness (N=61, r=-0.590, p<.001). A moderate positive correlation is observed between total phosphorus and kurtosis (N=61, r=0.308, p=.016). Moderate negative correlations were observed between magnetic susceptibility and organic matter (N=53, r=-0.401, p=.003), magnetic susceptibility and pH (N=53, r=-0.487, p<.001), pH and skewness (N=61, r=-0.384, p=.002), pH and kurtosis (N=61, r=-0.418, p=.001) and median particle size and kurtosis (N=61, r=-0.393, p=.002). A low-strength positive correlation is observed between total phosphorus and skewness (N=61, r=0.292, p=.023), with a low-strength negative correlation observed between organic matter and median particle size (N=59, r=-0.264, p=.043).

The strong negative correlation between total phosphorus and soil pH is of particular interest in this context. With this finding not being observed at the farm site, there is a difference established between the two different site activities. The presence of fish bone may be the determining factor; with the lowering of soil pH, increasingly acidic conditions may degrade bone quicker, generating greater levels of total phosphorus in the stratigraphy. This correlation gives a strong indication that this may be the case, something which can be determined by thin section micromorphological analysis. The moderate negative correlation between magnetic susceptibility and organic matter reveal the reduction in organic residues as a result of the burning process. With there being cultural deposits during phases of occupation, organic material is not being afforded the opportunity to establish itself and grow, which would help keep this value low.

Table 5: All Fishing Sites – Correlations

		Sample_LF	organic_matter	pH	Mean	Median	Skewness	Kurtosis
mgP_100g_soil	Pearson Correlation	.579**	-.085	-.773**	-.259*	-.180	.292*	.308*
	Sig. (2-tailed)	.000	.524	.000	.044	.164	.023	.016
	N	53	59	61	61	61	61	61
Sample_LF	Pearson Correlation		-.401**	-.487**	-.179	-.198	.234	.196
	Sig. (2-tailed)		.003	.000	.200	.156	.092	.160
	N		53	53	53	53	53	53
organic_matter	Pearson Correlation			-.191	-.330*	-.264*	.182	.127
	Sig. (2-tailed)			.148	.011	.043	.168	.336
	N			59	59	59	59	59
pH	Pearson Correlation				.333**	.247	-.384**	-.418**
	Sig. (2-tailed)				.009	.055	.002	.001
	N				61	61	61	61
Mean	Pearson Correlation					.939**	-.628**	-.525**
	Sig. (2-tailed)					.000	.000	.000
	N					61	61	61
Median	Pearson Correlation						-.590**	-.393**
	Sig. (2-tailed)						.000	.002
	N						61	61
Skewness	Pearson Correlation							.922**
	Sig. (2-tailed)							.000
	N							61

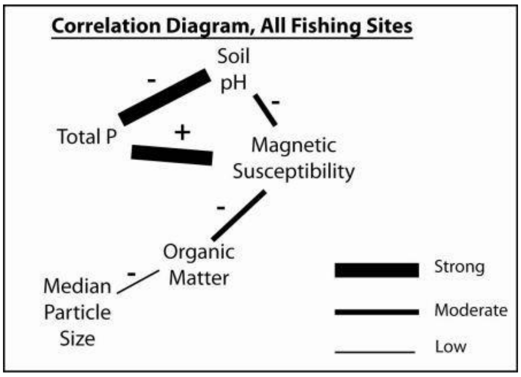


Figure 40: Correlation Diagram, All Fishing Sites

Correlations and trends were also found at some sites when analysed individually (Table 7), but this could not be undertaken at all sites given the low sample numbers obtained in the smaller stratigraphies. At Skálavík 1, a strong positive correlation is found between total phosphorus and magnetic susceptibility (N=12, r=0.643, p=.024). Strong negative correlations were observed between total phosphorus and soil pH (N=12, r=-0.743, p=.006), median particle size and skewness (N=12, r=-0.721, p=.008), and median particle size and kurtosis (N=12, r=-0.762, p=.004). Strong negative trends were observed between pH and skewness (N=12, r=-0.576, p=.050), and pH and kurtosis (N=12, r=-0.534, p=.074). Skálavík 2 reveals strong negative correlations between total phosphorus and skewness (N=7, r=-0.798, p=.032), total phosphorus and kurtosis (N=7, r=-0.859, p=.013), organic matter and skewness (N=7, r=-0.868, p=.011), organic matter and kurtosis (N=7, r=-0.836, p=.019), median particle size and skewness (N=7, r=-0.818, p=.024), and median particle size and kurtosis (N=7, r=-0.893, p=.007). Strong positive trends were observed between total phosphorus and organic matter (N=7, r=0.685, p=.090), and total phosphorus and median particle size (N=7, r=0.734, p=.061). A strong negative trend is observed between magnetic susceptibility and soil pH (N=7, r=-0.698, p=.081). Skálavík 3 reveals a strong positive trend between total phosphorus and magnetic susceptibility (N=7, r=0.705, p=.077), with strong negative trends being observed between median particle size and skewness (N=7, r=-0.753, p=.051), and median particle size and kurtosis (N=7, r=-0.695, p=.083). At Skálavík 4, there were strong negative trends between magnetic susceptibility and organic matter (N=7, r=-0.697, p=.082), and median particle size and kurtosis (N=7, r=-0.690, p=.086).

Table 6: Inner Fjord Sites vs. Outer Fjord Site – Correlations

Site_inner_outer			Sample_LF	organic_matter	pH	Mean	Median	Skewness	Kurtosis
Outer	mgP_100g_soil	Pearson Correlation	.465**	.417**	-.830**	-.354**	-.256	.351**	.332*
		Sig. (2-tailed)	.001	.002	.000	.009	.064	.010	.015
		N	45	51	53	53	53	53	53
	Sample_LF	Pearson Correlation		-.055	-.496**	-.278	-.304*	.305*	.198
		Sig. (2-tailed)		.721	.001	.064	.042	.042	.192
		N		45	45	45	45	45	45
	organic_matter	Pearson Correlation			-.456**	-.469**	-.357*	.269	.259
		Sig. (2-tailed)			.001	.001	.010	.057	.066
		N			51	51	51	51	51
	pH	Pearson Correlation				.459**	.341*	-.456**	-.459**
		Sig. (2-tailed)				.001	.012	.001	.001
		N				53	53	53	53
	Mean	Pearson Correlation					.942**	-.649**	-.554**
		Sig. (2-tailed)					.000	.000	.000
		N					53	53	53
	Median	Pearson Correlation						-.600**	-.411**
		Sig. (2-tailed)						.000	.002
		N						53	53
	Skewness	Pearson Correlation							.925**
		Sig. (2-tailed)							.000
		N							53
Inner	mgP_100g_soil	Pearson Correlation	.069	-.240	.000	.370	.316	-.209	-.271
		Sig. (2-tailed)	.872	.568	1.000	.367	.445	.619	.517
		N	8	8	8	8	8	8	8
	Sample_LF	Pearson Correlation		-.775*	.891**	-.633	-.776*	-.256	-.299
		Sig. (2-tailed)		.024	.003	.092	.024	.541	.472
		N		8	8	8	8	8	8
	organic_matter	Pearson Correlation			-.885**	.114	.721*	.109	.281
		Sig. (2-tailed)			.004	.788	.044	.797	.501
		N			8	8	8	8	8
	pH	Pearson Correlation				-.481	-.912**	-.098	-.189
		Sig. (2-tailed)				.227	.002	.817	.654
		N				8	8	8	8
	Mean	Pearson Correlation					.636	.262	.096
		Sig. (2-tailed)					.090	.530	.821
		N					8	8	8
	Median	Pearson Correlation						.117	.142
		Sig. (2-tailed)						.783	.738
		N						8	8
	Skewness	Pearson Correlation							.962**
		Sig. (2-tailed)							.000
		N							8

Table 7: All Sites – Correlations

Site			Sample_LF	organic_matter	pH	Mean	Median	Skewness	Kurtosis
Skálavík 1	mgP_100g_soil	Pearson Correlation	.643*	.127	-.743**	-.131	-.248	.400	.336
		Sig. (2-tailed)	.024	.694	.006	.685	.437	.198	.286
		N	12	12	12	12	12	12	12
	Sample_LF	Pearson Correlation		.281	-.520	-.041	-.056	.045	.017
		Sig. (2-tailed)		.377	.083	.901	.863	.889	.958
		N		12	12	12	12	12	12
	organic_matter	Pearson Correlation			-.126	.160	.221	-.141	-.040
		Sig. (2-tailed)			.695	.619	.489	.661	.903
		N			12	12	12	12	12
	pH	Pearson Correlation				.263	.319	-.576	-.534
		Sig. (2-tailed)				.409	.313	.050	.074
		N				12	12	12	12
	Mean	Pearson Correlation					.976**	-.669*	-.746**
		Sig. (2-tailed)					.000	.017	.005
		N					12	12	12
	Median	Pearson Correlation						-.721**	-.762**
		Sig. (2-tailed)						.008	.004
		N						12	12
	Skewness	Pearson Correlation							.976**
		Sig. (2-tailed)							.000
		N							12
Skálavík 2	mgP_100g_soil	Pearson Correlation	.199	.685	.001	.704	.734	-.798*	-.859*
		Sig. (2-tailed)	.669	.090	.999	.078	.061	.032	.013
		N	7	7	7	7	7	7	7
	Sample_LF	Pearson Correlation		-.168	-.698	-.179	-.289	.256	.226
		Sig. (2-tailed)		.719	.081	.702	.530	.580	.626
		N		7	7	7	7	7	7
	organic_matter	Pearson Correlation			.210	.431	.541	-.868*	-.836*
		Sig. (2-tailed)			.651	.334	.210	.011	.019
		N			7	7	7	7	7
	pH	Pearson Correlation				.334	.527	-.520	-.439
		Sig. (2-tailed)				.464	.224	.232	.325
		N				7	7	7	7
	Mean	Pearson Correlation					.952**	-.667	-.797*
		Sig. (2-tailed)					.001	.101	.032
		N					7	7	7
	Median	Pearson Correlation						-.818*	-.893**
		Sig. (2-tailed)						.024	.007
		N						7	7
	Skewness	Pearson Correlation							.977**
		Sig. (2-tailed)							.000
		N							7
Skálavík 3	mgP_100g_soil	Pearson Correlation	.705	.461	.639	-.067	-.085	-.069	-.116
		Sig. (2-tailed)	.077	.298	.122	.887	.856	.882	.804
		N	7	7	7	7	7	7	7
	Sample_LF	Pearson Correlation		.079	.669	-.295	-.291	-.039	-.057
		Sig. (2-tailed)		.866	.100	.521	.526	.934	.903
		N		7	7	7	7	7	7
	organic_matter	Pearson Correlation			-.234	-.459	-.462	.473	.414
		Sig. (2-tailed)			.613	.300	.297	.284	.356
		N			7	7	7	7	7
	pH	Pearson Correlation				.194	.191	-.095	-.060
		Sig. (2-tailed)				.676	.682	.840	.899
		N				7	7	7	7
	Mean	Pearson Correlation					.998**	-.755*	-.703
		Sig. (2-tailed)					.000	.050	.078
		N					7	7	7
	Median	Pearson Correlation						-.753	-.695

		Sig. (2-tailed)						.051	.083
		N						7	7
	Skewness	Pearson Correlation							.992**
		Sig. (2-tailed)							.000
		N							7
Skálavík 4	mgP_100g_soil	Pearson Correlation	.602	-.184	-.129	-.049	-.007	-.223	-.209
		Sig. (2-tailed)	.153	.694	.782	.917	.987	.630	.652
		N	7	7	7	7	7	7	7
	Sample_LF	Pearson Correlation		-.697	.426	-.680	-.580	.359	.422
		Sig. (2-tailed)		.082	.340	.092	.172	.429	.346
		N		7	7	7	7	7	7
	organic_matter	Pearson Correlation			-.655	.644	.536	.021	-.096
		Sig. (2-tailed)			.110	.119	.215	.965	.838
		N			7	7	7	7	7
	pH	Pearson Correlation				-.406	-.290	.028	.114
		Sig. (2-tailed)				.367	.528	.953	.808
		N				7	7	7	7
	Mean	Pearson Correlation					.979**	-.613	-.705
		Sig. (2-tailed)					.000	.143	.077
		N					7	7	7
	Median	Pearson Correlation						-.611	-.690
		Sig. (2-tailed)						.145	.086
		N						7	7
	Skewness	Pearson Correlation							.990**
		Sig. (2-tailed)							.000
		N							7
Arnardalur	mgP_100g_soil	Pearson Correlation	.183	.394	-.596*	-.604*	-.583*	.422	.258
		Sig. (2-tailed)	.694	.183	.019	.017	.023	.117	.354
		N	7	13	15	15	15	15	15
	Sample_LF	Pearson Correlation		-.439	-.010	-.491	-.581	.604	.432
		Sig. (2-tailed)		.324	.983	.264	.171	.151	.333
		N		7	7	7	7	7	7
	organic_matter	Pearson Correlation			-.567*	-.486	-.348	.308	.241
		Sig. (2-tailed)			.044	.092	.244	.306	.427
		N			13	13	13	13	13
	pH	Pearson Correlation				.465	.432	-.265	-.140
		Sig. (2-tailed)				.080	.108	.339	.620
		N				15	15	15	15
	Mean	Pearson Correlation					.965**	-.860**	-.558*
		Sig. (2-tailed)					.000	.000	.031
		N					15	15	15
	Median	Pearson Correlation						-.793**	-.415
		Sig. (2-tailed)						.000	.124
		N						15	15
	Skewness	Pearson Correlation							.875**
		Sig. (2-tailed)							.000
		N							15
Kálfeyri	mgP_100g_soil	Pearson Correlation	-.510	.479	-.472	-.898*	-.804	-.449	-.265
		Sig. (2-tailed)	.380	.414	.422	.039	.101	.448	.666
		N	5	5	5	5	5	5	5
	Sample_LF	Pearson Correlation		.420	.746	.486	.449	.500	.428
		Sig. (2-tailed)		.481	.148	.406	.448	.391	.472
		N		5	5	5	5	5	5
	organic_matter	Pearson Correlation			-.040	-.231	-.103	-.192	-.168
		Sig. (2-tailed)			.949	.708	.870	.757	.787
		N			5	5	5	5	5
	pH	Pearson Correlation				.156	.029	.644	.719
		Sig. (2-tailed)				.802	.964	.241	.171
		N				5	5	5	5
	Mean	Pearson Correlation					.968**	.282	.018
		Sig. (2-tailed)					.007	.645	.977
		N					5	5	5
	Median	Pearson Correlation						.050	-.214
		Sig. (2-tailed)						.937	.730

		N						5	5
	Skewness	Pearson Correlation							.955*
		Sig. (2-tailed)							.011
		N							5
Biskupsvík	mgP_100g_soil	Pearson Correlation	.934	-.929	.840	.511	.301	-.131	-.272
		Sig. (2-tailed)	.066	.071	.160	.489	.699	.869	.728
		N	4	4	4	4	4	4	4
	Sample_LF	Pearson Correlation		-.906	.711	.351	.150	-.241	-.261
		Sig. (2-tailed)		.094	.289	.649	.850	.759	.739
		N		4	4	4	4	4	4
	organic_matter	Pearson Correlation			-.581	-.714	-.552	.488	.595
		Sig. (2-tailed)			.419	.286	.448	.512	.405
		N			4	4	4	4	4
	pH	Pearson Correlation				.111	-.111	.426	.257
		Sig. (2-tailed)				.889	.889	.574	.743
		N				4	4	4	4
	Mean	Pearson Correlation					.973*	-.682	-.886
		Sig. (2-tailed)					.027	.318	.114
		N					4	4	4
	Median	Pearson Correlation						-.740	-.921
		Sig. (2-tailed)						.260	.079
		N						4	4
	Skewness	Pearson Correlation							.941
		Sig. (2-tailed)							.059
		N							4
Selvík	mgP_100g_soil	Pearson Correlation	-1.000**	1.000**	-1.000**	-1.000**	-1.000**	-1.000**	-1.000**
		Sig. (2-tailed)	.	.	.	.	.	.	.
		N	2	2	2	2	2	2	2
	Sample_LF	Pearson Correlation		-1.000**	1.000**	1.000**	1.000**	1.000**	1.000**
		Sig. (2-tailed)		.	.	.	.	.	.
		N		2	2	2	2	2	2
	organic_matter	Pearson Correlation			-1.000**	-1.000**	-1.000**	-1.000**	-1.000**
		Sig. (2-tailed)			.	.	.	.	.
		N			2	2	2	2	2
	pH	Pearson Correlation				1.000**	1.000**	1.000**	1.000**
		Sig. (2-tailed)				.	.	.	.
		N				2	2	2	2
	Mean	Pearson Correlation					1.000**	1.000**	1.000**
		Sig. (2-tailed)					.	.	.
		N					2	2	2
	Median	Pearson Correlation						1.000**	1.000**
		Sig. (2-tailed)						.	.
		N						2	2
	Skewness	Pearson Correlation							1.000**
		Sig. (2-tailed)							.
		N							2
Vat Booth	mgP_100g_soil	Pearson Correlation	1.000**	-1.000**	1.000**	1.000**	1.000**	-1.000**	-1.000**
		Sig. (2-tailed)	.	.	.	.	.	.	.
		N	2	2	2	2	2	2	2
	Sample_LF	Pearson Correlation		-1.000**	1.000**	1.000**	1.000**	-1.000**	-1.000**
		Sig. (2-tailed)		.	.	.	.	.	.
		N		2	2	2	2	2	2
	organic_matter	Pearson Correlation			-1.000**	-1.000**	-1.000**	1.000**	1.000**
		Sig. (2-tailed)			.	.	.	.	.
		N			2	2	2	2	2
	pH	Pearson Correlation				1.000**	1.000**	-1.000**	-1.000**
		Sig. (2-tailed)				.	.	.	.
		N				2	2	2	2
	Mean	Pearson Correlation					1.000**	-1.000**	-1.000**
		Sig. (2-tailed)					.	.	.
		N					2	2	2
	Median	Pearson Correlation						-1.000**	-1.000**

		Sig. (2-tailed)						.	.
		N						2	2
	Skewness	Pearson Correlation							1.000**
		Sig. (2-tailed)							.
		N							2

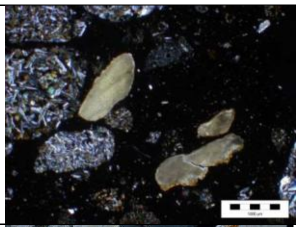
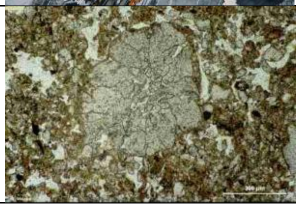
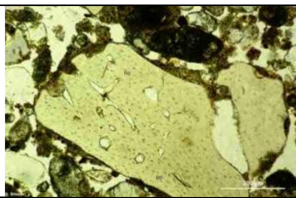
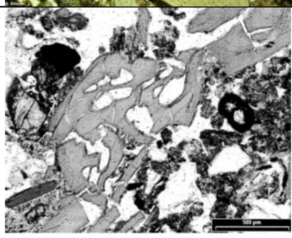
Arnardalur's results displays strong negative correlations between total phosphorus and soil pH (N=15, r=-0.596, p=.019), total phosphorus and median particle size (N=15, r=-0.583, p=.023), organic matter and soil pH (N=13, r=-0.567, p=.044), and median particle size and skewness (N=15, r=-0.793, p<.000). A strong positive trend is found between total phosphorus and magnetic susceptibility (N=4, r=0.934, p=.066) at Biskupsvík, alongside strong negative trends between total phosphorus and organic matter (N=4, r=-0.929, p=.071), and magnetic susceptibility and organic matter (N=4, r=-0.906, p=.094). No trends or correlations of significance or note were found at Kálfeyri, Selvík or Vatnsfjörður booth.

The Transition to Micro Scale

Following on from the statistical analysis is the beginning of analysis using thin section micromorphology. To assist with the understanding and interpretation of this section, a micromorphology interpretation key is outlined. This is in no way an exhaustive list of material observed under thin section, however, it gives a guide and outline to the key characteristics which relate to the formation processes, as well as the cultural material associated with particular economic practices, and deposits associated with periods of absence. Images largely acquired from Stoops, G. (2003). *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*, personal collections and Oxford Earth Sciences Image Store.

Micromorphology Interpretation Key

Table 8: Micromorphology Interpretation

Feature	Characteristics	Reference Image
Basalt	Contains irregularly-shaped although roughly rectangular crystals, with different ranges containing different interference colours.[548] Grains can often be more or less equal sized.	
Feldspar	Contains low relief and low birefringence, having grey or white interference colours which alternate.[549] Often contains two cleavages at right angles to one another.[550]	
Calcite	Contains high birefringence with delicate pastel shades of colour.[551] Parallel lines often found throughout fragments, as well as cross-hatching shapes sparingly spread out but still interconnected.	
Mammal Bone	Light brown/yellow in colour (PPL), haversian canals shown as black speckles on the bone surface. Burnt bones tend to be charred around the edges, ranging from light brown to black.[552]	
Fish Bone	Yellow/light brown in colour, depending on thickness. Contains little or no haversian canals, and contains a series of light linear striations visible under higher magnifications.[553] Degraded fish bone in certain environmental conditions are present as Calcium-Iron-Phosphate features.[554] Where the calcium has been	

[548] W.S. MacKenzie & A.E. Adams, *A Colour Atlas of Rocks and Minerals in Thin Section*, (London, 1994), p.74.

[549] University of Oxford. Oxford Earth Sciences Image Store <http://www.earth.ox.ac.uk/~oesis/index.html>, [Accessed 28/03/2012].

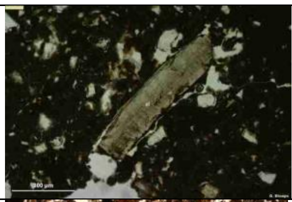
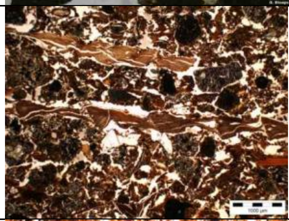
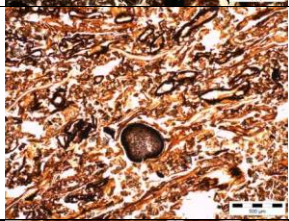
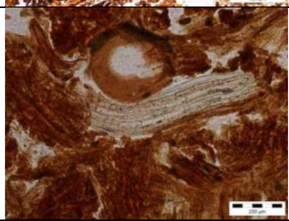
[550] MacKenzie & Adams, *A Colour Atlas of Rocks and Minerals in Thin Section*, p.50.

[551] Ibid., p.61.

[552] Stoops, *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*, p.76.

[553] Diaz, Personal Communication, August 2009.

[554] Simpson *et al.,* 'Cultural sediment analyses and transitions'.

	leached, yellow accumulations can be found. Bone shape and pattern is comparatively delicate with a greater shape variety present.	
Marine Shell	Mainly calcium carbonate, with a recognisable radial shape and fibrous texture.[555] Colours are varied (PPL) and white (OIL).	
Plant Fragments	Cellular remains, highly degraded or fragmented pieces can often mean that it has passed through a herbivore tract and indicates a livestock presence.[556]	
Fungal Spores	Well rounded cellular-like features with dark rim and smaller cellular features inside.[557] These insides are almost always complete, unlike regular plant residues.	
Cell Residues	Recognisable organic fragments with cells,[558] often deformed, contains more of a structure than plant fragments.	
Calcitic Spherulites	Spheres, around 5 to 15μm in size, white (OIL). These are calcium carbonates which form in the digestive tracts of herbivores, and represent a direct animal presence.[559]	

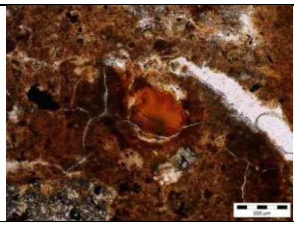
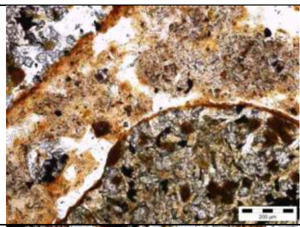
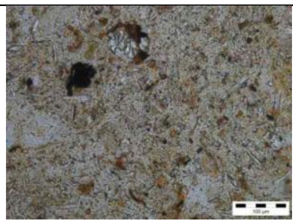
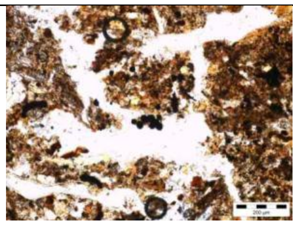
[555] Stoops, *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*, p.75.

[556] Simpson *et al., '*Relict Soils and Early Land Management in Loföten, Norway'.

[557] Stoops, *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*, p.125.

[558] Ibid*.,* p.88.

[559] M.G. Canti, 'An investigation of microscopic calcareous spherulites from herbivore dungs', *Journal of Archaeological Science*, 24 (1997), p.275-88; C. Lancelotti & M. Madella, 'The 'invisible' product: Developing markers for identifying dung in archaeological contexts', *Journal of Archaeological Science* (2011). doi: 10.1016/j.jas.2011.11.007

Hyaline Dopplerites	An amorphous fine organic material, brown (PPL), spherical with cracks, typically found beneath peat.[560]	
Coatings	Light layers, typically of clay, generally found around large mineral grains and infilling void space. These form when the terrain lies undisturbed, giving the assumption that these represent standstill phasing and site abandonment.[561]	
Calcium-Iron-Phosphates (CaFeP)	Radial amorphous infilling feature, a product of the dissolution and recrystallisation of bone material within void spaces of the soil or sediment matrix.[562] These have been found in sizable quantities in fishing sites in Norway.[563] The presence of CaFeP features is dependent on prevailing environmental conditions, and are mainly found in moist, temperate and sub-Boreal areas with acidic soil conditions.[564]	
Silicates	Phytoliths are common bodies in some plant tissues, including grasses and peats, with shape directly linked with the source vegetation type. They generally occur in the groundmass, and their orientation can give insight into levels of site decay. Diatoms are unicellular algae with radial or bilateral symmetry. These can be inherited from parent material (Marine) or remnants of soil microflora.[565] Both these features are clear in colour (PPL) and occasionally seen as very light white rims (OIL).	
Excremental Features	Spherical clusters representing biological activity, the features being the excrement of organisms living within the soil. High presence means a high biological difficulty which means enhanced levels of bioturbation which could make thin section interpretation difficult.	

560 Stoops, *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*, p.89.

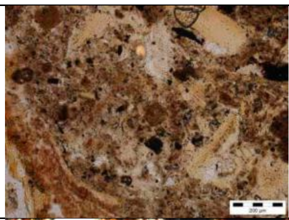
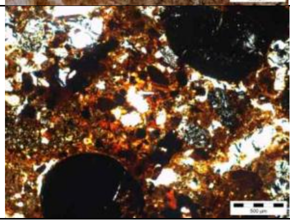
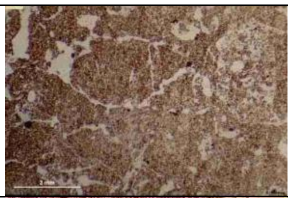
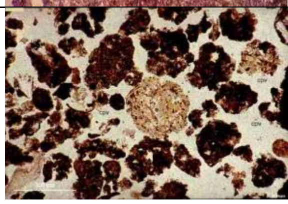
561 Ibid., p.106.

562 Adderley *et al.,* 'Calcium-iron-phosphate features in archaeological sediments'.

563 Simpson *et al.,* 'Cultural sediment analyses and transitions'.

564 Adderley *et al.,* 'Calcium-iron-phosphate features in archaeological sediments'.

565 Stoops, *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*, p.75.

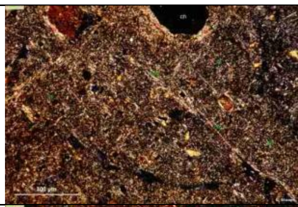
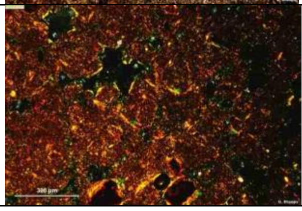
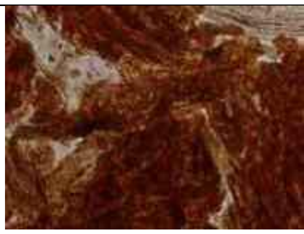
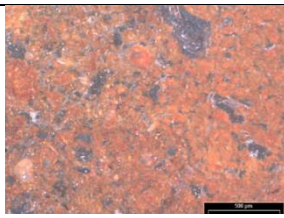
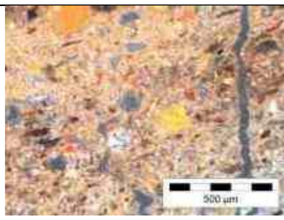
Yellow Accumulations	Found typically where there is the opportunity for infilling, showing yellow (PPL) and black (OIL), interpreted as bone or other biological material turning to solution where the calcium has been removed.	
Iron Accumulations	Orange/red (PPL) accumulations often found as nodules, typifying exposed areas which undergo wetting and drying conditions.	
Angular Blocky	Aggregates with angular edges, accommodating one another, few voids and separated with an intricate system of planar voids.[566]	
Subangular Blocky	Aggregates separated by short planar voids on all or most sides with the aggregate faces mostly accommodating each other.[567] This represents more of a slow, exposed accumulation of material.	
Crumb	Predominantly rounded, often rugged, porous aggregates not accommodating each other. Can be composed of small granules.[568] Soil surface may not be subject to the same degree of compaction than other surfaces. This tends to represent rapid accumulation and deposition of material.	
Platy	Aggregates predominantly horizontally stacked, separated by elongated planar voids.[569]	

[566] Ibid., p.88.

[567] Ibid.

[568] Ibid.

[569] Ibid.

Speckled	Randomly arranged, equidimensional or prolate domains of clay. When the microscope is rotated, domains extinguish successfully but the fine mass does not change.[570] Often found in peats, turfs and dung residues.[571]	
Crystallic	Contains small birefringent mineral grains determining interference colours as a whole.[572] Often found in the fuel residues of wood.[573]	
Peat	Low Temperature (400˚C), contains frequent silicates, very few irregular calcites, fine mineral material dark brown under Plain Polarised Light (PPL) and red under Oblique Incident Light (OIL). Groundmass faintly stipple speckled and contains the occasional organic fragment. High Temperature (800˚C), contains dominant silicates, frequent red heated minerals, little or no black organic material shown, faintly stipple speckled b-fabric. The fine mineral material is light brown (PPL) and yellow (OIL).[574]	
Turf	Low temperature contains very few silicates, fine mineral material brown (PPL) and red/orange (OIL), very few irregular calcites, b-fabric stipple speckled. Occasional black and dark brown organic material. High temperature contains very few silicates, frequent red heated minerals, very few irregular calcites. Fine mineral material is light brown (PPL) and yellow (OIL). No organic matter is observed, b-fabric stipple speckled.[575]	
Wood	Low temperature fine mineral material is grey (PPL) and grey and orange (OIL). Organic fragments are frequent and carbonised black, with Willow species porous and fibrous and Birch species being rod-like and sub-rounded. B-fabric is crystallic microfine (willow) or crystallic	

570 Stoops, *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*, p.96.

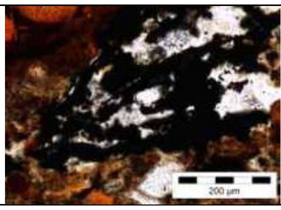
571 Simpson *et al.*, 'Fuel Resource Utilisation in Landscapes of Settlement'.

572 Stoops, *Guidelines for Analysis and Description of Soil and Regolith Thin Sections*, p.95.

573 Simpson *et al.*, 'Fuel Resource Utilisation in Landscapes of Settlement'.

574 Ibid.

575 Ibid.

	micro-medium (birch). High temperature burning shows no coarse mineral material but is dominated by brown (PPL) and light grey (OIL) fine mineral material. Non organic material is observed, with the b-fabric being crystallic micro-fine clustered.[576]	
Charcoal	Organic material, black under PPL and OIL, and can potentially be cellular depending on the source. If the sample is large enough, the rings can be used to calculate the age of the wood used.	
Accumulation Characteristics		
Slow	Typically subangular blocky microstructure with weathered components.	
Fast	Typically crumb microstructure with a highly random composition of materials contained within.	
Seasonal	Evidence of material associated with site abandonment such as iron accumulations, clay coatings, laminating bands of occupation on a regular basis.	
Continual	The seasonal materials are not present and occupational debris is more or less continual throughout the stratigraphy.	

The micromorphological observations and abundance quantification follow the key outlined by Bullock *et al.*, as expressed in Table 9. All thin section description tables in this research adhere to this key and should be used for purpose of reference.

Descriptor	**Abundance**	**Classification**
Very Dominant	> 70	4
Dominant	50-70	4
Frequent	30-50	3
Common	15-30	3
Few	5-15	2
Very Few	< 5	1
Trace	Trace	t

Table 9: Thin Section Material Abundances (Adapted from Bullock *et al.,* 1985)

[576] Ibid.

Bulk Soil Analyses and Micromorphology – Integrated Results

Vatnsfjörður Farm Case Study – The Control Site

The stratigraphy obtained from the Vatnsfjörður farm, as expected, is a stark contrast to the findings yielded from the coastal fishing sites. The difference in form, function and way in which material forming the stratigraphy has accumulated brought to the fore a highly stratified farm mound consisting of layer upon layer of debris, waste and residues from Icelandic farm life, dating from the time of settlement. It is because of this difference that a greater degree of confidence can be gained in the interpretation of the coastal sites undertaking exclusively – or almost exclusively – maritime economic activities. This finding alone can provide the foundation for the construction of a typography of terrestrial and maritime sites in Vestfirðir. The stratigraphy itself includes a range of complexity, with thick and thin horizons built up on top of one another, containing both fine material made up largely of fuel ash residues, to layers of rounded stones deposited as part of dredging and waterway clearance. The horizons containing predominantly fuel ash residues were found mainly in the lower half of the stratigraphy, before being capped by a rounded gravel then accumulation of thicker anthropogenic horizons. Where it was possible to establish the texture, these soils tended to be silty loams displaying a wide range of Munsell colours. Three radiocarbon dates were obtained from the Vatnsfjörður farm mound; AD 790 – 860 at horizon 2, AD 1000 – 1070 within horizon 3 and AD 1185 – 1255 within horizon 17.

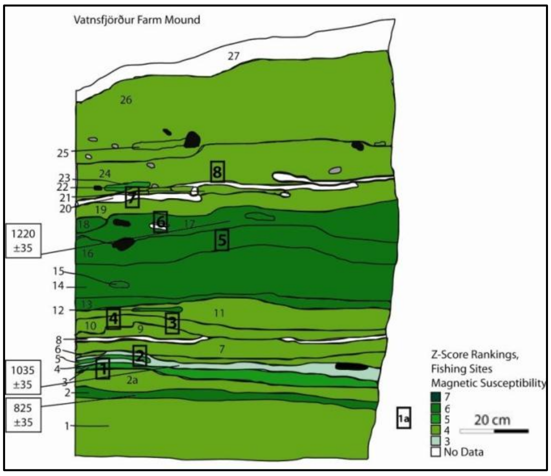


Figure 41: Vatnsfjörður Farm Intra-Stratigraphic Z-Score rankings of Magnetic Susceptibility

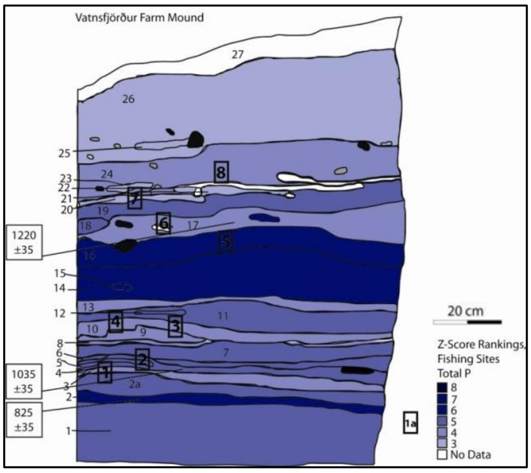


Figure 42: Vatnsfjörður Farm Intra-Stratigraphic Z-Score rankings of Total P

The lowest horizon in the stratigraphy is horizon 1, positioned entirely within the pre-AD 790 – 860 temporal period, is a gravel substrate which displays strong levels of total P and elevated levels of soil magnetism (Figure 41; Figure 42; Table 14). Organic levels were moderate, with soil pH being moderately acidic (Figure 43; Figure 44), which may enhance the degradation of organic material. Given the difficulty of obtaining a monolith in such material, a sample was obtained from an adjacent stratigraphic face with similar characteristics as horizon 1 and regarded as a continuation of the horizon and part of the same sequence. Within monolith 1A is a mixed microstructure, progressing from monic to crumb, then to subangular blocky (Table 10). The fuel residues present were almost exclusively turf residues, with few instances of peat. Charcoal and bone were present in distinct layers with varying degrees of abundance and preservation. Some of the larger basalt grains, linked with the subangular blocky microstructure have coatings, suggesting a period of standstill on the midden. These were accompanied by yellow infills, iron accumulation features and single-orientation silicates.

Table 10: Vatnsfjörður Farm, Thin Section Descriptions 1 & 1a

Vatnsfjörður Farm 1 – 1a

Section	Horizon	Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
		Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (yellow)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
1a	4	t	t	t		2	t			Patchy medium brown PPL. Orange/brown OIL.		2		3	2	2	t		3	t		1			Subangular blocky	-	Speckled	Enaulic
	3	t	t	t		1	t			Patchy medium brown PPL. Orange with few darker areas of unrubified material OIL.		t		2	t	t	t		1			t			Blocky/subangular blocky	-	Speckled	Enaulic
	2	2	t	t		2	1			Pale to medium reddish brown PPL. Greyish brown with red inclusions OIL.	t	t		3	1	1	t	1				1			Subangular blocky	-	Speckled	Enaulic
	1	2	t	t		t	2			Medium reddish brown PPL. Medium brown with dark brown inclusions and light dustings of orange/red OIL.		t		3	2			1		t					Subangular blocky to crumb	-	Speckled	Enaulic
1	5	t	t	t		t	3			Light to medium brown PPL. Brown with darker and orange areas OIL.	t	2	t	t	2			1	1	t					Subangular blocky/granular to crumb	-	Stipple Speckled	Enaulic
	4	t	t			2	2			Medium greyish brown PPL. Pale orange with darker orange flecks OIL.	1	2		1	2	1		t	1						Subangular blocky/parallel blocky	-	Speckled	Enaulic
	3	t	t			3				Light brown with hint of orange PPL. Brown with one part medium orange OIL.	t	t		t	2	1			1						Subangular blocky with areas of granular and crumb	-	Speckled	Enaulic
	2	t	t	t		2	t			Pale to medium brown with dark layers PPL. very pale orange with brown bands OIL.		2	1		1	1			1						Subangular blocky	-	Stipple speckled	Enaulic
	1	t	t	t	t	2	2	Yes	yes	Dark to medium brown with banding PPL. Pale to medium red/orange with dark brown OIL.	t	t	t	2	1	2		1	1						Subangular blocky with granular areas	-	Speckled	Enaulic

Table 11: Vatnsfjörður Farm, Thin Section Descriptions 2 & 3

Vatnsfjörður Farm 2-3

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures									
Section	Horizon	Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites	Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
3	5	t		2		4				Pale brown PPL. Greyish brown with some rubified inclusions OIL.	t	3	t	3	t	t			1					Subangular blocky with a platy pattern in places	-	Speckled/ Stipple speckled	Enaulic
	4	t				2				Medium to dark brown PPL. Dark brown and orange OIL.		2		t	1	2		1	2					Subangular blocky/crumb	-	Speckled	Enaulic
	3	t	1	t		4	t			Medium brown PPL. Pale reddish brown with dark inclusions OIL.		2	t	2	1	1			2					Subangular blocky with crumb in places	-	Speckled	Enaulic
	2	t	t	t		4	2			Medium brown with hints of red PPL. Dark brown with red and orange inclusions OIL.	t	3		2	2	1			3					Subangular blocky	-	Speckled	Enaulic
	1	t	t	t		2	t			Dark brown PPL. Dark orange OIL.	t	2		2	3	2		1	2					Crumb/subangular laminated layers	-	Speckled	Enaulic
2	6	t				2	2			Dark brown with lighter brown inclusion PPL. Orange OIL.		2		t	1	2			1					Subangular blocky	-	Speckled	Enaulic
	5	t	t	t		4	2			Medium yellowish brown PPL. Grey/yellow/brown with infrequent orange inclusions OIL.		2		2	2	1			1	t				Subangular blocky	-	Speckled	Enaulic
	4	2	t	t		t	3			Dark brown with medium dark brown patches PPL. Orange OIL.	t	2		2	1	2		1	2					Laminated horizontal crumb/subangular blocky	Unsorted	Speckled	Enaulic
	3	t	t			3	2			Yellowish brown PPL. Pale orange to yellowish grey OIL.		2		2		2			t					Subangular blocky/crumb	-	Speckled	Enaulic
	2	t	t			3	3			Dark brown PPL. Strong orange with few brown organic inclusions OIL.		2		2	2	2			2					Laminated horizontal crumb	-	Speckled	Enaulic
	1	t	t	t		2	3			Medium brown PPL. Pale orange with deeper orange areas OIL.		2	t	2	2				1					Subangular blocky to planar, with one crumb inclusion	-	Speckled	Enaulic

Table 12: Vatnsfjörður Farm, Thin Section Descriptions 4 & 5

Vatnsfjörður Farm 4-5

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section	Horizon	Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrange-ment	Groundmass B fabric	Related distribution
5	6	1	t				3			Black PPL. Grey/black OIL.		2		4	3	2									Crumb	-	Speckled where there are fuel ash residues	Coarse Enaulic
	5	t	t			3	3			Brown with a hint of red PPL. Pale brown with orange flecks OIL		2	1					t	1						Subangular blocky	-	Speckled	Enaulic
	4	2	t				2			Dark brown with medium brown inclusions PPL. Medium brown OIL.	t	3	1	2					t						Subangular blocky/crumb	-	Speckled	Enaulic
	3	2	t				2			Dark brown PPL. Orange OIL.		3		2	2	3			2						Subangular blocky	-	Lightly speckled	Enaulic
	2	2	t			1	2			Medium brown with lenses of light and dark brown PPL. Pale brown with orange lenses and flecks OIL.		2		2	3	1		1	1						Subangular blocky/laminated crumb	-	Lightly speckled	Enaulic
	1	1	t				t			Medium brown with pale grey lenses PPL. Pale brown with orange and yellow flecks OIL.	t			2	1	2		t							Subangular blocky/planed crumb	-	Speckled	Enaulic
4	6	1	1			2	t			Medium brown PPL. Pale orange to orange OIL.		2		2	2	1			t						Subangular blocky	-	Speckled	Enaulic
	5	t	t				4			Dark brown/black PPL. Bright orange OIL.		2		3	3				1						Stratified crumb	-	Light speckle	Enaulic
	4	3	t		1	t	t			Medium to reddish brown PPL. Pale orange/brown OIL.	t	1	1		2	2		1	1						Crumb	Unsorted	Stipple speckled	Enaulic
	3	t	t			3	t			Medium reddish brown PPL. Reddish brown OIL.		3		2	t	t			t						Subangular blocky/crumb	-	Speckled	Enaulic
	2	1	t			3	3			Dark brown with medium brown patches PPL. Orange with dark orange, red and yellow inclusions OIL.	1	t		1	3	2			1						Crumb	-	Speckled	Enaulic
	1	1	t			3				Medium brown with a hint of red PPL. Dark brown with red flecks OIL.		2	1		t	1			2						Crumb	-	Speckled	Enaulic

Table 13: Vatnsfjörður Farm, Thin Section Descriptions 6, 7 & 8

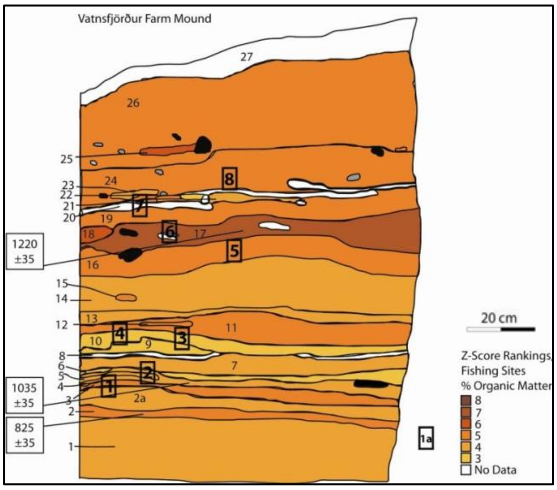
Vatnsfjörður Farm 6-8

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section	Horizon	Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Yellow)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
8	2	t	t				t			Reddish brown PPL. Dark to medium brown with reddish tinge and red flecks OIL	t	2		t	3				t						Subangular blocky with crumb	-	Speckled	Enaulic
	1	2	t			4	2			Medium to light medium brown PPL. Medium to pale orange/brown OIL.		t		2	2		t		t						Subangular blocky	-	Speckled	Enaulic
7	4	2	t			3	3			Grey brown/reddish brown clusters PPL. Grey/medium brown OIL.		3	1		2				t						Crumb with subangular blocky patches	-	Speckled, clustered in places	Enaulic
	3	2	t				3			Dark brown/medium reddish brown PPL. Dark brown/grey to medium brown OIL.		t	t		3	1			1						Subangular blocky/crumb	unsorted	Clustered speckled	Enaulic/fine enaulic
	2	2	t			3	t			Medium brown/greyish brown PPL. Grey/brown with few orange turf clusters and orange flecks OIL				2	2				t						Subangular blocky/crumb	Moderate to well sorted	Clustered speckled	Enaulic
	1	2	1			4	2			Light/medium brown PPL. Grey brown with orange and dark brown clusters OIL.		1	1	2	2										Subangular blocky	-	Speckled	Fine enaulic
6	4	2	t			1	2			Grey reddish brown PPL. Dark brown/pale orange brown OIL.				3	2			t							Crumb	-	Speckled	Enaulic
	3	t	t				2			Black PPL. Grey black with orange patches OIL.				4				1							Crumb	-	Speckled where there are fuel ash residues	Enaulic
	2	t	t				t			Reddish brown with dark brown clusters PPL. Medium brown with orange clusters OIL.		2		3					2						Crumb	-	Speckled	Enaulic
	1	t	t				2			Black PPL. Grey/black OIL.				4	3				t						Crumb	-	Undifferentiated	Enaulic

Table 14: Vatnsfjörður Farm Mound Laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low	High Frequency
56	Vat Farm H26	6.0	36.38	222.13	227.06	215.67
55	Vat Farm H25	5.6	39.95	232.20	122.97	116.56
54	Vat Farm H24	5.9	32.61	273.40	123.33	117.25
53	Vat Farm H23	6.2	20.52	258.75	527.22	499.56
52	Vat Farm H22	6.3	11.98	160.79	220.53	204.72
51	Vat Farm H21	6.3	15.38	197.75	218.64	204.97
50	Vat Farm H20	6.5	-	186.42	-	-
49	Vat Farm H19	6.3	27.8	470.71	128.75	122.33
48	Vat Farm H18	6.0	43.55	597.97	1086.78	1082.39
47	Vat Farm H17a	5.9	-	646.49	1079.97	1076.64
46	Vat Farm H17	6.2	59.81	371.83	1067.00	1064.22
45	Vat Farm H16	6.2	36.93	778.34	1137.36	1130.75
44	Vat Farm H15	6.2	31.86	759.11	1044.39	1042.69
43	Vat Farm H14	6.2	23.42	817.71	1186.86	1179.56
42	Vat Farm H13	6.3	14.00	353.16	280.47	172.61
41	Vat Farm H12	6.2	28.44	548.53	1038.33	1006.17
40	Vat Farm H11	5.8	34.36	471.62	244.78	230.78
39	Vat Farm H10	6.0	11.59	351.68	129.11	551.17
38	Vat Farm H9	6.0	11.02	402.95	216.44	131.56
37	Vat Farm H8	5.7	-	324.22	-	-
36	Vat Farm H7	5.8	18.91	502.75	296.06	227.17
35	Vat Farm H6	5.8	11.86	540.29	485.97	358.92
34	Vat Farm H5	5.7	16.63	541.2	546.50	462.61
33	Vat Farm H4	5.8	17.19	553.11	112.03	23.75
32	Vat Farm H3	5.8	28.03	399.29	522.33	483.11
31	Vat Farm H2a	5.9	24.54	462.47	271.72	252.58
30	Vat Farm H2	6.0	30.91	641.92	1082.67	1079.58
29	Vat Farm H1	6.2	17.26	546.70	169.58	163.00
	Rep H2	5.9	26.12	629.88	1080.55	1077.56
	Rep H4	5.6	18.02	561.26	115.61	24.98
	Rep H13	6.3	14.33	348.12	284.82	175.05
	Rep H23	6.3	20.89	248.87	525.12	499.01

The top of monolith 1A captures the lowest part of soil horizon 2, where the large bone component fades away, becoming highly fragmented and intimately mixed with the fine mineral material. The elevated level of bone material coincides with a rise in level of total P, indicating a greater contribution of degraded bone to this value. The increase in fuel residues is also coupled with a rise in soil magnetism.



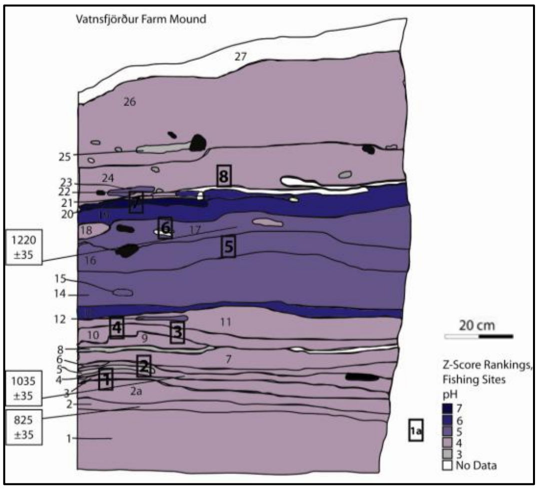


Figure 43: Vatnsfjörður Farm Intra-Stratigraphic Z-Score rankings of Organic Matter

Figure 44: Vatnsfjörður Farm Intra-Stratigraphic Z-Score rankings of pH

Table 15: Vatnsfjörður Farm Site, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
56	Vat Farm H26	1.92	68.08	29.2	0.8	0.0	51.16	34.46	1.503	1.856
55	Vat Farm H25	1.8	47.1	30.6	13.3	7.2	171.6	65.55	2.975	9.005
54	Vat Farm H24	1.31	55.49	31.8	9.2	2.2	100.8	50.23	3.849	18.90
53	Vat Farm H23	0.76	69.34	26.1	2.8	1.0	64.48	33.05	6.042	48.21
52	Vat Farm H22	2.91	67.19	28.9	1.0	0.0	51.37	31.85	1.479	1.562
51	Vat Farm H21	1.43	72.17	25.6	0.8	0.0	47.85	29.39	1.667	2.408
50	Vat Farm H20	2.37	72.83	24.5	0.3	0.0	43.75	29.52	1.660	2.964
49	Vat Farm H19	3.79	67.41	19.7	4.3	4.8	89.25	28.73	3.118	9.218
48	Vat Farm H18	0	70.3	25.2	2.3	2.2	70.08	34.85	4.387	21.50
47	Vat Farm H17a	0.69	60.31	21.2	6.8	11.0	182.6	41.56	2.637	6.198
46	Vat Farm H17	0.41	51.99	24.0	10.5	13.1	220.2	56.33	2.248	4.190
45	Vat Farm H16	2.9	63.2	24.9	7.5	1.5	83.93	35.69	4.426	25.99
44	Vat Farm H15	4.97	72.53	20.9	1.6	0.0	42.91	28.58	2.522	9.155
43	Vat Farm H14	3.33	62.07	29.5	4.2	0.9	67.75	37.64	4.344	26.55
42	Vat Farm H13	6.19	59.21	21.8	7.8	5.0	103.9	31.19	2.693	6.823
41	Vat Farm H12	7.01	74.59	18.0	0.4	0.0	36.19	20.23	2.131	4.780
40	Vat Farm H11	5.72	67.08	26.5	0.7	0.0	47.11	27.18	1.577	1.959
39	Vat Farm H10	8.02	76.98	14.8	0.2	0.0	31.49	20.28	2.131	6.207
38	Vat Farm H9	8.78	67.02	23.6	0.6	0.0	43.39	24.90	1.718	2.574
37	Vat Farm H8	3.9	55.1	26.4	12.1	2.5	107.8	43.39	2.623	7.532
36	Vat Farm H7	7.66	69.84	21.0	1.5	0.0	43.23	23.07	2.641	9.721
35	Vat Farm H6	10.9	69.4	19.6	0.1	0.0	34.40	21.33	1.624	3.175
34	Vat Farm H5	6.21	57.19	27.3	4.9	4.4	97.15	37.32	3.057	9.211
33	Vat Farm H4	8.51	69.49	21.7	0.3	0.0	39.16	25.56	1.809	3.926
32	Vat Farm H3	6.95	71.05	21.7	0.3	0.0	40.63	24.90	1.838	3.374
31	Vat Farm H2a	6.16	73.64	19.9	0.3	0.0	38.17	24.46	1.931	4.362
30	Vat Farm H2	0.71	64.19	32.2	2.3	0.6	64.80	44.16	5.240	39.96
29	Vat Farm H1	2.58	57.02	36.5	3.9	0.0	64.85	50.38	1.944	4.976
	Rep H2	0.77	62.33	33.5	2.9	0.5				
	Rep H4	9.02	68.18	22.5	0.3	0.0				
	Rep H13	5.15	61.05	21.6	7.6	4.6				
	Rep H23	0.89	68.51	27.2	2.6	0.8				

Capping this layer is soil horizon 2A (Table 11), a horizon firmly positioned between the AD 790 – 860 and AD 1000 – 1070 radiocarbon ages, which shows a reduction in levels of soil magnetism alongside a drop in total P levels. Monolith 1 samples the uppermost part of this horizon, alongside soil horizons 3, 4 and 5. The lowest part of monolith 1 displays a subangular blocky area, reflecting a period of reduced intensity. Traces of peat ash and wood ash residue make their way into the stratigraphy, washed in from other parts of the midden. Capping this is soil horizon 3, a distinctive dark brown organic layer with a vastly reduced value of total P but elevated value of soil magnetism compared to soil horizon 2A. Capping this is an area with reduced soil magnetism levels, with the uppermost part of the monolith showing an increase in total P and soil magnetism. The uppermost two microstratigraphic horizons change from subangular blocky to crumb microstructure, with an ever-increasing proportion of bone and charcoal present.

Monolith 2, which captures horizons 4 to 7 and samples the lower end of the AD 1000 – 1070 to AD 1185 – 1255 temporal period, reveals alternating content patterns. Levels of total P were steady throughout the monolith, with soil magnetism levels starting low before increasing and dropping. Organic matter levels were also constant, with the soil becoming more acidic midway through the monolith at soil horizon 5. The lowest area of the monolith is rich in bone material with a subangular blocky to platy microstructure, before being capped by a band rich in plant material which coincides with a drop in soil magnetism levels. Upwards from here is a sharp transition to a strongly rubified layer. There is little organic material represented in the microstratigraphy, which may be associated with the increased acidity levels. It does appear to be a direct association with the elevated soil magnetism levels. Overlaying this is a band containing coarser fragments, which is further capped with an intimate mix of iron features, plant material and highly fragmented bone. These transitions all show swift and changing deposits on to the midden, alongside periods of reduced activity allowing features associated with abandonment to form.

Monoliths 3 and 4 both capture parts of soil horizons 9, 10 and 11 (Table 12). The lowest area of monolith 3 displays fine mineral material intimately mixed with fragmented bone, charcoal and plant residues, with the microstructure being predominantly subangular blocky. Capping this is a horizon, associated with soil horizon 10, revealing a distinct band of plant material and silicates which show no sign of alteration, suggesting that conditions were such that these features were allowed to form. Excremental pedofeatures present in this horizon show minimal alteration under thin section. Capping this is horizon 11, where elevated levels of total P were observed. The monolith displays intermittent microstratigraphic bands of peat and wood ash residues, whilst at the top of the monolith a rippled dark brown layer displaying a less intense mix of bone, plant material, charcoal and iron nodules can be found within the fine mineral material matrix. These additional features were coupled with an increase in organic matter in soil horizon 11. The rippled microstratigraphic horizon may be associated with an exposed surface being subject to water-based modification.

Monolith 4 displays similar features to monolith 3, with charcoal and turf residues mixed with layers of other fuel ash material. The microstructures change from subangular blocky to crumb, reflecting the changing deposition patterns, before a thicker seam of charcoal and bone material is identified. Capping this is a band of fuel residue and plant material, returning back to a subangular blocky microstructure.

Soil horizon 12 is a dark reddish brown fuel ash inclusion entirely contained within soil horizon 11, displaying an elevated value of fuel ash material and a similar value of total

P. The soil pH is more neutral than the surrounding soil horizons, which may reflect a difference in content. No monolith was obtained which captures this soil horizon.

Above soil horizon 11 is soil horizon 13, which displays a reduction in total P but the beginnings of a sustained period of elevated soil magnetism. This is a transitional period in the stratigraphy, as there were fewer sharp laminations of fuel ash residue observed in the field, just as the pH is becoming more neutral. Organic matter drops slightly.

The deposit which makes up horizon 14 is rounded gravel. This displays elevated values of soil magnetism and total P, suggesting that wherever the material originated from, it was subject to high levels of anthropogenic influence. There is a small inclusion within the horizon, horizon 15, which maintains the same values as the material which encompasses it, save for a slight elevation in organic matter. Due to the difficulty in sampling from this gravel material no monolith was obtained.

Capping the gravel deposit is soil horizon 16, a silty clay loam with continually elevated values of total P and soil magnetism. Monolith 5 samples from this horizon, and displays distinct microstratigraphic layering comprising mainly of turf residues with traces of plant material, charcoal and some iron accumulation features. The lowest part of the monolith reveals more in the way of excremental features and a subangular blocky microstructure, before a distinct increase in the presence of bone midway up the monolith, capped off with a band of darker material comprising almost entirely of bone and charcoal.

Monolith 6 captures horizon 17 which yielded the AD 1185 – 1255 radiocarbon age, and a small area of horizon 19 (Table 13). The high levels of soil magnetism is reflected in the observation that a significant part of the monolith is comprised of charcoal material, with a few turf inclusions which make up a small percentage. Intimately mixed bone material is more frequent at the foot of the monolith, before dropping in frequency and returning in the uppermost microstratigraphic layer. The microstratigraphy in this area is predominantly crumb. Capping this area is a fine mineral material containing burnt turf residues, as well as intimately mixed bone, charcoal, plant fragments and basalt grains with light coatings. The reduced component of bone material appears to be associated with the reduction in total P, with the increase in organic matter directly associated with the elevated presence of charcoal.

The undulating soil horizon 19, reflecting post-AD 1185 – 1255 activity on the site, displays a return to elevated levels of total P and pH, but a drop in soil magnetism and organic matter. It is represented by the lowest part of monolith 7, which contains a larger presence of silicates which have not been heavily modified. Throughout the area is an elevated proportion of bone material, intimately mixed with plant material, dark amorphous material and charcoal contained within a subangular blocky microstructure. Overlying this is soil horizon 20, a crumb microstructure with larger bone fragments, plant material and other domestic waste. The more neutral pH would have aided preservation of the bone material, reflected in the reduction in total P values for the horizon.

Overlying this is a grey material, before the resumption of a darker brown band containing domestic wastes including peat residues, bone, plant material and charcoal within a subangular blocky microstructure. Soil magnetism levels progressively increase in horizons 24 and 23, the latter of which is entirely contained within horizon 24. The reduction in a pH for the uppermost layer, associated with horizon 23, is reflected in the reduction in total P value as these conditions would have preserved the bone material to a greater degree.

Levels of total P increase once more at soil horizon 24, represented by the entire monolith 8. The lower part of the monolith is an intimate mix of bone and charcoal material, alongside a dark material rich in silicates. Fine mineral material can be found clustered, despite the main microstructure being subangular blocky. Bone and charcoal were found in distinct clusters, reflecting mixing or an erratic episode prior to deposition. With these features found in the upper part of the stratigraphy, they may not have been subject to the same degree of compression as underlying horizons which might, over time, have found themselves flattened out under the weight of overlying horizons.

Soil horizons 25 and 26, which make up the remainder of the stratigraphy, display similar levels of total p and soil magnetism, but differing levels of pH and organic matter. The more acidic pH is linked with higher levels of organic matter, reflecting the high concentration of charcoal material which makes up this horizon.

Vatnsfjörður farm demonstrates the characteristics of a farm mound well, and reflected throughout were changes observed under thin section having a close association with the soil chemistry of the stratigraphy. Higher levels of soil magnetism were directly linked with increases in fuel residue deposits, with the presence of bone material being strongly associated with the values of total P. The strongest anthropogenic influences appear to be on the eve of the AD 1185 – 1255 radiocarbon date (Figure 45), around the time of the rounded gravel deposit on the midden. Also demonstrated is the importance of preservation under particular environmental conditions; where bone is identified but in a horizon with a more neutral pH, this is linked with reduced levels of total P. The majority of this stratigraphy reflects activity prior to AD 1185 – 1255, giving an important dimension on cultural deposits associated with Iceland before the political change of the thirteenth century AD.

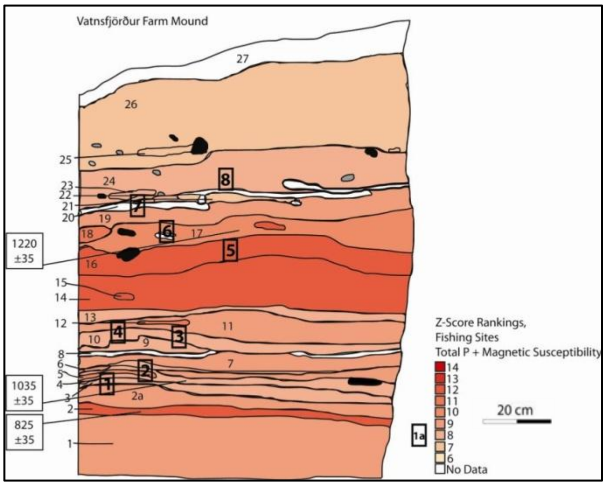


Figure 45: Vatnsfjörður Farm Intra-Stratigraphic Integrated Z-Score rankings of Total P and Magnetic Susceptibility.

Fishing Sites – Individual Site Analysis

Skálavík 1 Case Study

Skálavík 1 is a site which displays a range of stratigraphic complexity at a macro level, from the thin inclusions at the foot to the uniform, deep deposits at the top of the stratigraphy. Throughout the profile were strong indications of an anthropogenic presence, which becomes progressively stronger around the AD 1050 – 1110 radiocarbon age (Figure 46; Figure 47), before becoming reduced over the course of time. The strongest anthropogenically influenced horizons appear to be associated with soil horizons 5 and 8 (Figure 48), dating to the late eleventh or early twelfth century. Regarding the soil texture within the stratigraphy, almost every horizon contains a loam component, predominantly clay loams with elements of sand and silt contained within.

The soil colours at a detailed Munsell level show no commonality or pattern throughout, reflecting subtle differences in the activities which went into forming the cultural material. The stronger anthropogenic presences display more reddish brown shades, with dark browns being the other common colour.

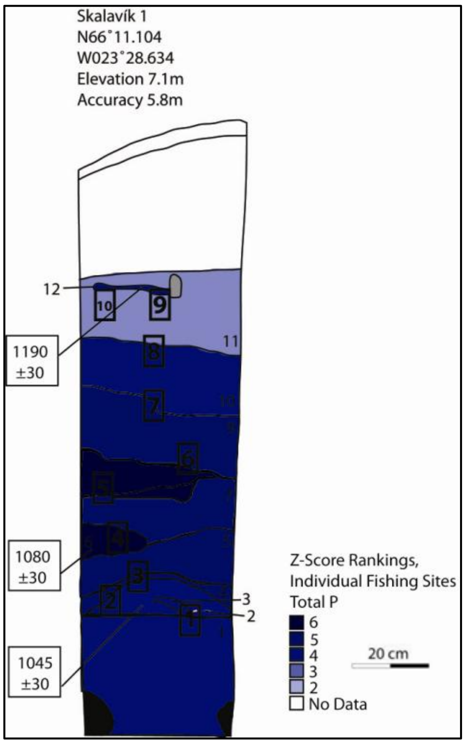


Figure 46: Skálavík 1 Intra-Stratigraphic Integrated Z-Score rankings of Total P

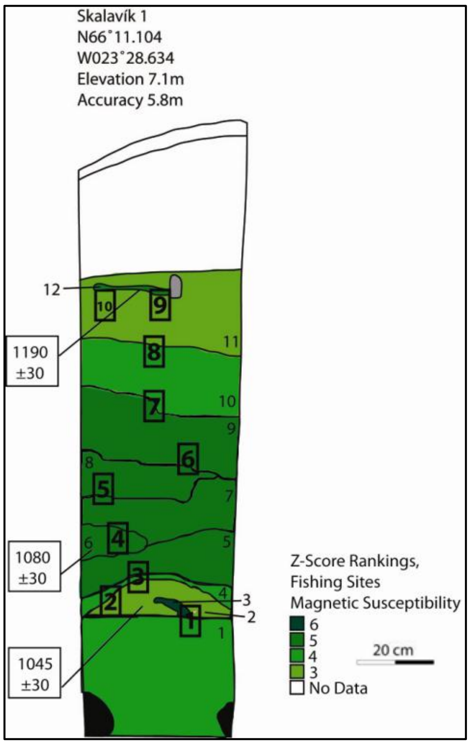


Figure 47: Skálavík 1 Intra-Stratigraphic Integrated Z-Score rankings of Magnetic Susceptibility

At the lowest part of the stratigraphy, levels of magnetic susceptibility and total P were elevated (Table 16). These results were supported by the micromorphological observations, where distinct bands, some containing fuel residues, can be found. The subangular blocky microstructure contained within the lower part of monolith 1 suggests a slow, exposed accumulation of material. The fuel residues present in this microstratigraphic horizon were peat and birchwood, suggesting the availability of these resources within a relatively short distance from the earliest period of settlement on the site.

Table 16: Skálavík 1 laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low Frequency	High Frequency
12	Skálavík 1/12	5.2	16.62	903.86	717.2	684
11	Skálavík 1/11	5.1	21.40	402.58	218.1	208
10	Skálavík 1/10	5.0	23.92	809.93	609.7	575.3
09	Skálavík 11/9	4.5	22.82	1005.46	898.8	821.3
08	Skálavík 1/8	4.1	22.69	1193.32	733.7	672.7
07	Skálavík 1/7	4.0	20.06	1021.75	973.6	889.9
06	Skálavík 1/6	4.2	17.51	1380.22	928.3	844.4
05	Skálavík 1/5	4.1	18.22	1053.38	890.4	814.8
04	Skálavík 1/4	4.4	17.71	999.71	591.1	539
03	Skálavík 1/3	4.6	18.27	871.27	1083.6	1080.1
02	Skálavík 1/2	4.6	16.07	853.06	152.9	141.9
01	Skálavík 1/1	4.8	7.20	717.92	386.2	376.2

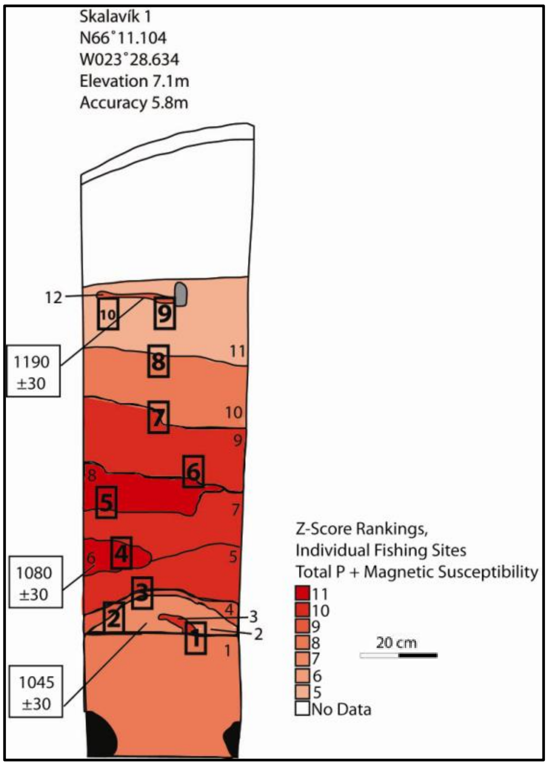


Figure 48: Skálavík 1 Intra-Stratigraphic Integrated Z-Score rankings of Total P and Magnetic Susceptibility.

Progressing into horizon 2, organic matter increases (Figure 49), however, there is a notable drop in magnetic susceptibility. Now found under thin section, the upper part of monolith 1 alongside fuel residues, were more in the way of plant materials (Table 17). Their inclusion potentially reduces the ratio of the presence of fuel residues in the horizon, suggesting a period of reduced level of occupation or abandonment. Supporting the idea of abandonment is the presence of iron-stained colours. Observed in a distinct cluster under thin section adjacent to these abandonment indicators within the upper microstratigraphic horizon of monolith 1 were a growing number of bone flecks and fragments. The transition of microstructure from subangular blocky to crumb between the lower and upper parts of the monolith, coinciding with the arrival of poorly sorted material indicates a change in deposition pattern, which is becoming more rapid over the course of time. These anthropogenic inclusions can be matched with soil horizon 3, a small but identifiable area of the stratigraphy which reveals much higher levels of magnetic susceptibility and total P. The increased presence of bone residues in the upper part of monolith 1 can be directly related to the increase in total P in soil horizon 3. The soil texture changes from a predominantly silty clay loam throughout the entire stratigraphy, to silty clay further reiterating a change in site activity. The observations at macro and micro level show a distinct change taking place on the site at some time in the eleventh century, coinciding with the soil horizon yielding a radiocarbon assay (horizon 2) from AD 1050 – 1110 .

Table 17: Skálavík 1 Thin Section Descriptions 1, 2, 3 & 4

Skálavík 1, 1-4

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section	Horizon	Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
4	3	2	t				1			Medium and dark brown mix PPL. Orange with bright orange clusters OIL.		t		1	2				1						Subangular blocky/crumb	Unsorted	Speckled	Enaulic
	2	t	t	t	t	1	1			Light to medium brown with dark brown patches PPL. Orange with pale patches OIL.		1	1						t			t			Subangular blocky	-	Speckled	Enaulic
	1	t	t		t	t	1			Medium brown with speckled interface PPL. Orange with brighter patches OIL		1	t	1					t			1			Subangular blocky/crumb	-	Speckled	Enaulic
3	4	t	t	t		2	3			Dark brown with greyish clusters PPL. Grey with red/orange and dark clusters OIL.		t	t	3	t	t			2						Subangular blocky	-	Speckled/ striated	Enaulic
	3	t	t			1	2			Dark brown with light brown patch PPL. Red/orange with lighter brown areas OIL		1	1	t	1	1			t			1			Subangular blocky	-	Speckled	Enaulic
	2	t					2			Dark brown with yellow flecks PPL Orange/red OIL.					3	2			1	t		1			Massive	-	Speckled	Enaulic
	1	t	t	t		3	3			Medium brown/dark brown/greyish mix PPL. Reddish brown with orange flecks with dark and yellow inclusions OIL.	t	t		2	2	1			1	t					Subangular blocky	Unsorted	Speckled	Enaulic
2	2	t	t			3	1			Light yellowish brown mix with medium brown bands PPL. Medium brown with red/orange and dark brown inclusions OIL.	t	t	t		2	1			1			2			Subangular blocky	Unsorted	Speckled and stratified in places	Enaulic
	1	2	t	t	1	3	1			Light yellowish brown PPL. Light greyish brown with patches of dark brown and reddened material OIL.	t	t	t	t	2	2			1			3			Subangular blocky	Unsorted	Speckled though striated in places	Enaulic
1	2	2	t			3	2			Light yellowish brown with redder and lighter areas PPL Light brown with orange flecks OIL	t			1	2	1						1			Subangular blocky/crumb	Poorly sorted	Crystallic speckled/ striated	Enaulic
	1	t	t			3	t			Medium dark brown and yellowish light brown PPL. Orange brown and dark brown with orange flecks OIL.		2	t		2	t						3			Subangular blocky	-	Crystallic speckled/ striated	Enaulic

Table 18: Skálavík 1 Thin Section Descriptions 5, 6 & 7

Skálavík 1, 5-7

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section	Horizon	Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
7	4	1	t				2			Medium brown PPL. Strong orange-red with red and yellow flecks OIL.		t		t	2				t				t		Crumb to subangular blocky	Unsorted	Lightly speckled	Enaulic
	3	2	t				2			Medium brown with dark brown PPL. Pale orange to deeper brown/orange with red and yellow flecks OIL.	t	2	t	2	2	1			2				1		Crumb with areas of subangular blocky	Poorly sorted	Speckled	Enaulic
	2	1	t				2			Light to medium greyish brown PPL. Very light orange-brown to orange with yellow and red flecks OIL.		1	t	1	t	t			t						Subangular blocky with areas of crumb	Unsorted	Speckled	Enaulic
	1	t	t				4			Greyish brown to dark medium brown PPL Strong orange with pale orange, red and yellow flecks OIL.	t	2		2	t	t			1			1	t		Subangular blocky/crumb	-	Speckled	Enaulic
6	2					1	1			Light greyish brown PPL. Pale orange with red clusters OIL.	t	2	1	2	t				1						Subangular blocky/crumb	Unsorted	Speckled	Enaulic
	1	2	t			t	2			Medium to medium dark brown mix PPL. Orange with dark orange, yellow and deep red flecks OIL.		3	1	3	1	t			t				t		Subangular blocky/crumb	Unsorted	Speckled	Enaulic
5	2	t	t			t	3			Medium greyish brown PPL. Intense orange changing to pale orange OIL	t	3		t	t	t			t						Subangular blocky/slightly platy	-	Speckled	Enaulic
	1	t	t		t		4			Medium to dark brown mix PPL. Orange with red and yellow inclusions OIL	t	t		3	2	1						1			Subangular blocky	Unsorted	Speckled	Enaulic

Table 19: Skálavík 1 Thin Section Descriptions 8, 9 & 10

Skálavík 1, 8-10

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures									
Section	Horizon	Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Yellow)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites	Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
10	3	2	t			2	2			Medium to darker brown PPL. Orange-brown to pale orange with red patches, red and orange flecks OIL.	t	t	1	3	2		1	t	1			t		Crumb with patches of subangular blocky	Well sorted	Speckled	Enaulic
	2	3	t		1		2			Medium reddish brown with darker brown patches PPL. Orange to strong orange with red and orange flecks OIL.	t		1	2	2			1						Crumb	Well sorted	Speckled	Enaulic
	1	2	t		1	1	2			Light to medium brown PPL. Pale orange with areas of strong orange and medium brown OIL.	t	1	t	3	2	1		1	2					Subangular blocky with discreet crumb areas	Moderate to poorly sorted	Speckled	Enaulic
9	3	2	t	t		2				Light brown and medium brown PPL. Dark brown, orange and bright red mix OIL.	1	2	t	2	1	t		t	2					Crumb with subangular blocky patches	Moderately sorted	Speckled	Enaulic
	2	3	t				2			Medium to medium reddish brown PPL. Orange/brown with red flecks OIL		1	1	2	2	2		1						Crumb	Moderate to well-sorted	Speckled	Equal enaulic
	1	3	t	t			2			Light to medium brown PPL. Strong orange/brown with orange and red flecks OIL.			1	3	1	1		1	1					Crumb with areas of subangular blocky	Moderately sorted	Speckled	Enaulic
8	2	2	t				2			Very dark brown PPL. Medium orange brown with red and orange flecks OIL.			1	2	1	t			t	1				Subangular blocky	Unsorted	Speckled	Enaulic
	1	3	t				t			Medium brown PPL. Medium brown with red and orange flecks OIL.	t	t	t	2	1	1			1					Subangular blocky	Moderately sorted	Speckled	Enaulic

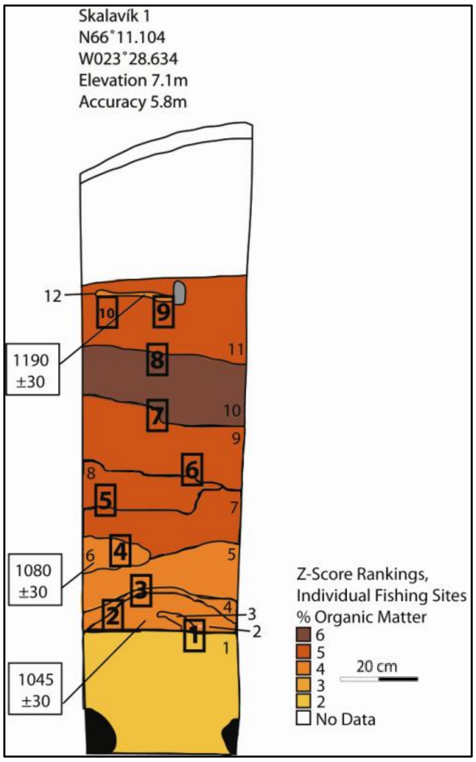


Figure 49: Skálavík 1 Intra-site Stratigraphic Z-Score rankings of Percentage Organic Matter

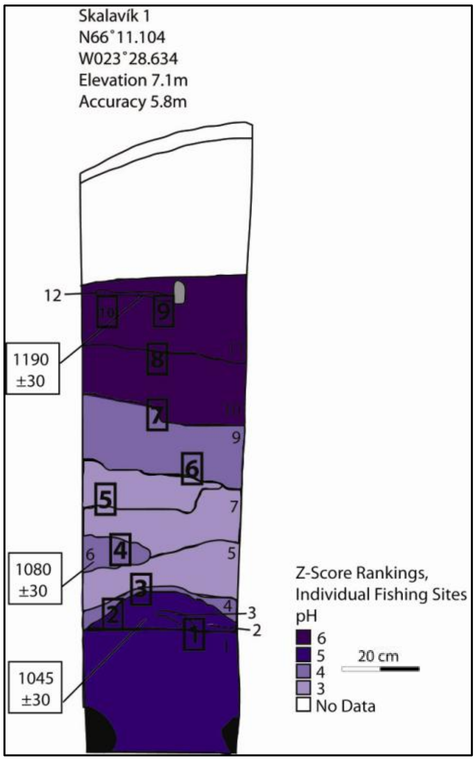


Figure 50: Skálavík 1 Intra-site Stratigraphic Z-Score rankings of pH.

Monolith 2 samples part of soil horizons 2 and 4. Soil horizon 2, an area which encompassed the strongly anthropogenic horizon 3, displays contrasting abandonment indicators in the form of iron accumulations, degraded plant material, fungal spores and uni-directional silicate formation (Figure 51), all represented in the lower part of monolith 2. Flecks of burnt material can also be identified within this microstratigraphic horizon, but this may be attributed to slope wash cascading over the sheet midden from elsewhere. The stark change reiterates the significance of the activity which resulted in the deposition of soil horizon 3, as an intense period of on-site activity took place. Capping horizon 2 is soil horizon 4, which displays highly contrasting characteristics to the underlying horizon under soil thin section. There is an increased volume of sand-material in comparison to surrounding horizons (Table 20), which may be associated with the remnants of fuel burning, in turn linked with an increase in magnetic susceptibility. With total P levels remaining elevated, these were coupled with rich areas of bone and burnt material revealed in the upper part of monolith 2, reflecting the association between bone material and total P. Bone is present in a fragmented state, suggesting it may have undergone an episode of trampling after deposition. This horizon and the overlying horizon 5 were firmly positioned between AD 1015 – 1075 and AD 1050 – 1110, giving a strong indication to the nature of on-site activity at the end of the eleventh century.

Table 20: Skálavík 1, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
12	Skálavík 1/12	2.74	34.16	30.2	22.5	10.4	236.7	109.4	2.428	6.045
11	Skálavík 1/11	1.81	26.49	30.3	26.1	15.3	292.3	152.0	1.780	2.915
10	Skálavík 1/10	3.98	49.62	28.6	16.9	0.9	108.8	54.66	2.202	6.631
09	Skálavík 11/9	2.83	42.97	34	15.9	4.3	147.6	73.59	2.982	10.55
08	Skálavík 1/8	2.37	46.43	34.9	10.8	5.5	145.9	65.43	3.306	11.65
07	Skálavík 1/7	2.5	45	34.4	14	4.1	136.9	68.27	3.189	11.86
06	Skálavík 1/6	2.12	33.58	30.9	22.9	10.5	234.4	109.0	2.246	5.316
05	Skálavík 1/5	2.58	43.62	32.8	15.3	5.7	156.1	71.70	2.765	8.506
04	Skálavík 1/4	2.44	37.26	32.7	18.3	9.3	211.6	91.70	2.580	6.881
03	Skálavík 1/3	2.66	37.04	33.3	22.2	4.8	168.1	92.02	2.202	5.619
02	Skálavík 1/2	3.68	48.02	33.5	11.8	3	115.3	59.57	3.198	12.42
01	Skálavík 1/1	4.57	56.33	25.9	10.3	2.9	101.2	44.26	2.918	9.138

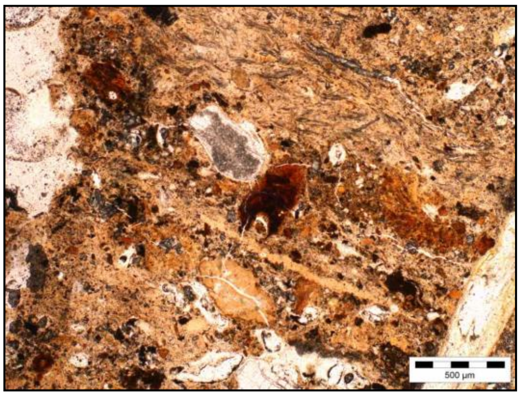


Figure 51: (Skálavík 1, Figure 1). Distinct patterns of banding, incorporating iron influenced material, fuel residues, silicates and potential bone material, 4x mag, PPL

Monolith 3 captures varying levels of activity and change on the site at this time, sampling from soil horizons 2, 4 and 5. Present were distinct bands of material, some of which at times display very strong bone components, particularly in association with soil horizons 4 and 5, which fade over time, replaced by dark amorphous and peat material. Some of the microscopic transition observations within parts of the monolith were very sharp, highlighting swift change in activity at the site from bone and fuel material in horizon 4 (predominantly turf) (Figure 52; Figure 54) to abandonment features such as iron nodules, excremental features (Figure 53) and plant remains linked with areas of soil horizon 5. On-site activity at the end of the eleventh century appears not necessarily continual, with periods of absence away from the site being represented in the stratigraphic record, however, the human occupational periods have left behind evidence of daily life. The microstructure returns to subangular blocky in the upper part of monolith 3, suggesting slower rates of soil accumulation and exposed surface areas.

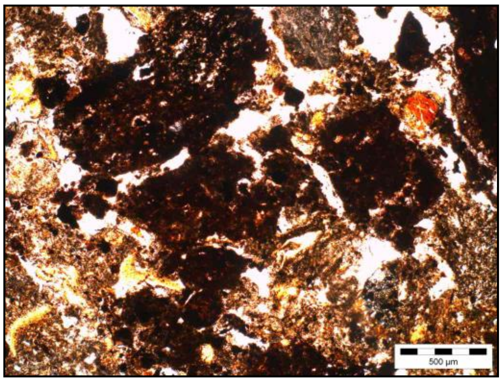


Figure 52: (Skálavík 1, Figure 2) turf residue, 4x mag, PPL

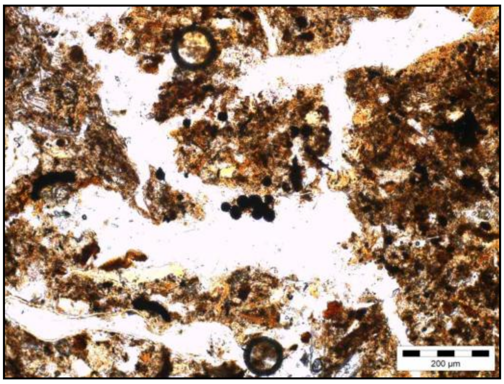


Figure 54: (Skálavík 1, Figure 3) turf residue, 4x mag, OIL

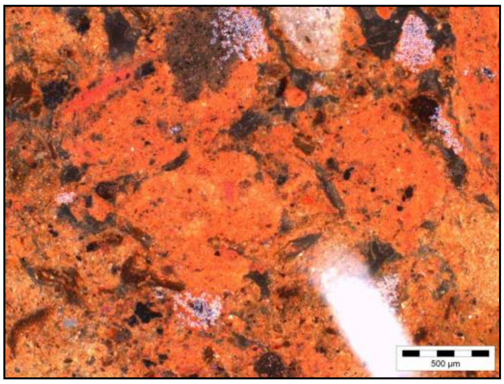


Figure 53: (Skálavík 1, Figure 4) excremental features, 10x mag, PPL

One of the highest levels of total P and magnetic susceptibility were identified at horizon 6, which has a more neutral pH than the soil horizons which encompass it (Figure 50). This may be attributed to differences in anthropogenic activity which leads to an enhanced signature within the soil. Sampling this is monolith 4, which reveals an episode of rapid accumulation as demonstrated by the crumb microstructure, containing a bone, birchwood and peat infusion. The bone displays evidence of fragmentation and degradation, however, not burning, reflecting the direct association between levels of total P and bone material. Fuels were being burnt at high temperatures, reflecting potential industrial processes taking place. Turf residues were present at higher levels than other monoliths, supporting this idea. With basaltic grains being a deposit associated with the burning of turf, this may support the finding of increased sand grains within horizon 6 given the increased volume of residue found at this location. Progressing up the stratigraphy, the rate of accumulation slows down, with the microstructure reverting back to subangular blocky in the uppermost part, taken from soil horizon 7. The slower, exposed areas reflect a possible site abandonment period, reflected in the presence of iron nodules and cellular plant material in the upper parts of the monolith.

With levels of total P and magnetic susceptibility remaining high in the middle areas of the stratigraphy at Skálavík 1, the broader stratigraphic record gives the impression of a continual period of occupation on the site. The micromorphological record, however, reveals evidence to the contrary. The lowest part of monolith 5, which samples from soil horizon 7 (Table 18), shows an intense horizon of fractured bone material, as well as burnt fragments reflecting domestic waste deposits, supported with the observation that more and more bone material is becoming intermixed with fuel residues. Progressing up the monolith and into soil horizon 8, plant fragments and abandonment indicators such as fungal spores and excremental features grow in their occurrence. With a vertical inclusion of birch material, likely to have been washed into a void space on the occupational surface, this movement of material reflects a heavily worked surface area. The presence of highly elevated levels of total P and continued high levels of magnetic susceptibility shows a strong presence, but the remains of plant residues and abandonment features highlight that these were not continual.

The lowest part of monolith 6 displays strong anthropogenic characteristics, as demonstrated in the lower to middle parts of monolith 5, with bone material being well mixed with rubified and unrubified material. Turf is being burnt as the remains of such process is present in clusters alongside charcoal and burnt bone. Traces of iron features show a brief presence (Figure 55), as the monolith enters soil horizon 9. This is an area with a notably reduced level of total P, but maintaining high levels of soil magnetism. Soil pH becomes more neutral, as the general pattern of soil horizons show increasing thickness and continual episodes of deposition in contrast to the smaller laminations found below.

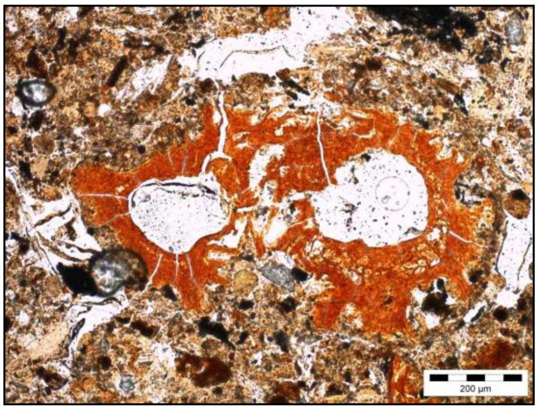


Figure 55: (Skálavík 1, Figure 5), iron infilling feature, 10x mag, PPL

Monolith 7 is taken from where soil horizons 9 and 10 meet, where a distinct increase in organic matter is recorded. Soil pH becomes more neutral, as levels of soil magnetism begin to noticeably drop. The stronger anthropogenic presence is matched with a crumb microstructure across parts of the whole monolith, containing fine bone fragments amongst fuel residues burnt at high and low temperatures. This activity is represented by steady levels of total P within soil horizon 10. Cutting through one of the main stratigraphic areas is an area of subangular blocky material containing bone, charcoal and plant material, adjacent to an intimate mix of turf and bone (Figure 56). The infrequent appearance of hyaline dopplerites, fungal spores and iron-influenced areas, particularly in the upper parts of the monolith, suggests a drop in the level of intensity at some time during the twelfth century. The dopplerites would suggest wetter conditions, and through their association with peat material, may be indicating a growth in organic matter at the site. Associated with this time period is a reduction in sand within the stratigraphy. Given that the site may have been unoccupied, the absence of sand reflects a period of coastal stability and reduced storminess. In turn, changes in the manner in which fishing sites were occupied may be related to social reasons rather than inclement environmental conditions.

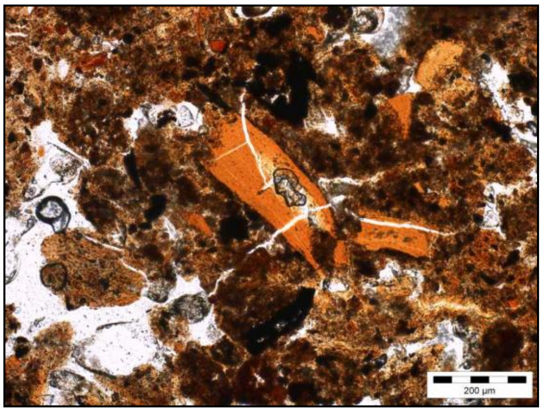
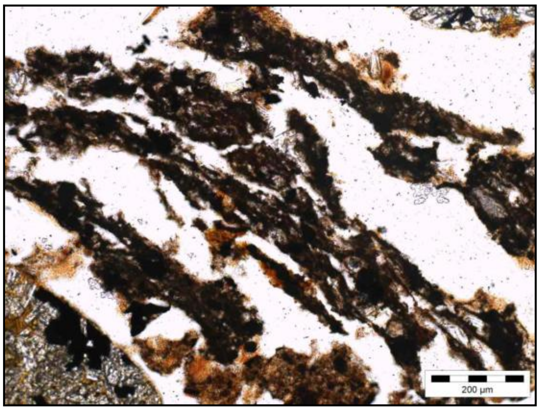


Figure 56: (Skálavík 1, Figure 6), mix of fragmented bone and organic material, 10x mag, PPL

At the junction of soil horizons 10 and 11, is monolith 8, sampling from the uppermost part of the higher organic horizon. The soil pH remains steady, whilst the levels of total P and soil magnetism drop. The monolith here is considerably darker at its lower part, reflecting the increased organic component. Turf residues were identified in the lower part of the monolith, with traces of bone material but not at the same level as monoliths lower in the stratigraphy. The microstructure is dominantly subangular blocky, with distinct areas of crumb where increases in burnt remains can be found, directly associated with anthropogenic deposits. With the anthropogenic signature sporadic and reducing over the course of the stratigraphy, this suggests that by the end of the twelfth century and possibly into the thirteenth century, the site was undergoing a transition. There is a sharp increase in sand inclusion at horizon 11, particularly in reference to horizon 10, suggesting that natural processes such as increasing regularity of storm events may have been depositing material on the site.

Monoliths 9 and 10 capture soil horizon 11 (Table 19), and the rich anthropogenic inclusion of horizon 12. The lower parts of the monolith were much like monolith 8, a turf matrix containing rubified and unrubified bone material, but this time more in the way of charcoal traces. In the uppermost part of monolith 9 were basaltic fragments, some of which display signs of coatings. The microstructure remains subangular blocky, indicating a prolonged period of inactivity on the site allowing such coatings to form. At the top of the monolith, soil horizon 12, were remains of turf, birchwood and bone residues, within a crumb matrix (Figure 57; Figure 58), suggesting a swift occupational deposit. Supporting this were elevated levels of total P and magnetic susceptibility, with the drop in organic matter representing an increase in mineral material finding its way into the stratigraphy.



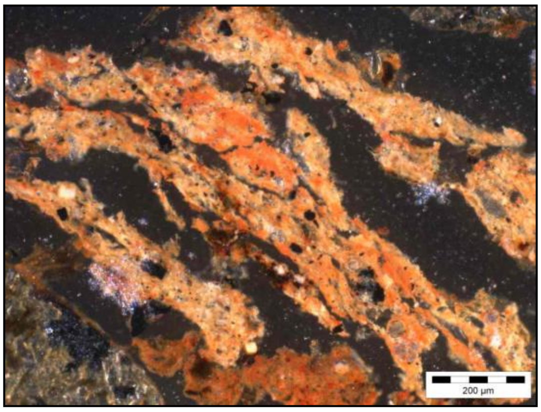
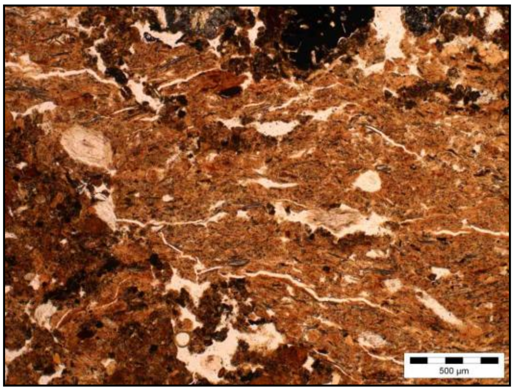


Figure 57: (Skálavík 1, Figure 7) heated turf material, 10x mag, PPL

Figure 58: (Skálavík 1, Figure 8) heated turf material, 10x mag, OIL

Monolith 10 reveals areas of unburnt turf, also seen in monolith 9, which is mixed with charcoal and other debris. Few fungal spores and abandonment features appear, alongside some plant fragments. The microstructure is predominantly subangular blocky (Figure 59; Figure 60). With a strong anthropogenic signal recorded, there appears to be a distinct and separate episode isolating horizon 12 from the areas around it. At the time of the late eleventh to the early twelfth century, activity increased on site, however, not to levels experienced previously. There is a distinct absence of bone material identified, which reflects a broader change over the course of the eleventh century.



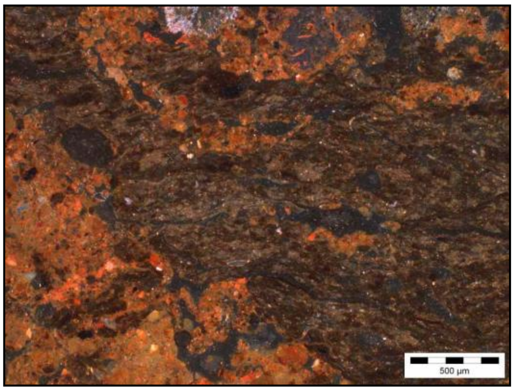


Figure 59: (Skálavík 1, Figure 9) subangular blocky microstructure, 4x mag, PPL

Figure 60: (Skálavík 1, Figure 10) subangular blocky microstructure, 4x mag, OIL

Skálavík 2 Case Study

Skálavík 2 is a site which displays a range of stratigraphic complexity, however, like Skálavík 1, is characterised by a higher frequency of stratigraphic horizons in the lower areas, with larger, more horizons at the top expressing more in the way of uniformity. This stratigraphy did not yield any radiocarbon ages, with the subsequent intention here to bring the micro and macro-scale evidence together to give a robust and comparative interpretation of the analytical systems being used.

The texture of the soil is almost evenly split within the stratigraphy; the lower half displaying predominantly silty and sandy clay textures, with the upper half being loamy sand. The Munsell colour of 10YR 2/2 is the most frequently recorded, with the overlying colour of the lower half of the stratigraphy being browns and dark browns, with the upper half being dark yellowish brown.

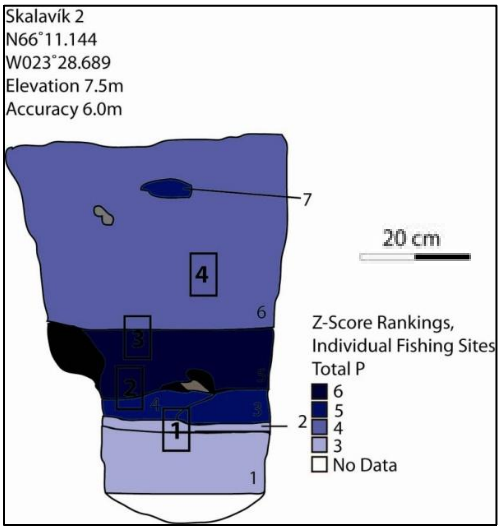


Figure 61: Skálavík 2 Intra-stratigraphic Z-Score rankings of Total P

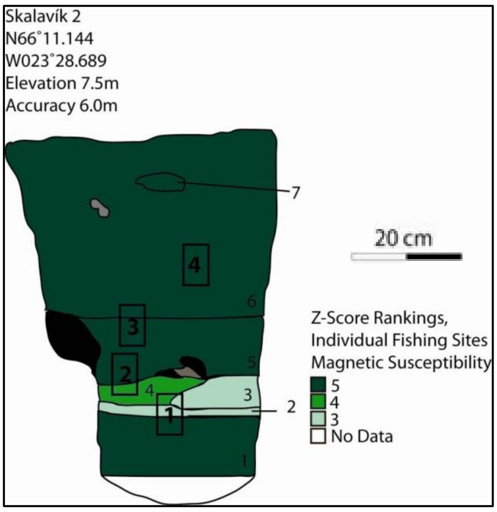


Figure 62: Skálavík 2 Intra-stratigraphic Z-Score rankings of Magnetic Susceptibility

The lowest soil horizon, horizon 1, contains the lowest volume of organic matter anywhere in the stratigraphy (Figure 66), alongside the lowest levels of total P (Figure 61), but an elevated content of soil magnetism (Figure 62; Table 21). With the anthropogenic signature being identified right down to the beach level, it suggests that fishing booths were built directly on the rocky foreshore. The strongest anthropogenic presence is found at horizon 5. The soil horizon is represented in the lower part of monolith 1, which reveals a mineral-rich context with a subangular blocky microstructure. The fuel residues which remain, a mix of turf and peat, were found amongst some degraded and often rubified bone material. Plant residues were also finding their way into the stratigraphy, and alongside instances of hyaline dopplerites and traces of unburnt peat, suggest that the occupation during this period may not have been continual.

Table 21: Skálavík 2 laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low Frequency	High Frequency
07	Skálavík 2/7	5.1	27.27	848.27	305.7	296.2
06	Skálavík 2/6	5.0	26.96	755.30	391.2	374.9
05	Skálavík 2/5	5.0	23.83	915.36	392.5	371.8
04	Skálavík 2/4	5.0	25.41	876.07	228	216.7
03	Skálavík 2/3	5.2	24.41	830.06	165.4	158
02	Skálavík 2/2	5.1	22.10	524.31	108.8	107.8
01	Skálavík 2/1	5.0	13.98	556.90	395.3	386.7

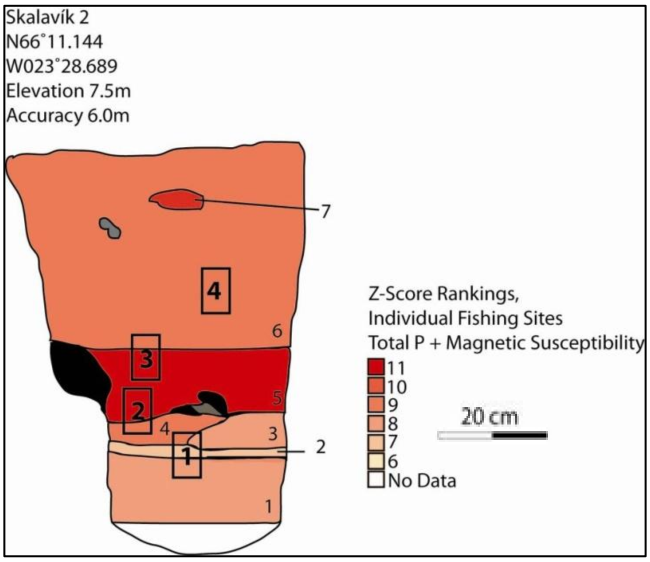


Figure 63: Skálavík 2 Intra-Stratigraphic Integrated Z-Score rankings of Total P and Magnetic Susceptibility.

Table 22: Skálavík 2 Thin Section Descriptions 1, 2, 3 & 4

Skálavík 2, 1-4

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section	Horizon	Basalt	Feldspar	Calcite	Heated Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
4	2	2	t	t		4	2			Medium reddish brown with dark clusters PPL. Dark brown with orange-brown and yellowish-brown clusters and red and yellow flecks OIL	t	2	2	2	2	1		1	1		1	1			Angular blocky	Poorly sorted	Speckled	Enaulic
	1	2	t	t		1	1	yes	yes	Medium reddish brown to greyish brown PPL. Orange to pale orange with red and yellow flecks OIL.	1	1	1	2	1			t	2			2			Angular blocky	Moderately sorted	Speckled	Enaulic
3	2	2	t	t		3	2			Medium dark brown with distinct bands PPL. Orange-brown with common yellow and red flecks OIL.		1	1	2	2				2		1	2			Subangular blocky	Moderately well sorted	Speckled	Enaulic
	1	2	t			4	3			Medium light brown with medium brown clusters PPL. Pale brown and orange brown with red and yellow flecks throughout OIL		1	t	3	1			1	1			2			Subangular blocky	Moderately well sorted	Speckled	Enaulic
2	2	t	t			4				Pale yellowish brown PPL. Pale brown with medium brown clusters and red and yellow flecks OIL		1	t	1	1				1			1			Subangular blocky	-	Speckled	Enaulic
	1	1	t		1	3	2			Medium reddish brown with light areas PPL. Medium to dark brown with bands and red and yellow flecks OIL	2	2	t	3					2			2			Subangular blocky	-	Speckled	Enaulic
1	2	2	t		1	3	2			Pale yellowish brown PPL. Yellowish brown with red and yellow flecks OIL.	t	2	1	1	1				3			2			Subangular blocky	Unsorted	Speckled	Enaulic
	1	3	t			3	1			Yellowish grey brown PPL. Yellowish mid-brown with red and yellow flecks OIL.	2	3	1	1	2			1	2			2	t		Subangular blocky	Unsorted	Speckled	Enaulic

Of particular interest is the boundary observed within monolith 1 (Table 22), representing the junction between soil horizons 1 and 2 (Figure 64; Figure 65). The lower part of the monolith displays a higher degree of uniformity, with the boundary being a line of fungal spores, plant materials, iron nodules and larger basaltic inclusions which begins a period of standstill and a reduced anthropogenic presence. Stratified layers of rubified and unrubified material lie on top of one another, before a period of uniform abandonment, supported by the low levels of total P and soil magnetism. The uppermost part of the monolith, capturing soil horizons 3 and 4, displays a progressive increase in burnt fuel residues, including small charcoal fragments. With a rise in total P and small increase in soil magnetism being noted, it would appear that the site becomes resettled and activity commences once more. Bone material increases in frequency, some of which is undergoing a process to solution, which is reflected in the elevated levels of total P. An increase in volume of sand is identified in soil horizon 3 (Table 23), which may reflect the increasing amount of turf residues being deposited. With a mildly acidic pH (Figure 67), this may be influencing bone preservation and the conversion of a solid into solution.

Table 23: Skálavík 2, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
07	Skálavík 2/7	2.05	37.25	38.5	20.8	1.4	135.8	89.38	2.174	7.258
06	Skálavík 2/6	2.51	39.79	36.4	19.1	2.2	136.8	82.31	2.633	10.06
05	Skálavík 2/5	2.23	32.67	32.1	24.7	8.3	220.6	116.1	2.557	7.375
04	Skálavík 2/4	2.2	35.3	36.8	21.9	3.8	161.9	96.81	2.538	8.429
03	Skálavík 2/3	2.1	29.3	31.6	30.3	6.7	215.5	137.7	2.080	5.434
02	Skálavík 2/2	3.13	42.07	34	18.3	2.5	135.2	75.97	3.019	12.65
01	Skálavík 2/1	3.57	51.33	33.3	10	1.8	97.32	53.70	3.626	17.43

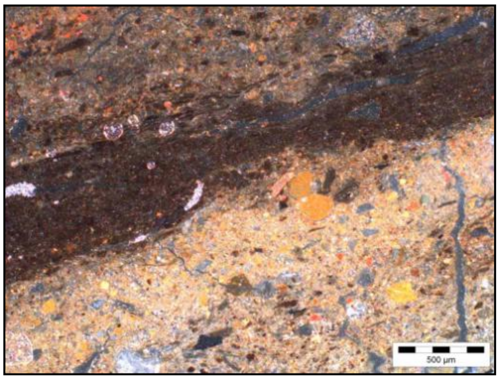


Figure 64: (Skálavík 2, Figure 1), sharp turf boundary, 4x mag, PPL

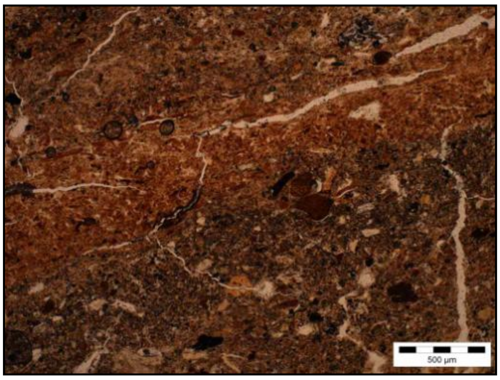


Figure 65: (Skálavík 2, Figure 2), sharp turf boundary, 4x mag, OIL

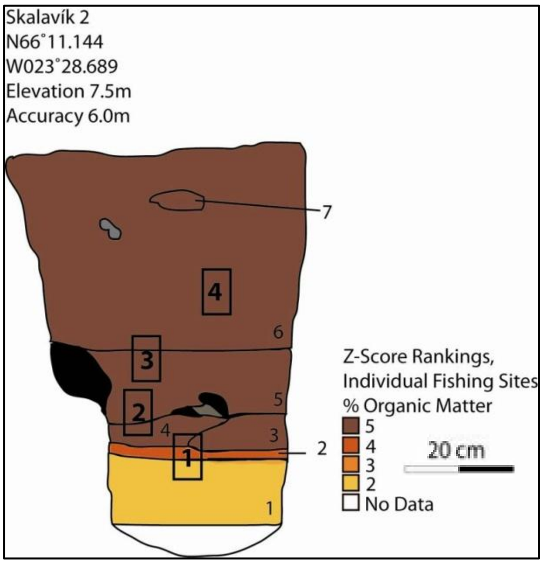


Figure 66: Skálavík 2 Intra-stratigraphic Z-Score rankings of Percentage Organic Matter

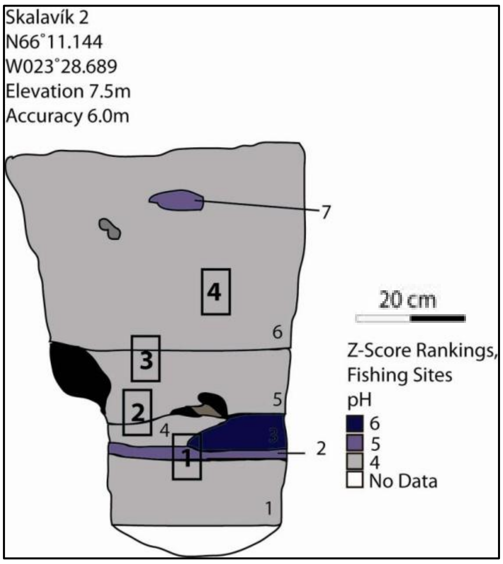


Figure 67: Skálavík 2 Intra-stratigraphic Z-Score rankings of pH

Monolith 2 represents the soil horizons 4 and 5, which show a progressively increasing value of total P and magnetic susceptibility. The lowest part of the monolith shows light colour variances, reflecting changes in depositional pattern whilst maintaining a subangular blocky microstructure. In one distinct area associated with soil horizon 4, one layer of mixed fuel residues is capped by a band of iron-influenced plant material. As the monolith progresses upwards into soil horizon 5, the deposition pattern show more in the way of swift anthropogenic deposits and a crumb microstructure, whilst retaining some subangular blocky microstructure areas. Charcoal is found in higher frequency at the base of the monolith, which decreases in frequency before returning to firm a rich cluster near the top, intimately mixed with turf and degraded plant material and a rich seam of degraded bone material cutting across the monolith very abruptly. These features were firmly within soil horizon 5. The bone identified within the uppermost part of the stratigraphy displays high levels of degradation and conversion to solution. This finding is strongly linked to the elevated levels of total P, and evidence pointing towards higher levels of anthropogenic activity.

The upper part of soil horizon 5 is represented in monolith 3, which shows an effective continuation of degraded bone and charcoal material (Figure 68), but this time displaying clusters of calcium-iron-phosphate features (Figure 69), a dark brown radial feature with orange and red tones around the outer edges. The main fuel residue within the lower part of the monolith is turf with remnants of heated minerals. With higher levels of sand material present, this may be linked to the presence of turf residues. There is a noticeable change in the monolith midway up, as it progresses into soil horizon 6. Here, the microstructure changes from crumb to subangular blocky, with an ever reducing presence of bone material. The reduction in total P levels also echoes this transition. The bone which is present is intimately mixed with fuel residues and iron nodule accumulations, suggesting the exposure of domestic debris after abandonment. Plant material and fungal spores, potentially enhancing the organic matter results show a site which now has an ever-reducing anthropogenic presence.

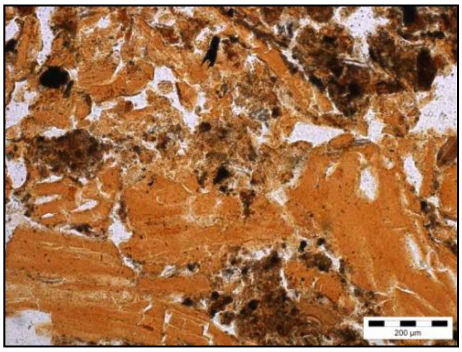


Figure 68: (Skálavík 2, Figure 3) highly fragmented bone, 10x mag, PPL

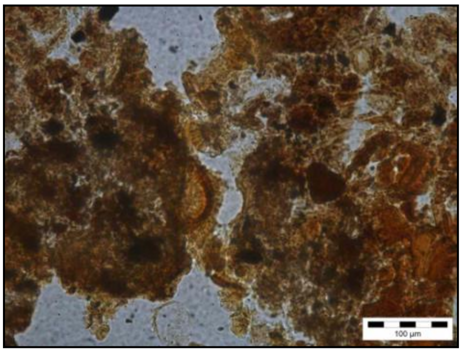


Figure 69: (Skálavík 2, Figure 4) Calcium-Iron-Phosphate Feature (CaFeP), 20x mag, PPL

The uniform deposit of soil horizon 6 is also represented in monolith 4, which is rich in organic material which is predominantly turf, containing flecks of fuel residues which have been washed into the stratigraphy. The microstructure is crumb, with distinct areas of subangular blocky, suggesting a changing pattern of deposition. Traces of fragmented bone were found in discreet areas (Figure 70), intimately mixed with plant materials, suggesting an episode of working which has brought abandonment and occupational indicators together. Elevated soil magnetism values and high total P value (despite a reduction on the underlying monolith) alongside degraded bone and calcium-iron-phosphate features (Figure 71) suggest an anthropogenic presence which is having a varying signature on the stratigraphy. Sand inclusion is comparatively low in reference to the rest of the stratigraphy, however, there were coated basalt grains present which would only be permitted to form if the site was abandoned for a prolonged period of time. This is found in the uppermost part of monolith 4, in a horizontal formation, with an organic band interspersed with fungal spores and plant residues.

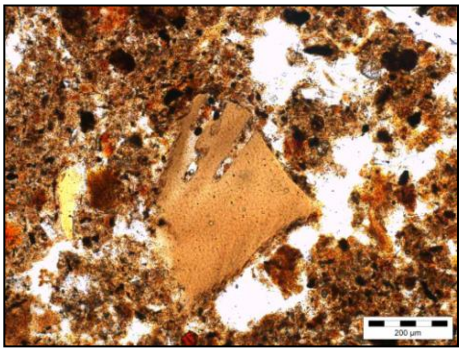


Figure 70: (Skálavík 2, Figure 5) bone material within a well-mixed matrix, 10x mag, PPL

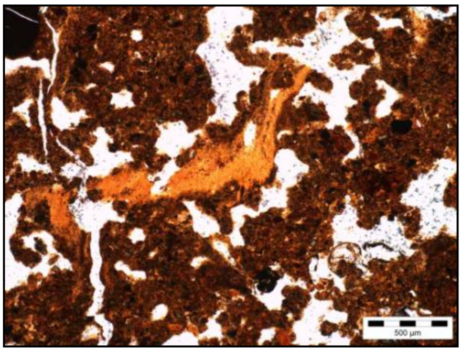


Figure 71: (Skálavík 2, Figure 6) bone degrading to solution and converting to CaFeP, 4x mag, PPL

Skálavík 3 Case Study

Skálavík 3 is a site which displays a relatively un-complex stratigraphy, with varying bands of thick and thin accumulations observed at field level. Three radiocarbon ages were obtained from throughout the stratigraphy; AD 1280 – 1340 at soil horizon 1, AD 1545 – 1605 at soil horizon 3 and AD 1685 – 1745 at soil horizon 7. The youngest age indicates that this was a site expanded during the late thirteenth or early fourteenth century. Soil textures were predominantly clay loams, with no one Munsell colour dominating. Tones were showing mainly to be dark to very dark browns.

The lowest horizon in the stratigraphy reveals a moderate anthropogenic presence both in values of soil magnetism and total P recorded (Figure 72; Figure 73; Table 24). The elevated volume of organic material suggests a reduced mineral component to the horizon, particularly in comparison to soil horizons 3 and upwards. Soil horizon 2 is a stark contrast, yielding significantly elevated values of soil magnetism and the highest level of P recorded in the stratigraphy. This value may be influenced somewhat by the iron pan, bringing together a concentration of material at one distinct point in the stratigraphy.

Table 24: Skálavík 3 laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low Frequency	High Frequency
07	Skálavík 3/7	4.9	16.79	508.97	403.5	384.6
06	Skálavík 3/6	5.0	14.95	1840.28	388	372.6
05	Skálavík 3/5	4.9	15.12	1125.27	250.1	243.9
04	Skálavík 3/4	4.9	19.50	717.92	238.5	228.3
03	Skálavík 3/3	5.0	20.81	551.15	420.7	394
02	Skálavík 3/2	5.0	22.05	838.69	419.2	394.3
01	Skálavík 3/1	4.7	21.85	814.72	260.6	246

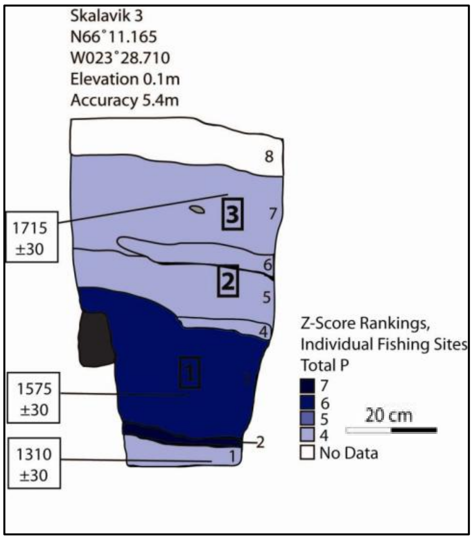


Figure 72: Intra-Stratigraphic Z-Score rankings of Total P

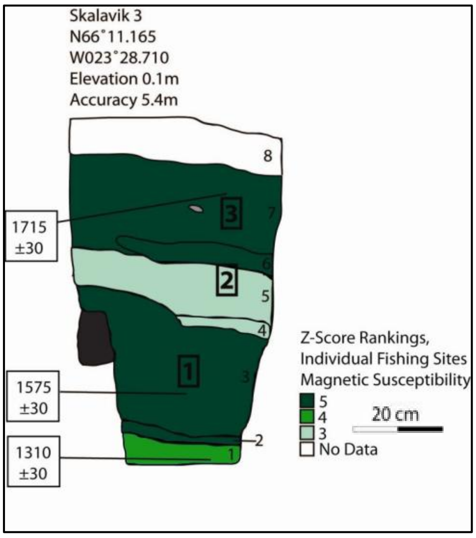


Figure 73: Intra-Stratigraphic Z-Score rankings of Magnetic Susceptibility.

Soil horizon 3 is one of the most intense periods of occupation on the site, with some of the highest levels of P and soil magnetism in the stratigraphy recorded here. The most elevated anthropogenic level can be found at horizon 2 (Figure 74). The activity here is firmly dated to the mid to late sixteenth century. Monolith 1 (Table 25), positioned firmly within this horizon, displays a heavy anthropogenic presence in the form of bone, charcoal, domestic waste throughout, intermixed with plant matter (Figure 75). Bone is found in solution, including an instance of a calcium-iron-phosphate feature (Figure 76) can be related to the elevated levels of total P .

Table 25: Skálavík 3 Thin Section Descriptions 1, 2 & 3

Skálavík 3, 1-3

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material			Pedofeatures									
Section	Horizon	Basalt	Feldspar	Calcite	Shell	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites	Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
3	2	3	t				4			Dark brown to very dark brown PPL. Pale orange/brown with red, yellow and orange flecks OIL.	1		2	4		1						2		Granular	Poorly sorted	Speckled	Enaulic
	1	3	t			1	3			Dark brown with occasional light brown inclusions PPL. Pale orange/brown with orange and red flecks OIL.	t		3	3		1			2			2		Crumb/granular	Poorly sorted	Speckled	Enaulic
2	3	3	t			3				Dark brown with medium brown patches PPL. light orange with dark red patches OIL	t		2	1		2			1			2	t	Subangular blocky	Sorted	Speckled	Enaulic
	2	4	2			3				Light to medium brown PPL. Light to medium brown with pale orange and red flecks OIL	1		2	1		1			1			2		Subangular blocky	Moderately sorted	Speckled	Enaulic
	1	3	t			4				Light brown organo mineral PPL. light brown with orange patches and red flecks OIL.	2	2	1	1		t		1	1					Subangular blocky	Sorted	Speckled	Enaulic
1	3	1	t			4	1			Medium brown with infrequent light brown fissures PPL. Orange brown with red flecks OIL.	t	3	1	3		2			2			3		Angular blocky	Unsorted	Speckled	Enaulic
	2	2	t			t				Medium brown progressing to dark brown PPL. Deep red with light yellow flecks OIL.	1		1	3	2	1		t	1			t		Angular blocky	Unsorted	Speckled	Enaulic
	1	2	t		t	1	1	yes		Brown to dark brown PPL. Red-yellow to red OIL.	1		2	2	1	2	1		1			1		Angular blocky	Unsorted	Speckled	Enaulic

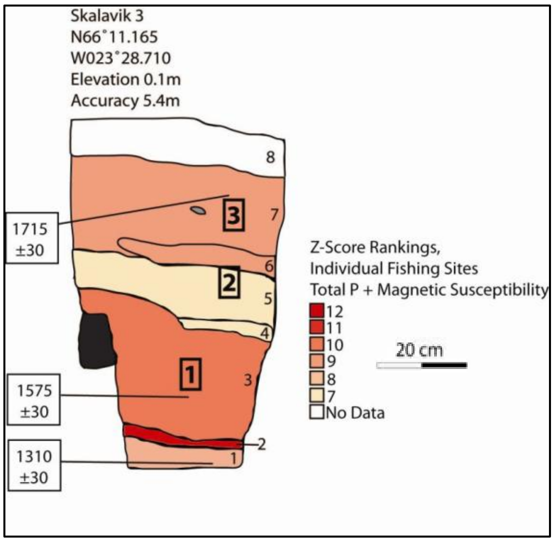


Figure 74: Intra-Stratigraphic Integrated Z-Score rankings of Total P and Magnetic Susceptibility

Occupation is not constant. Observed under thin section were microstratigraphic differences showing alternating bands of charcoal and turf fuel residues, capped by an iron-influenced boundary intermixed with charcoal and basalt, overlain by a boundary of organic matter, before reverting back to a bone-rich context. Iron features were a common occurrence throughout the monolith, revealing at times, exposed wetting and drying conditions. When there was activity at the site, it was intense and contrasting and leaving behind poorly sorted debris, but not sufficient to change the microstructure from its subangular blocky characteristics to more crumb-like, associated with other swift deposits.

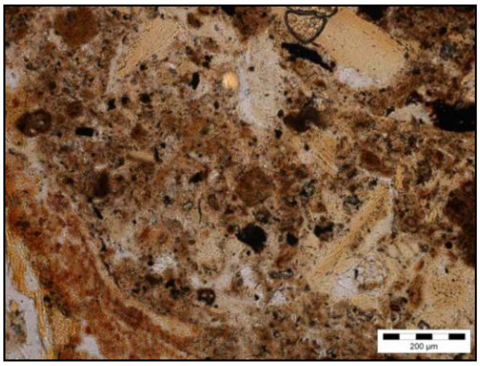


Figure 75: (Skálavík 3, Figure 1), mix of poorly sorted plant and bone residue, 10x mag, PPL

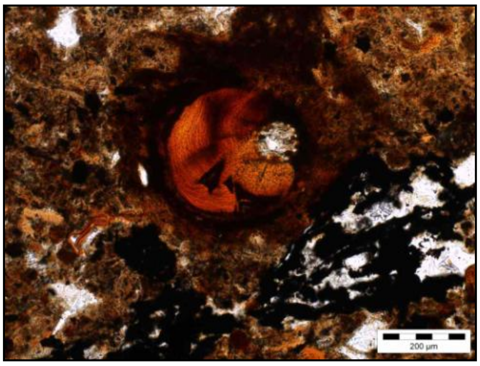


Figure 76: (Skálavík 3, Figure 2), CaFeP feature alongside a charcoal fragment, 10x mag, PPL

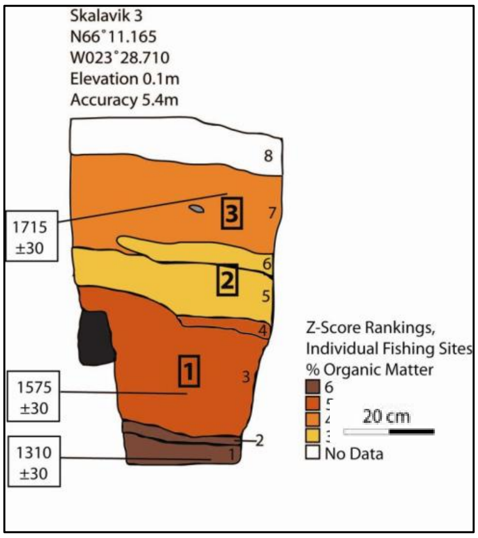


Figure 77: Intra-Stratigraphic Z-Score rankings of Organic Matter

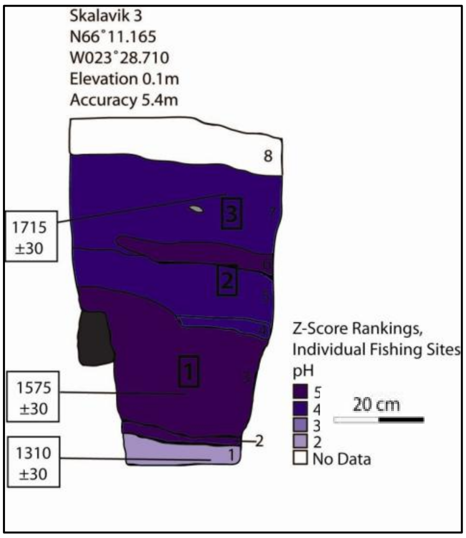


Figure 78: Intra-Stratigraphic Z-Score rankings of pH

Soil horizon 4, capping the right side of the stratigraphy, reveals a reduction in intensity on the site through reduced levels of total P and soil magnetism. Soil horizon 5 continues this trend, but this time features a reduction in organic matter (Figure 77). The sharp increase in sand material within the stratigraphy contributes to the idea that this was a phase of abandonment (Table 26), suggesting it was now subject to stronger coastal storm episodes. Monolith 2, which captures this soil horizon, echoes this theory.

Table 26: Skálavík 3, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
07	Skálavík 3/7	3.26	38.14	31.2	22.3	5.1	168.2	89.10	2.212	5.663
06	Skálavík 3/6	3.32	35.88	30.8	25.6	4.4	174.2	100.7	2.220	6.548
05	Skálavík 3/5	1.85	20.95	21.5	29.4	26.3	425.1	273.0	1.218	0.784
04	Skálavík 3/4	2.03	34.77	37.7	19.7	5.8	182.8	98.97	3.271	12.39
03	Skálavík 3/3	1.65	30.25	40.9	22.3	4.9	180.5	107.9	2.914	10.87
02	Skálavík 3/2	2.46	27.84	33.5	26.3	9.9	231.2	132.8	1.900	3.651
01	Skálavík 3/1	3.27	45.33	32.8	15.8	2.8	125.2	66.66	2.558	7.888

The pale fabric that makes up the lower part of the monolith is rich in silicates (Figure 79), and infused into plant material. Basaltic grains display coatings (Figure 80), iron nodules were present (Figure 81) and fungal spores were a regular feature within the matrix. This lower microstratigraphic horizon is capped by larger basalt grains, potentially related to the influx of larger mineral material, before a band of birchwood and turf fuel residues were observed as soil horizon 6 commences. Little in the way of bone is observed in the main part of the stratigraphy, and with the microstructure subangular blocky.

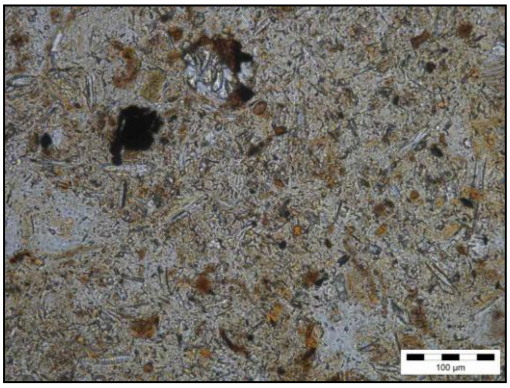


Figure 79: (Skálavík 3, Figure 3) silicate-rich matrix, 20x mag, PPL

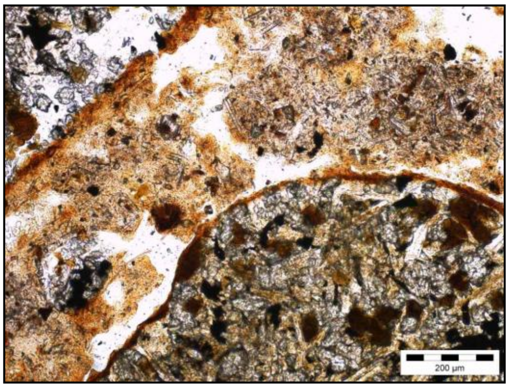


Figure 80: (Skálavík 3, Figure 4) silicate infills and coatings covering basalt, 10x mag, PPL

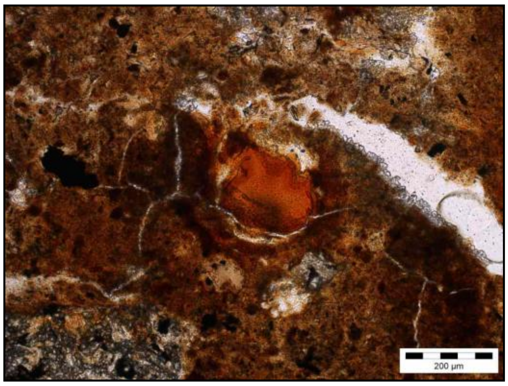


Figure 81: (Skálavík 3, Figure 5) iron-infill and accumulation, 10x mag, PPL

It appears this site was abandoned for a prolonged period of time, before the resumption of on-site activity. Both the monolith and soil horizon were firmly placed between two radiocarbon ages, indicating that there was a period of prolonged abandonment at the site sometime between the mid to late sixteenth century and the early eighteenth century AD.

Soil horizon 6 reveals similarities to soil horizon 5, save for a more neutral pH and an increase in soil magnetism (Figure 78). The sand component in the particle size analysis drastically reduces, suggesting the site is not being subject to the same storm events. The uppermost part of monolith 2 captures this horizon, and the minute component of bone material which it contains.

Capping this is soil horizon 7, from which the radiocarbon age of AD 1685 – 1745 was obtained. This is the second-thickest horizon, and displays a higher degree of uniformity at site-level. Levels of magnetic susceptibility were continually elevated, with levels of total P being much like the horizon below. Monolith 3 reveals a stark contrast to monolith 2, in that the range and volume of bone material has increased in various states of preservation; fragmented and un-fragmented, rubified and unrubified (Figure 82). Progressing up the monolith, the frequency of charcoal increases (Figure

83), forming a dominant layer intermixed with fungal spores and cell residues. This mixing of presence and abandonment indicators suggests a form of disturbance which has brought these groups of features together. This charcoal and plant residue component may be linked with the elevated volume of organic matter within the soil horizon 7.

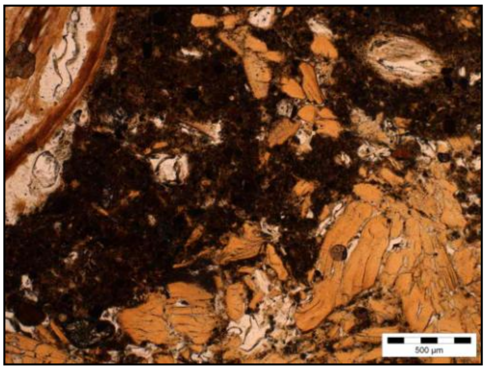


Figure 82: (Skálavík 3, Figure 6) highly fragmented bone adjacent to an organo-mineral cluster, 4x mag, PPL

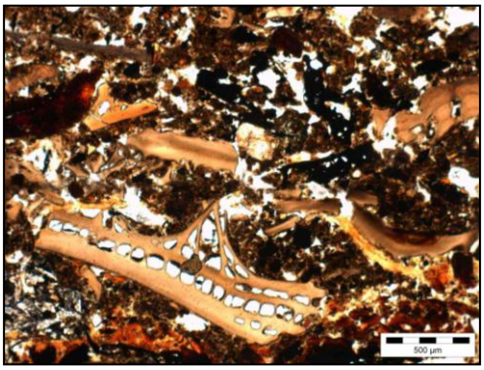


Figure 83: (Skálavík 3, Figure 7) fragmented rubified bone alongside charcoal material, 4x mag, PPL

Underlying the distinctive charcoal component, the main fuel residue is peat, which links well with the elevated levels of soil magnetism. The microstructure of the monolith displays a subangular blocky presence, with distinct areas of granular microstructure. During distinct periods, there appears to be a strong anthropogenic presence, but this may have been exposed to some degree. The reduced frequency of iron nodule accumulations suggests the absence of prolonged periods away from the site. With a changing method of fishing in the eighteenth century, there may have been a reduced waste component given the processing of produce at sea. The result of this would be a strong coastal presence with reduced wastes finding their way into the sheet midden.

The stratigraphy at Skálavík 3 reveals some features of interest, none more so than the presence of a prolonged abandonment phase, firmly dated between AD 1545 – 1605 and AD 1685 – 1745, reflected in the values and findings from soil horizon 5 and the majority of monolith 2. The evidence points towards a period of hiatus during the seventeenth century, which is not reflected elsewhere. The presence of silicates and coated mineral grains alongside iron accumulation features points towards a very significant period on the site.

Skálavík 4 Case Study

The stratigraphy at Skálavík 4 also displays a range of stratigraphic complexity, with a thick underlying horizon being capped by a series of thin but inherently different horizons, which were sealed and overlain by a thick, uniform and organically rich horizon. No radiocarbon ages were obtained from this stratigraphy, however, samples were obtained for bulk soil analysis and monoliths obtained for thin section analysis which will generate a narrative of the stratigraphy.

The soil horizons all contain a loam texture, some of which vary in the degree of inclusion of sand and silt. The most frequent Munsell colour recorded is 5YR 3/3 dark reddish brown, with the remaining horizons predominantly containing dark brown overtones. Present were horizons heavily influenced by well-rounded gravel material, indicating some degree of water-based influence on the deposit.

The lowest part of the stratigraphy is a rounded, gravel-rich substrate, which fills in the larger voids left by the beach boulder material. Found throughout were instances of charcoal flecks, which reveals a significant contribution to the total P and soil magnetism levels in the stratigraphy (Figure 84; Figure 85;

Table 27). The values found here were the highest in the stratigraphy, indicating a strong human presence right from the earliest period (Figure 88). The nature of the rounded stone material caused problems in placing the Kubiëna tin, yielding no sample for micromorphological analysis.

Table 27: Skálavík 4 laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low Frequency	High Frequency
07	Skálavík 4/7	5.8	9.31	571.27	576	561.9
06	Skálavík 4/6	5.4	12.01	407.37	440.2	422.9
05	Skálavík 4/5	5.4	9.65	488.85	603.6	590.4
04	Skálavík 4/4	5.4	13.25	526.23	423.9	413.2
03	Skálavík 4/3	5.4	13.45	531.98	411	400
02	Skálavík 4/2	5.4	12.98	507.06	411.5	399.2
01	Skálavík 4/1	5.5	11.47	466.80	715.6	701.8

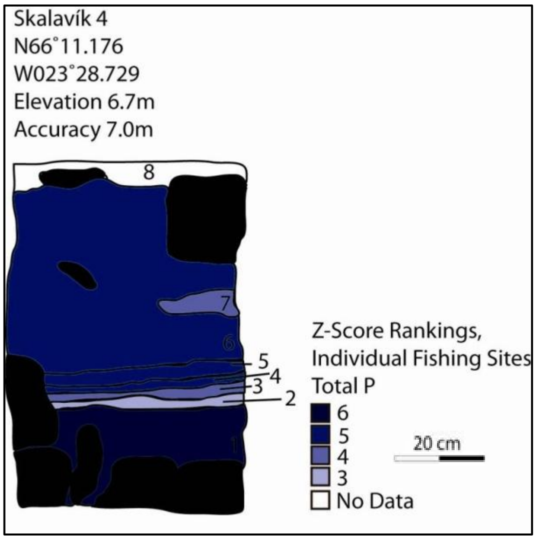


Figure 84: Skálavík 4 Intra-Stratigraphic Z-Score rankings of Total P

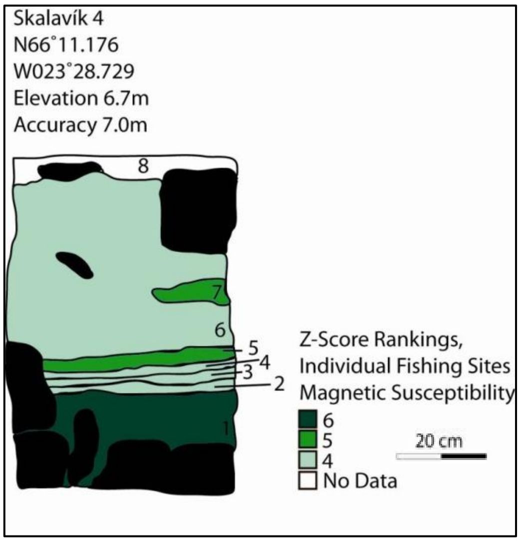


Figure 85: Skálavík 4 Intra-Stratigraphic Z-Score rankings of Magnetic Susceptibility

The alternating bands of material observed in the field were captured in monolith 1 (Table 28). These display fine, discreet micro-horizons within each soil horizon, some of which contain sharp boundaries between each context. Horizon 2 shows a reduced anthropogenic presence, reflected in reduced levels of total P and soil magnetism alongside increased volumes of basalt grains with light coatings within a matrix of fungal spores, iron accumulations and hyaline dopplerites. Soil horizon 3 displays an increasing turf presence, reflected in the increase in organic matter (Figure 86) and proportion of sand material. Towards the top of the monolith, associated with horizon 5, the remains of silicates increases indicating the burning of turf material, reflected in a further increase in soil magnetism and total P, and reduction in the proportion of organic matter present.

Table 28: Skálavík 4 Thin Section Descriptions 1 & 2

Skálavík 4, 1-2

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section	Horizon	Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Yellow)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
2	3	3	t			2	1			Very dark brown with darker patches PPL. Medium brown with pale orange inclusions and red and orange flecks OIL.		1	1		2			t	1			1	1		Angular blocky	Poorly sorted	Speckled	Enaulic
	2	1	t			t				Very dark brown getting progressively lighter PPL. Medium brown with pale orange influence with flecks of deep red OIL.	1		1	1	2			1	1			1			Subangular blocky	-	Speckled	Enaulic
	1	4	t			1				Dark brown with light brown pockets PPL. Light orange-brown with darker clusters and red flecks OIL.	t		1		2			1	1			1			Subangular blocky	Moderately well sorted	Speckled	Enaulic
1	5	4	t			3	t	yes		Pale medium brown getting progressively darker PPL. Light orange brown with red flecks OIL.		2	1		1			2	1		1	t			Subangular blocky	Well sorted	Speckled	Enaulic
	4	1	t	t		3				Medium greyish brown PPL. Orange brown with growing pale component with red and orange flecks OIL	t		t		1		1		t			1			Subangular blocky	-	Speckled	Enaulic
	3	2	t	t		1				Medium brown with dark inclusions PPL. Orange-brown with deeper red patches and common red flecks OIL.			t		1			1	1			1	t		Subangular blocky	Moderately sorted	Speckled	Enaulic
	2	3	t			3	1			Medium to greyish brown PPL. Pale yellowish brown with deep orange and red patches with red and yellow flecks OIL.			1					t	1				1		Subangular blocky	Sorted	Speckled	Enaulic
	1	4	t			1				Medium brown with dark speckles PPL. Medium orange brown with red and orange flecks OIL			t	t	1			1	1			1			Subangular blocky	Well sorted	Speckled	Enaulic

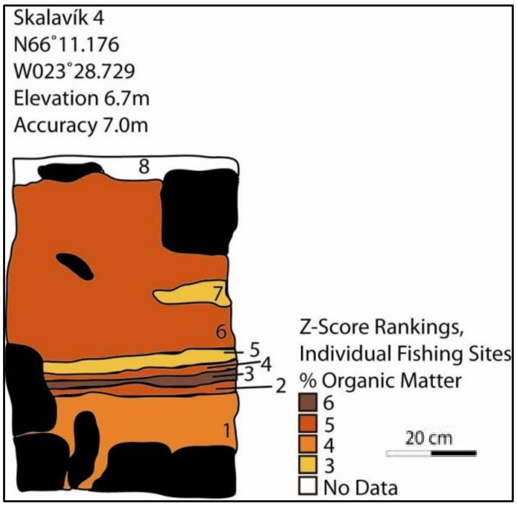


Figure 86: Skálavík 4 Intra-site Stratigraphic Z-Score rankings of Percentage Organic Matter

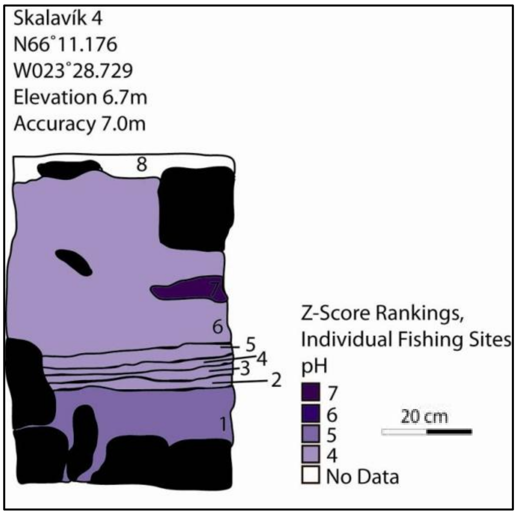


Figure 87: Skálavík 4 Intra-site Stratigraphic Z-Score rankings of and pH

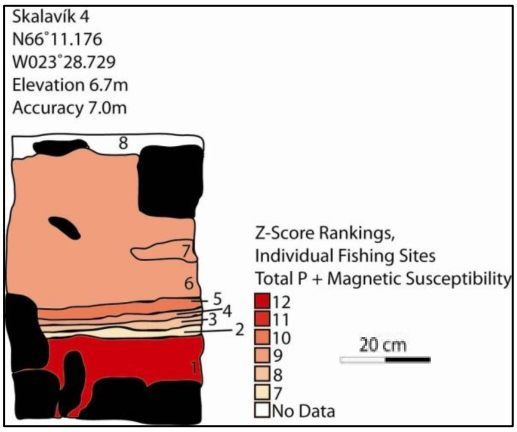


Figure 88: Skálavík 4 Intra-Stratigraphic Integrated Z-Score rankings of Total P and Magnetic Susceptibility

Few instances of highly fragmented bone material were found throughout discreet parts of the monolith, more associated with the stronger anthropogenic presence, but not found in any level of abundance as reflected at other stratigraphies, often intermixed with domestic wastes. There is one instance of a calcium-iron-phosphate feature identified (Figure 89), alongside a potentially datable tephra shard (Figure 90).

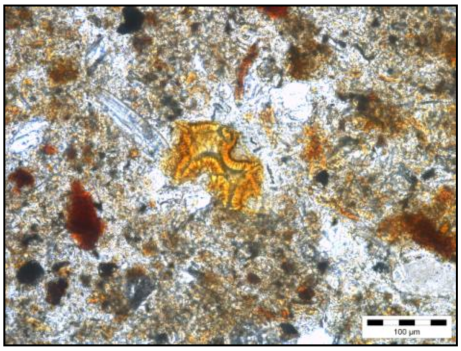


Figure 89: (Skálavík 4, Figure 1) CaFeP feature, 20x mag, PPL

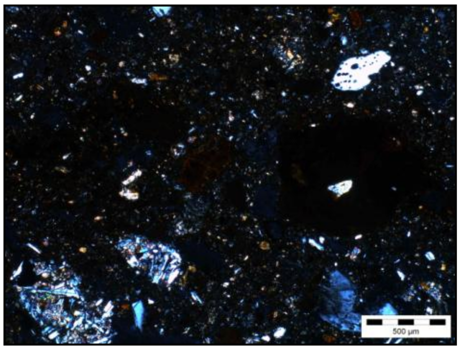


Figure 90: (Skálavík 4, Figure 2) tephra shard, 4x mag, OIL

The discreet bands of material making up soil horizons 2 to 5 were capped by a uniform horizon 6, which is a moderately rich organic deposit containing elevated levels of total P but a reduced soil magnetism component. Levels of sand in the particle size analysis suggest additional deposition as a result of abandonment and coastal storminess (Table 29). Soil horizon 7 cuts into this from the right hand side, yielding a reduced organic component and a reduction in total P, but a higher level of soil magnetism. The contents of monolith 2 were mostly represented by soil horizon 6, with a small area of horizon 7 captured.

Table 29: Skálavík 4, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
07	Skálavík 4/7	3.89	40.81	31.7	21.2	2.4	138.2	77.86	2.187	6.206
06	Skálavík 4/6	2.51	28.49	26.4	26.7	15.9	302.1	158.5	1.801	2.988
05	Skálavík 4/5	5.43	47.27	27.9	17.5	1.9	116.1	54.80	2.204	6.037
04	Skálavík 4/4	3.19	36.51	28	23	9.3	213.7	99.32	1.989	4.371
03	Skálavík 4/3	2.05	26.85	32.8	22.8	15.5	303.3	141.0	1.952	3.151
02	Skálavík 4/2	2.89	42.31	33.6	15.9	5.3	158.7	74.72	3.117	11.38
01	Skálavík 4/1	3.54	40.66	36.1	15.9	3.8	139.1	76.74	2.953	10.41

The characteristics displayed by monolith 2 were those reflecting an abandoned site, mainly dark brown under PPL and characterised by iron nodules, plant residues and fungal spores (Figure 91). Well-sorted basalt grains were more dominant, reflecting a heavier influence of coastal storm activity. The crumb microstructure suggests that parts of this horizon were formed swiftly. Where horizon 7 is sampled, turf ash residues appear alongside peat ash residues (Figure 92) and some hyaline dopplerites. Traces of bone and charcoal were found intimately mixed, suggesting the re-occupation and utilisation of the site after a prolonged period of absence. Despite these more striking observations reflecting an anthropogenic influence, levels of total P were reduced in comparison to soil horizon 6, but with pH being more neutral (Figure 87), these may have created more suitable conditions for the preservation of bone material, reducing the chance of conversion to solution and adding to the total P value. The rise in soil magnetism does reflect the fuel residue observations.

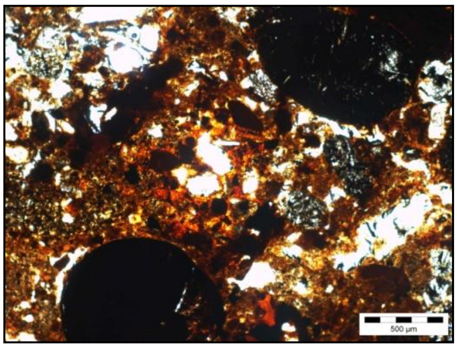


Figure 91: (Skálavík 4, Figure 3) iron accumulations and rubified material, 4x mag, PPL

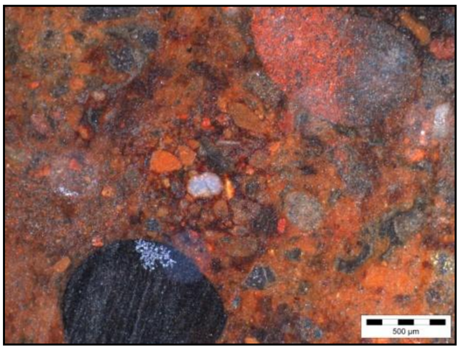


Figure 92: (Skálavík 4, Figure 4) heavily influenced rubified material, 4x mag, OIL

Kálfeyri Case Study

The site at Kálfeyri yields a moderately constant series of soil horizons in terms of size, all of which carry a varying degree of anthropogenic signatures. The texture most frequently present is a sandy silt loam, with sandy loams making up the remainder. No individual Munsell colour is repeated, however, the overlying colours, mainly associated with the upper three soil horizons were dark browns. Soil horizon 2, which displays a very strong anthropogenic presence, interestingly yields a dark reddish brown colour. Two radiocarbon ages were obtained from the lowest soil horizon and also soil horizon 3, dating to AD 1205 – 1275 and AD 1280 – 1340 respectively.

Soil horizon 1, yielding a radiocarbon age of AD 1205 – 1275, displays the weakest anthropogenic signal within the stratigraphy, with reduced levels of total P and soil magnetism (Figure 93; Figure 94; Table 30). These results were a striking contrast to soil horizon 2, which displays the highest total P values and elevated levels of soil magnetism on site. A sharp and unrivalled peak in clay sized particles were observed in the particle size analysis at horizon 2, which may go some way to explaining the retention of the total P in the soil. The dark reddish brown colour tone is like that found in Skálavík 1, where there it displays the strongest anthropogenic characteristics found in the stratigraphy (Figure 95). Through difficulties encountered in the field, the lowest monolith is obtained from monolith 2, capturing the upper part of soil horizon 3 and lower part of soil horizon 4.

Table 30: Kálfeyri Laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low Frequency	High Frequency
20	Kalf 5	5.7	24.90	454.79	527.50	548.50
19	Kalf 4	5.9	15.81	345.85	481.19	354.28
18	Kalf 3	5.4	15.72	401.00	369.00	356.33
17	Kalf 2	5.4	21.10	518.98	369.61	464.22
16	Kalf 1	5.6	19.89	299.51	516.31	505.97

Soil horizon 3, which yields the radiocarbon age of AD 1280 – 1340, displays a reduced level of total P compared to soil horizon 2, but maintains a strong value of soil magnetism. This is a mineral-rich deposit of mainly basaltic lavas infused with burnt turf residues. Found interspersed within the matrix were remnants of fragmented bone and charcoal, alongside fungal spores and plant materials. The slightly more acidic pH conditions may have influenced levels of bone degradation (Figure 96). The subangular blocky microstructure suggests some degree of exposure in the development of this horizon. The values from the soil chemical analyses indicate a strong period of development and subsequent reduction in intensity between the thirteenth and fourteenth centuries AD.

Table 31: Kálfeyri Thin Section Descriptions 2, 1a & 1

Kálfeyri, 2, 1a & 1

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section	Horizon	Basalt	Feldspar	Hornblende	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
1	5	4			t		2			Medium reddish brown PPL. Medium red with red flecks OIL.		2		2			2		t			1			Subangular blocky	Uniform	Speckled	Enaulic
	4	t	t		t	t	3			Light to medium brown PPL. Light orange/brown OIL.	t	t		2		1	1		1			1			Subangular blocky	-	Speckled	Enaulic
	3	t	t	t		t	2			Dark brown PPL. Pale orange OIL		1		4					t			1			Subangular blocky	-	Speckled	Enaulic
	2	t	t			t	3			Dark and light brown PPL. Light brown/pale orange OIL		1		2			2		t			1			Subangular blocky	-	Speckled	Enaulic
	1	2	t	t	t	2	3			Medium brown PPL. Light brown with patches of pale orange OIL.		1		3			2		1			1			Crumb	Moderate	Speckled	Enaulic
1a	2	2	t			t	3			Medium brown with dark inclusions PPL. Medium brown with dark flecks OIL	t	1		2		1			t			t			Crumb	Unsorted	Speckled	Enaulic
	1	2	t			t	3			Medium to dark brown PPL. Dark reddish brown with red flecks OIL	t	t		2	1				t			1			Crumb	Unsorted	Speckled	Coarse enaulic
2	2	3	t				2			Reddish brown PPL. Medium brown with patches of red and orange OIL.	t	t		2					t			3			Subangular blocky	Moderately	Speckled	Enaulic
	1	3	t			t	3	yes		Light to medium brown PPL. Medium brown with red and orange flecks OIL	t	t		2								3			Subangular blocky	Moderately	speckled	Enaulic

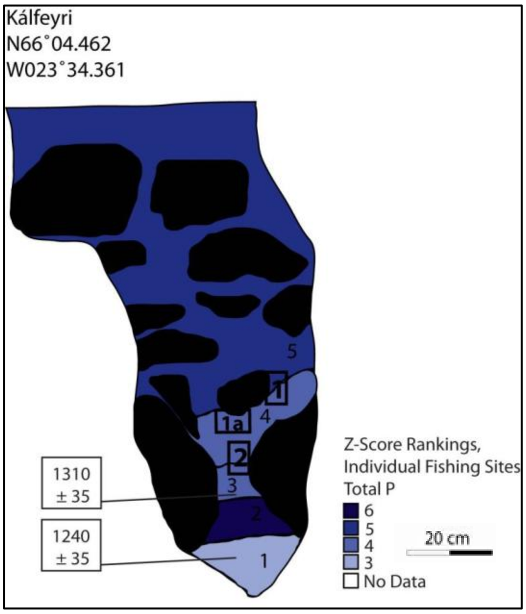


Figure 93: Kálfeyri Intra-Stratigraphic Z-Score rankings of Total P

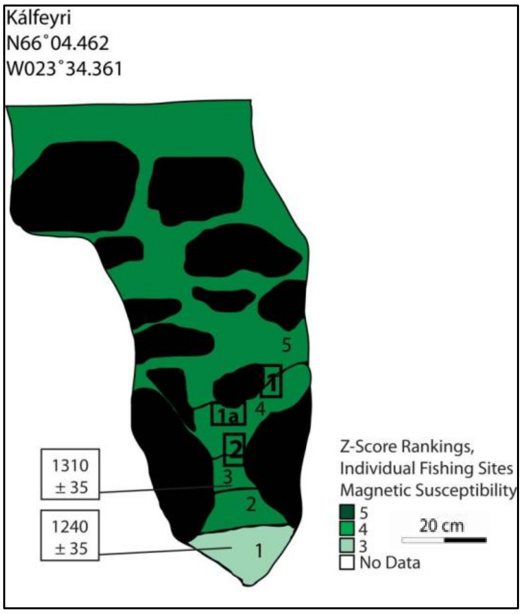


Figure 94: Kálfeyri Intra-Stratigraphic Z-Score rankings of Magnetic Susceptibility

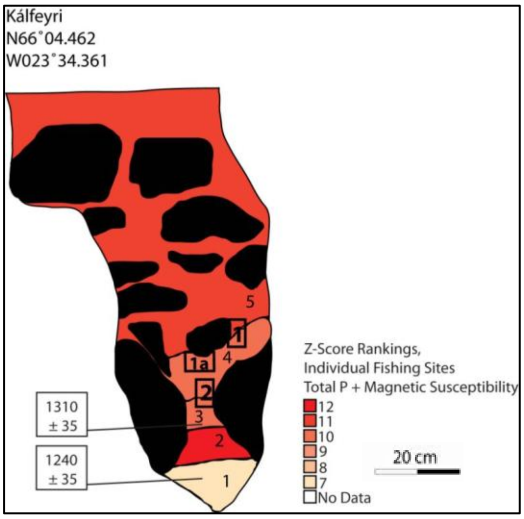


Figure 95: Kálfeyri Intra-Stratigraphic Integrated Z-Score rankings of Total P and Magnetic Susceptibility

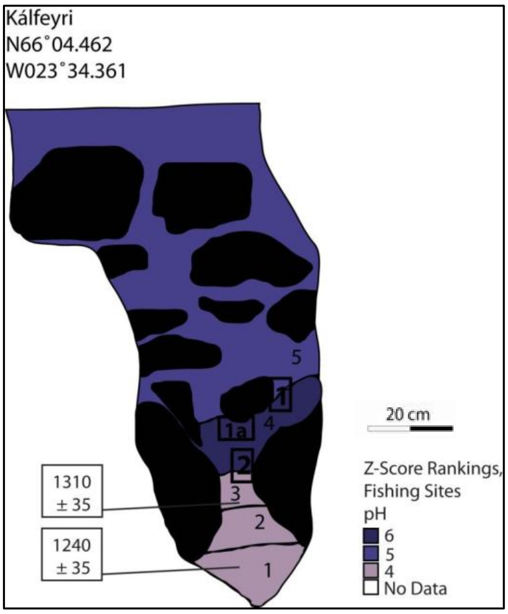


Figure 96: Kálfeyri Intra-site Stratigraphic Z-Score rankings of pH

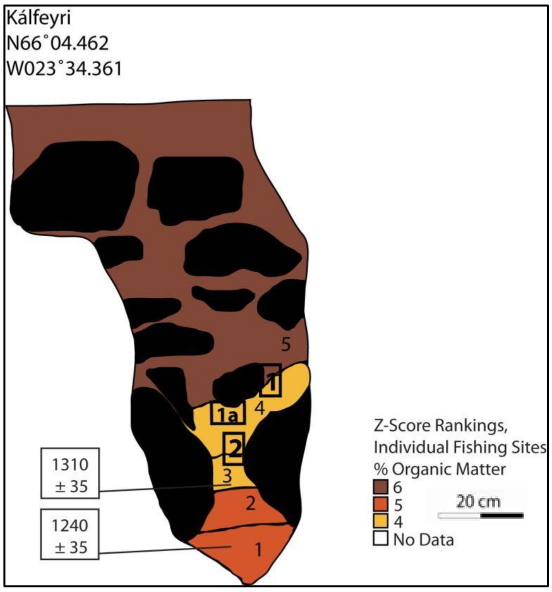


Figure 97: Kálfeyri Intra-site Stratigraphic Z-Score rankings of Percentage Organic Matter

In the upper part of monolith 2 (Table 31), bone is present in a variety of states, both rubified and unrubified. Yellow accumulations were also present, indicating a level of bone degradation. The microstructure remains subangular blocky, with discreet areas of crumb where there appears to be a swift deposit taking place. This part of the monolith is represented by soil horizon 4, where soil magnetism levels were maintained but there is a drop in levels of total P, emphasising a possible reduction in site intensity. Monolith 1A presents information to the contrary; more in the way of an anthropogenic material is identified in the form of bone in various states of preservation and charcoal fragments. Soil pH is more neutral here than in underlying horizons, which may have gone some way in preserving material and lowering the signal of total P. The crumb microstructure suggests that this was a period of swift deposition, but there were periods of activity away from the site in the form of fungal spores, plant material and iron accumulations. The lower area of monolith 1 also captures material from soil horizon 4. Here, the microstructure changes from crumb to slight subangular blocky with a continuation of highly fragmented bone material and charcoal, some of which forms a band at the uppermost part of the horizon.

Table 32: Kálfeyri, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
20	Kálfeyri 5	4.22	54.28	29.1	7.1	5.3	120.5	48.21	3.363	11.63
19	Kálfeyri 4	3.31	54.19	25.5	10.2	6.8	150.1	50.99	3.387	13.07
18	Kálfeyri 3	3.95	43.35	31.9	11.7	9.1	187.9	69.08	2.794	7.806
17	Kálfeyri 2	38.8	61.2	0.00	0.00	0.00	16.77	25.31	-0.416	-1.764
16	Kálfeyri 1	2.36	25.74	29.2	21.7	21.0	351.1	157.2	1.602	1.808

Soil horizon 5 sees an increase in total P levels and maintenance of soil magnetism levels. Turf and peat ash residues were identified under thin section observation, and more in the way of iron accumulations and basaltic material characterise the uppermost microstratigraphic horizons. Bone is found throughout, but mainly in a highly fragmented state. The soil pH becomes slightly more acidic than soil horizon 4, which may in turn have an impact on the levels of material preservation. A basaltic layer caps the monolith and begins to dominate the microstratigraphic horizon. Organic matter is at its on-site highest within this soil horizon (Figure 97), which may be a response to greater instances of plant material and charcoal residues.

Arnardalur Case Study

Arnardalur is a site which displays a moderately complex and varied stratigraphy, with an assortment of thin and thick horizons containing varying signatures associated with an anthropogenic presence. The radiocarbon age obtained from horizon 3 yields an age of AD 1730 – 1800, revealing this stratigraphy as a representation of activity from the eighteenth century onwards. There is, however, an earlier radiocarbon age dating to AD 1630 – 1700 obtained from horizon 8/1 further up the stratigraphy, suggesting that there may have been activity earlier on the site and a mobilisation of material with an inherent radiocarbon age finding its way to this stratigraphic context.

Regarding the textures of the soil, all horizons displayed loamy characteristics, predominantly sandy loams and loamy sands. The colours found themselves in some distinct groups, with 10YR 2/2 very dark brown, 10YR 3/1 very dark gray, and 7.5YR 3/2 dark brown all more or less equally represented across the stratigraphy. There were inherent differences present, but the recurring colours would suggest a cycle or repetition of activities taking place to form this cultural material.

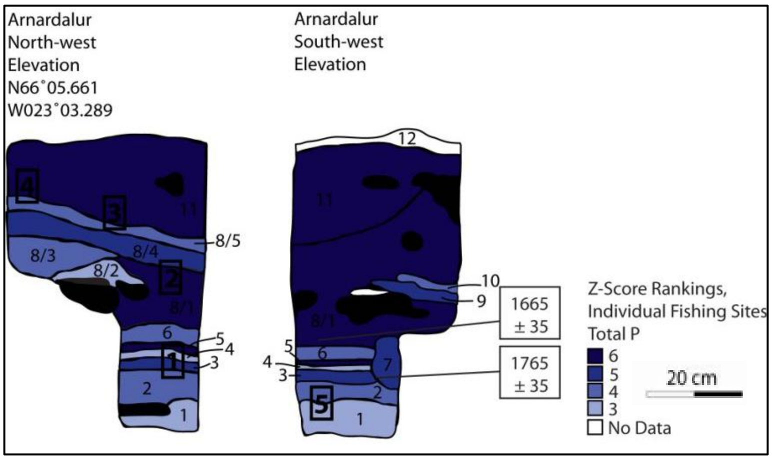


Figure 98: Arnardalur Intra-Stratigraphic Z-Score rankings of Total P

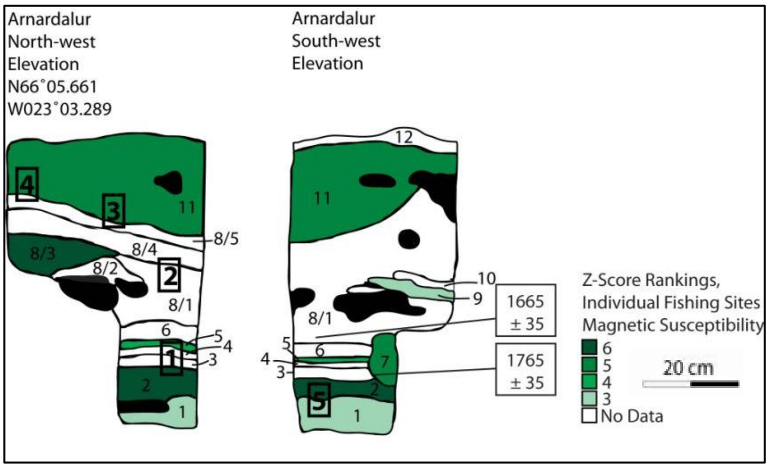


Figure 99: Arnardalur Intra-Stratigraphic Z-Score rankings of Magnetic Susceptibility

The lowest soil horizon displays the lowest levels of total P and magnetic susceptibility within the stratigraphy (Figure 98; Figure 99; Table 33), resulting in the band with the lowest anthropogenic influence (Figure 101). Particle size results show that this horizon is dominantly made up of sand material. This horizon is represented by the lowest part of monolith 5, which reveals layers of basalt-rich material between layers of dark brown organic material and plant residues (Figure 100), but also containing traces of bone and shell fragments. The microstructure is predominantly subangular blocky, with the material found displaying varying degrees of sorting. A change is observed midway up the monolith, where there is an increase in bone fragments and yellow infills amongst other anthropogenic features. This is associated with soil horizon 2, which reveals an increased level of total P alongside elevated levels of soil magnetism. The sand component of the bulk soil sample drastically reduces, associated with a change in microstructure to crumb and the presence of burnt turf residues, revealing a swift change in on-site activity.

Table 33: Arnardalur Laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low Frequency	High Frequency
15	Arnardalur 11	6.4	9.56	247.75	290.36	285.47
14	Arnardalur 10	6.8	17.86	151.70	-	-
13	Arnardalur 9	6.5	44.44	215.21	60.67	60.22
12	Arnardalur 8/5	6.9	11.88	145.60	-	-
11	Arnardalur 8/4	6.7	15.19	211.14	-	-
10	Arnardalur 8/3	6.9	4.30	152.37	458.14	456.78
09	Arnardalur 8/2	6.8	-	100.17	-	-
08	Arnardalur 8/1	7.1	6.96	224.25	-	-
07	Arnardalur 7	6.8	10.45	191.03	267.75	263.22
06	Arnardalur 6	6.7	3.35	165.03	-	-
05	Arnardalur 5	6.8	17.37	237.81	194.33	191.53
04	Arnardalur 4	7.2	-	117.35	-	-
03	Arnardalur 3	6.9	2.12	183.79	-	-
02	Arnardalur 2	7.0	5.24	169.33	419.92	412.53
01	Arnardalur 1	7.2	1.16	77.34	4.36	6.47

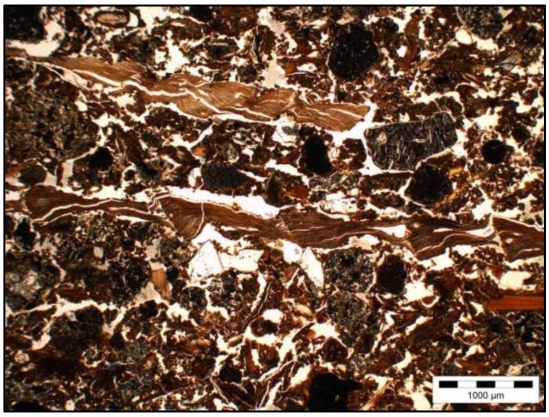


Figure 100: (Arnardalur Figure 1) Plant material amongst a darker crumb matrix of organic and mineral material, 2x mag, PPL.

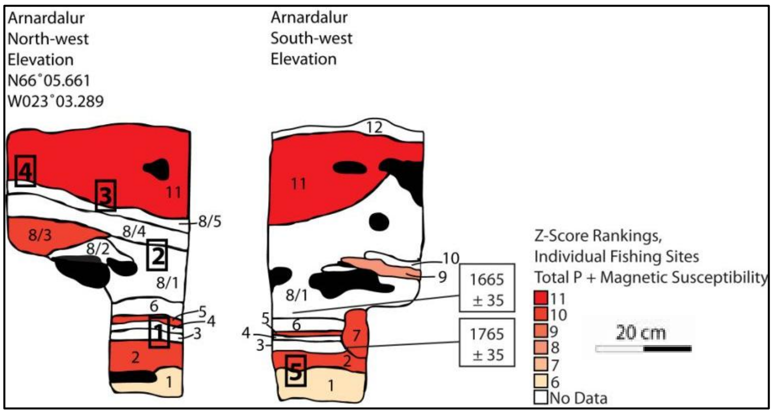


Figure 101: Arnardalur Intra-Stratigraphic Integrated Z-Score rankings of Total P and Magnetic Susceptibility

The lowest were of monolith 1 (Table 34; Table 35) also obtains material from horizon 2, revealing layers of basalt, coatings and infills, (Figure 102) and plant material infused with anthropogenic material. Monolith 1 captures the distinct bands observed in the field, soil horizons 2 to 5. Despite the results from the stratigraphic record being incomplete, the opportunity is still there to observe the natural and anthropogenic influences on the stratigraphy. The bands observed reflect distinct episodes of intensity present on the site. Soil horizon 3 shows a further increase in total P, and an increase in peat ash residues under thin section.

Table 34: Arnardalur Thin Section Descriptions 1, 2, 3 & 4

Arnardalur, 1-4

Section	Horizon	Coarse Mineral Material: Basalt	Feldspar	Shell Material	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Coarse Organic Material: Fungal Spores	Plant Material	Cell Residues	Fine Organic Material: Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Pedofeatures: Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites	Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
4	1	4	t		t	t	3			Medium to medium dark brown PPL. medium brown with red and orange flecks OIL.	t	2	t	t	2	1			t	t		t		Crumb	Moderately sorted	Speckled	Enaulic
3	2	4	t		t	t	2			Medium to dark brown PPL. Dark to medium brown progressing to reddish brown OIL.	t	2	t	t	2				1			1		Subangular blocky	Poorly sorted	Speckled	Enaulic
	1	3	t			t	2			Medium to dark brown PPL. dark brown with red and orange flecks OIL.	t	3	t	2	2	2			t					Crumb	Poorly sorted	Speckled	Enaulic
2	4	3	t			3	1			Medium brown with dark brown areas PPL. Medium brown with red and orange flecks OIL	t	2	t		1	2						t		Crumb with areas of subangular blocky material	Poorly sorted	Speckled	Enaulic
	3	2	t	t		3	t			Medium brown with reddish tinge PPL. medium to dark brown with red and orange flecks OIL	t	3	t		t	2			t			1		Angular blocky with crumb inclusions	Moderately sorted	Speckled	Enaulic
	2	4	t		t	t	2			Light to medium brown PPL. dark to medium brown with red and orange flecks OIL		3	t		t	t				1		t		Crumb	Moderate to well sorted	Speckled	Enaulic
	1	4	t			t	1			Medium brown with reddish brown bands PPL. Dark brown with hints of red OIL.	t	2	t	t	1			t	1	1				Crumb	Moderately well sorted	Speckled	Enaulic
1	4	4	t	t		t	t			Medium light brown PPL. Medium light brown OIL		2		t	1			t	1		t	1		Crumb	Well sorted	Speckled	Enaulic
	3	t	t			t	t			Reddish medium brown PPL. Dark brown with red and orange flecks OIL	t	3	t		t							t		Subangular blocky	-	Speckled	Enaulic
	2	3	t			t	t	yes	pos s	Medium brown with red patches PPL. dark brown with lighter patches OIL	t	2	t		t	t		t	1	t		t		Subangular blocky/crumb	Moderately well sorted	Speckled	Enaulic
	1	4	t		t	t	t			Medium Brown with dark patches PPL. Medium to dark brown OIL	t	2	1	t	t	1			t			2	t	Crumb	Moderately Well Sorted	Speckled	Enaulic

Table 35: Arnardalur Thin Section Descriptions 5

Arnardalur 5

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section		Basalt	Feldspar	Shell	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
5	3	4	t	t		2	1			Medium reddish brown PPL. Light brown OIL, influenced by silicates.		2	t					t	1						Subangular blocky/crumb	Poorly sorted	Speckled	Enaulic
	2	4	t	t		t	3			Medium brown with dark brown patches PPL. medium brown with dark reddish areas OIL.	1	3	t	t	t	t			1		t				Subangular blocky	Poorly sorted	Speckled	Enaulic
	1	4	t		t	t	2			Very dark reddish brown PPL. medium reddish brown with red flecks OIL.		t			2	1		t	1			t			Subangular blocky	Moderately sorted	Speckled	Enaulic

With the microstructure being crumb, this reveals a swift deposit. A reduction in total P is observed in horizon 4, which correlates with a change in the microstructure to subangular blocky, reflecting an exposed period on site. More in the way of plant material and fungal spores were observed than neighbouring contexts, but there is little in the way of coarse mineral material present. There is further change in the overlying horizon, with a sharp increase in total P at horizon 5, represented by a crumb microstructure and bone fragments (Figure 103; Figure 104; Figure 105) alongside rubified material.

A drop in total P is observed in horizon 6, before resumption to significantly elevated levels at horizon 7, and even further in horizon 8/1. Despite showing a degree of uniformity in the field, the lower part of monolith 2 reveals distinct bands of basalt-rich material (Figure 107), some of which containing coatings, between layers of more organic but rubified layers. Peat and turf were the most common fuel residues identified, with wood ash present on occasion. Bone is identified in varying degrees of preservation (Figure 108; Figure 109; Figure 110; Figure 111). Microstructure is predominantly crumb, and deposition pattern often somewhat erratic. Faecal material is found on occasion which may have contributed to post-depositional disturbance

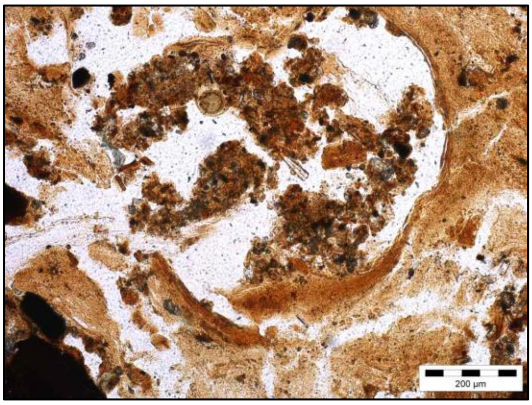


Figure 102: (Arnardalur Figure 2) coating with darker mineral material infilling the void, 10x mag, PPL

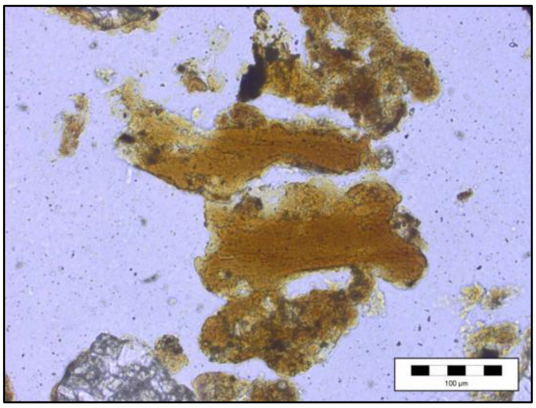


Figure 103: (Arnardalur Figure 3) degraded bone, 20x mag, PPL

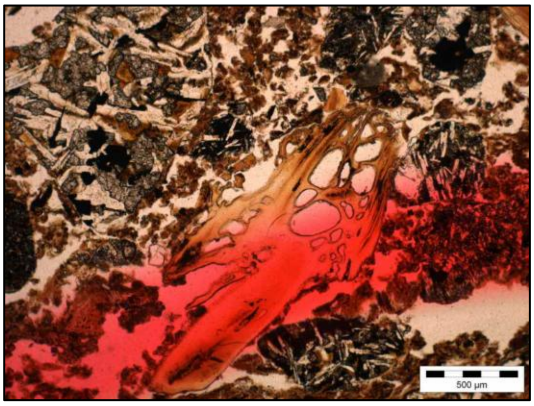


Figure 104: (Arnardalur Figure 4) well preserved bone, 4x mag, PPL

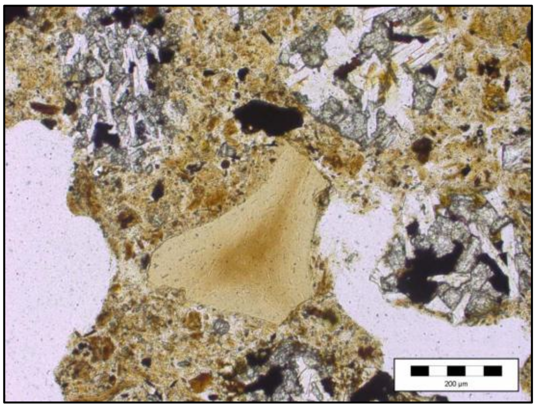


Figure 105: (Arnardalur Figure 5) bone within a fine mineral material mix, 10x mag, PPL

(Figure 112), however, it appears that the general nature of the deposition may have been the main contributing factor to this.

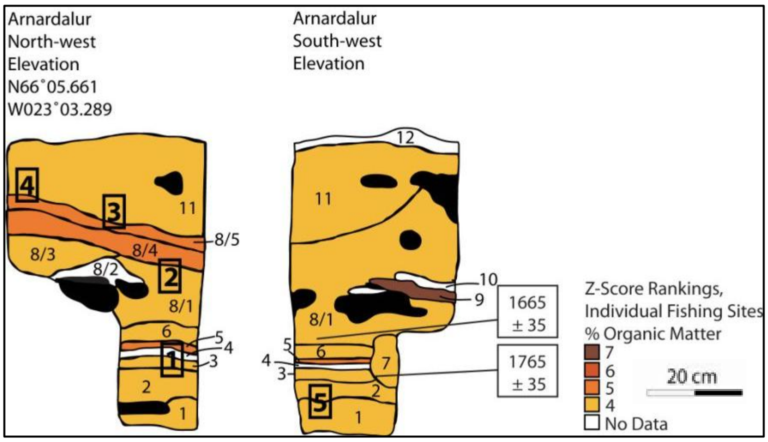


Figure 106: Arnardalur Intra-Stratigraphic Z-Score rankings of Organic Matter

Soil horizon 8/4, which caps horizon 8/1, shows a reduction in the levels of total P, but an increase in organic material present (Figure 106). The microstructure is still predominantly crumb, with some areas of subangular blocky appearing. This can be attributed to the organic layer which caps the lower part of the monolith, containing elevated levels of plant material. Progressing upward, bone is found in increasing volume, intimately mixed with basalt grains and fuel ash residues.

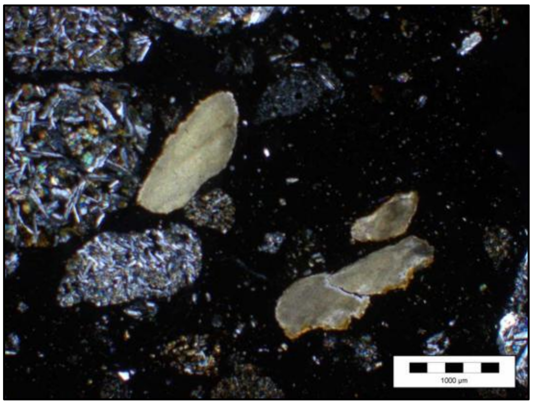


Figure 107: (Arnardalur Figure 6) rounded mineral composition, 2x mag, OIL

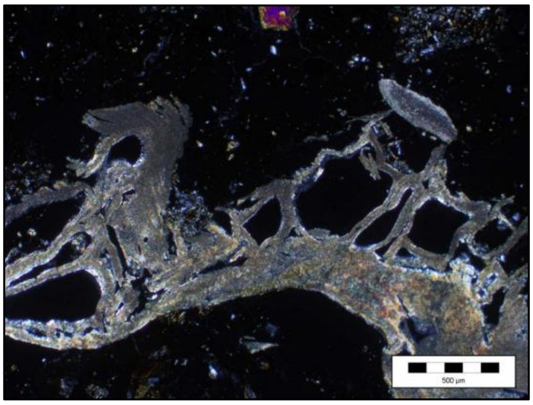


Figure 109: (Arnardalur Figure 8) possible calcified bone, 4x mag, OIL

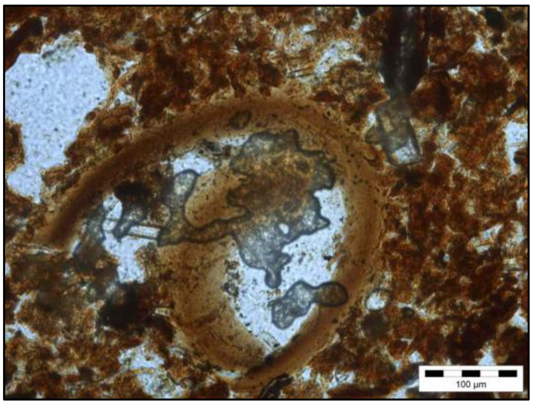


Figure 108: (Arnardalur Figure 7) fish bone undergoing conversion to solution, 20x mag, PPL

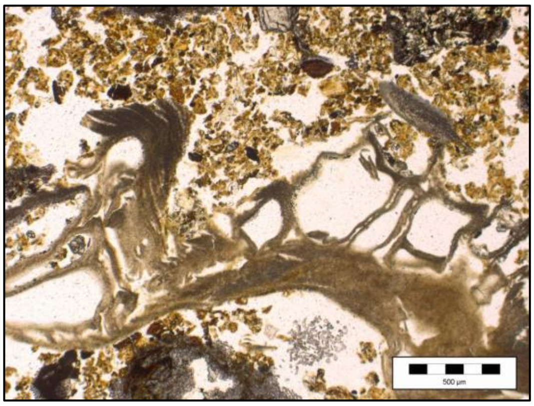


Figure 110: (Arnardalur Figure 9) possible calcified bone, 4x mag, PPL

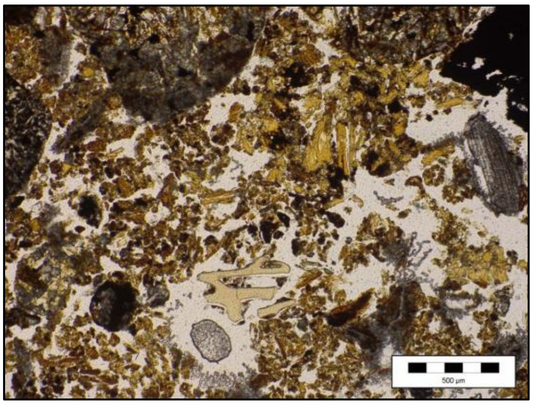


Figure 111: (Arnardalur Figure 10) highly fragmented bone within an erratic composition of material, 4x mag, PPL

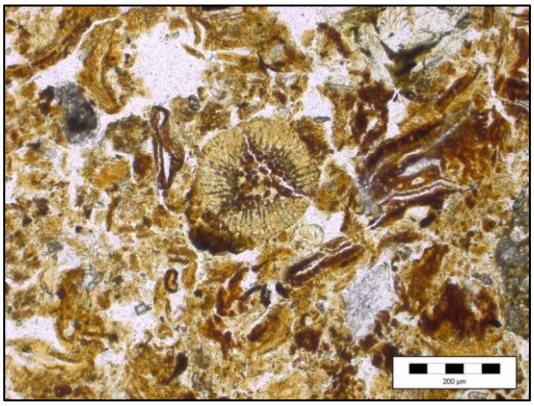


Figure 112: (Arnardalur Figure 11) faecal material contained within plant residues, 10x mag, PPL

Soil horizon 8/5, captured by the lowest areas of both monoliths 3 and 4, displays a drop in the level of total P. Particle size analysis shows a peak in the volume of sand material making up this horizon (Table 36). Levels of organic matter were still maintained and dominate the lower part of monolith 3, infused with mineral material and charred bone remains (Figure 113; Figure 114).

Table 36: Arnardalur, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
15	Arnardalur 11	1.57	25.53	26.0	18.5	28.4	401.5	171.2	1.162	0.569
14	Arnardalur 10	1.04	23.16	45.5	20.9	9.4	229.6	117.1	2.451	6.543
13	Arnardalur 9	1.67	79.23	19.0	0.1	0.0	39.85	28.42	1.964	4.587
12	Arnardalur 8/5	0.8	13.3	26.4	25.0	34.5	494.5	355.9	0.922	0.0053
11	Arnardalur 8/4	2.36	40.64	40.9	11.6	4.5	141.2	74.07	3.401	13.57
10	Arnardalur 8/3	1.79	24.91	36.8	22.0	14.5	268.1	123.0	1.591	2.234
09	Arnardalur 8/2	1.85	27.05	26.5	21.4	23.2	456.1	214.1	1.312	0.650
08	Arnardalur 8/1	1.85	270.5	26.5	21.4	23.2	354.6	154.7	1.301	0.908
07	Arnardalur 7	2.16	36.74	32.0	19.0	10.1	212.1	90.46	2.143	4.747
06	Arnardalur 6	1.55	22.85	27.1	27.0	21.5	344.9	198.2	1.173	0.692
05	Arnardalur 5	2.11	21.29	30.3	23.2	13.1	253.4	115.6	1.737	2.678
04	Arnardalur 4	1.76	32.04	30.7	16.6	18.9	323.1	110.5	1.832	2.586
03	Arnardalur 3	2.93	38.37	22.2	18.5	18.0	303.9	92.72	1.867	3.034
02	Arnardalur 2	4.38	45.92	27.6	15.9	6.2	161.4	62.34	2.909	9.992
01	Arnardalur 1	0.00	6.45	1.53	4.32	87.7	1185	1211	-0.579	-0.220

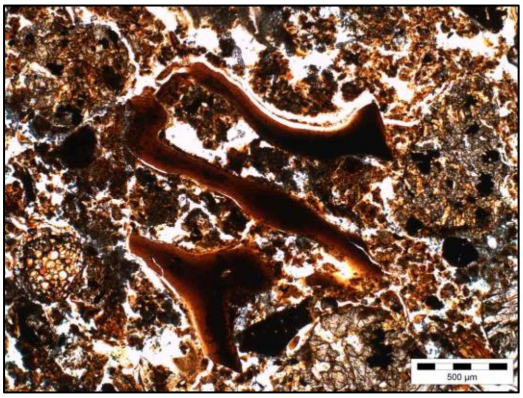


Figure 113: (Arnardalur Figure 12) charred bone material, 4x mag, PPL

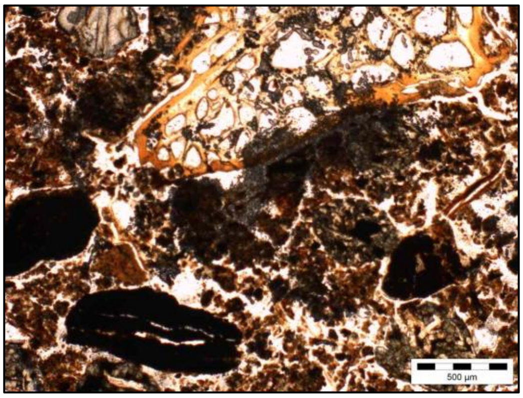


Figure 114: (Arnardalur Figure 13) lightly charred bone material, 4x mag, PPL

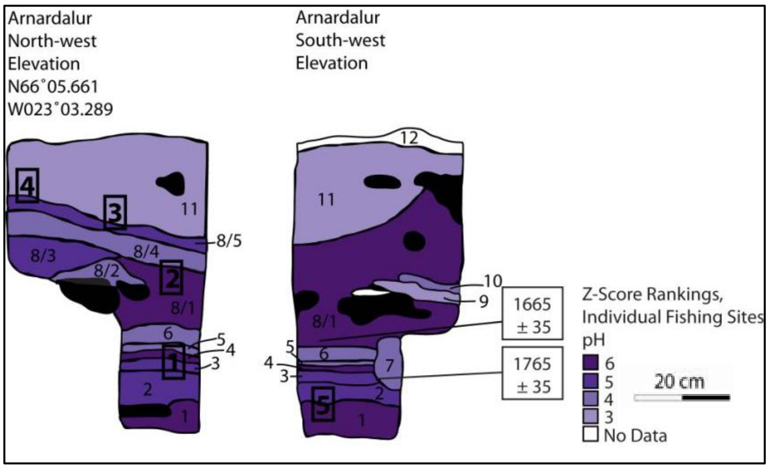


Figure 115: Arnardalur Intra-Stratigraphic Z-Score rankings of pH

Progressing into the overlying horizon 11, basalt grains were found alongside peat ash and turf residues, as plant material reduces in frequency reduce whilst fungal spores were consistent. The increased mineral component is reflected in the reduction of organic matter within soil horizon 11. Monolith 4, which mostly contains material from horizon 11, is almost uniform in its content, with an intimate mix of natural and anthropogenic features, including bone material in various states of preservation (Figure 116; Figure 117; Figure 118; Figure 119; Figure 120; Figure 121; Figure 122). The elevated levels of total P were a reflection of the degraded bone component. With the pH being more acidic than underlying soil horizons (Figure 115), this may have influenced bone preservation and provided a greater proportion of material in its conversion to solution. Distinct clusters of material show indication of site occupation and abandonment which have gathered together. The microstructure is predominantly crumb, with areas of subangular blocky representing periods of greater exposure. This is supported by the presence of iron nodule accumulations and plant material (Figure 123).

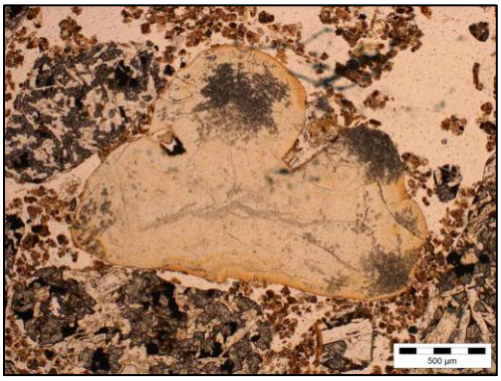


Figure 116: (Arnardalur Figure 14) unknown bone feature, 4x mag, PPL

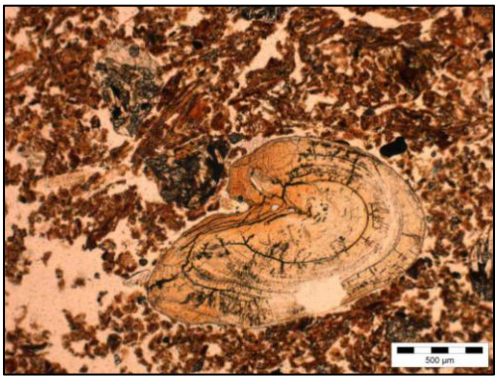


Figure 118: (Arnardalur Figure 16) fish vertebrae feature, 4x mag, PPL

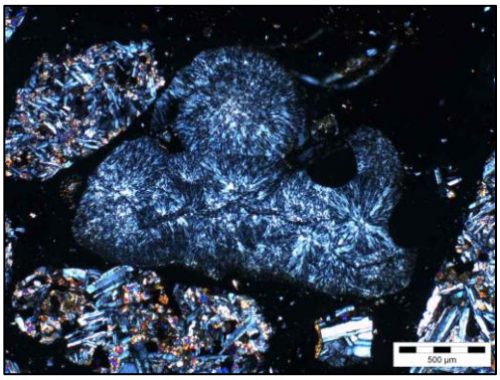


Figure 117: (Arnardalur Figure 15) unknown bone feature, 4x mag, OIL

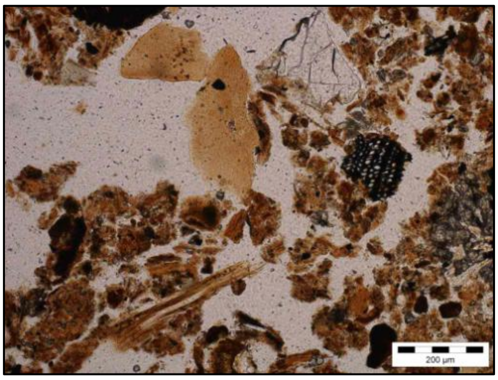


Figure 119: (Arnardalur Figure 17) bone degraded to solution, 10x mag, PPL

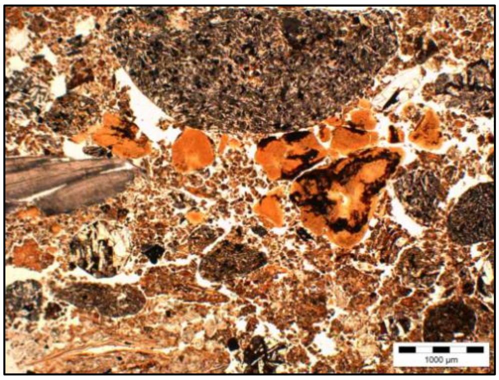


Figure 120: (Arnardalur Figure 18) fragmented and iron-influenced bone, 2x mag, PPL

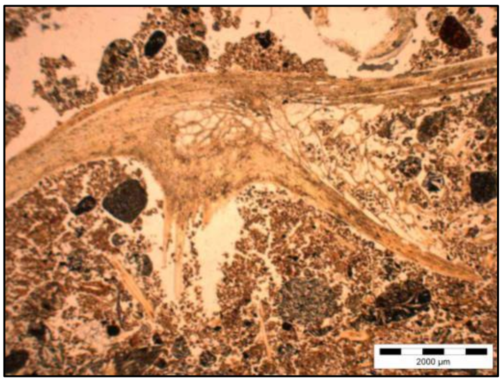


Figure 121: (Arnardalur Figure 19) well-preserved bone, 1.25x mag, PPL

Figure 122: (Arnardalur Figure 20) lightly fragmented bone with excremental material adjacent, 20x mag, PPL

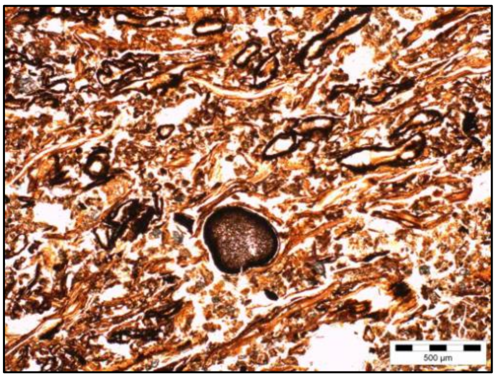


Figure 123: (Arnardalur Figure 21) plant material, 4x mag, PPL

What is observed at Arnardalur is a strong on-site presence, however, there is a vastly reduced volume of bone material intact within the thin sections compared to sites such as Skálavík. There is a recognition that this activity is from a later temporal period, which may indeed reflect the changes within the fisheries which took place between the eleventh and the eighteenth centuries.

Biskupsvík Case Study

The site at Biskupsvík reveals a stratigraphy containing a variance of horizon thicknesses, but revealing a site highly influenced by organic material originating from a nearby wetland. The site reveals an anthropogenic presence from its lowest horizons, which become less prominent moving up the stratigraphy. The soil textures, like many other fishing sites sampled, contain a dominant loam component, most of which were organic loams. 5YR 3/1 very dark gray and 10YR 3/1 very dark gray were the most frequent Munsell colours, with dark browns and reddish brown also present. It was only possible to obtain four samples for bulk soil analysis, however, the two monoliths obtained capture the lowermost five soil horizons. One radiocarbon assay was obtained from horizon 4, yielding an age of AD 1715 – 1785. This helps separate the stratigraphy in two, with soil horizons 1 and 2 showing activity before this date, and soil horizon 5 upwards revealing activity after.

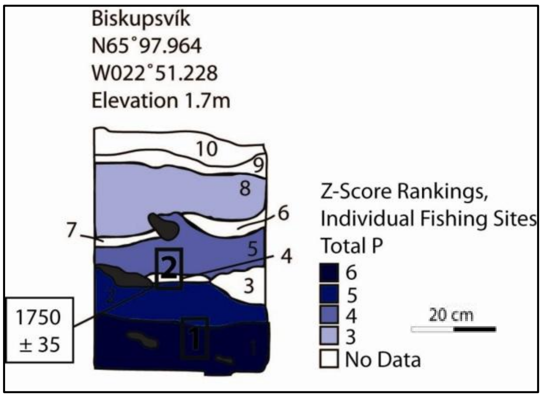


Figure 124: Biskupsvík Intra-Stratigraphic Z-Score rankings of Total P

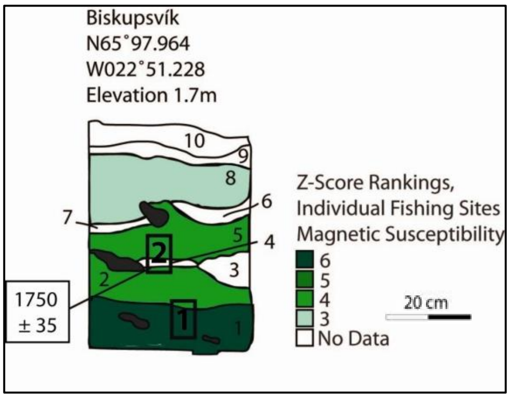


Figure 125: Biskupsvík Intra-Stratigraphic Z-Score rankings of Magnetic Susceptibility

The lowest part of the stratigraphy contains the highest levels of total P and magnetic susceptibility (Figure 124; Figure 125; Table 38), as well as the lowest levels of organic matter and most neutral pH compared to the rest of the site (Figure 126; Figure 127). The lowest part of monolith 1 (Table 37) reveals an organic-rich layer rich in single-orientation silicates. Plant remains were interspersed with peat and turf residues, as well as some bone fragments. The microstructure is a platy crumb, apparently influenced by the plant remains.

Table 37: Biskupsvík Thin Section Descriptions 1 & 2

Biskupsvík, 1 & 2

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section	Horizon	Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
2	7	t	t	1		2	t			Medium to dark brown PPL. Dark brown OIL.			2		2	1			t	t		t			Crumb	Moderately well sorted	Speckled	Enaulic
	6		t	t		2	t			Greyish brown PPL. Light medium brown with red flecks OIL.		1	1		1				t	t					Subangular blocky	-	Speckled	Enaulic
	5	t	t	t						Medium dark brown PPL. medium brown OIL.		3	1	1		1			t	1					Crumb	-	Speckled	Enaulic
	4	t	t	2		4	t			Medium brown with a hint of red PPL. Medium to dark brown mottled OIL.		2	1			1			t	t					Platy/subangular blocky	Moderately sorted	Speckled	Enaulic
	3	t	t	2		t	t			Medium brown with dark brown bands PPL. Medium reddish brown with dark brown OIL.		3	t	2					t						Platy crumb, more defined at lower part of the section	Well sorted	Speckled	Enaulic
	2	t	t	2		4				Medium to dark brown PPL. Compact medium to dark brown OIL.		3	2		2				t						Platy crumb	Well sorted	Speckled	Enaulic
	1	t		3		t				Medium to dark brown PPL. Medium to dark brown OIL.	t	2	2		2				t						Platy crumb	-	Stippled	Enaulic
1	4	2	t	t		t	t	yes	yes	Medium brown getting progressively darker PPL. Medium brown OIL.		t	2	t	2			t	t	1					Platy crumb	-	Stippled	Enaulic
	3	t	t				t			Light medium brown with dark inclusions PPL. Medium brown with some darker brown area OIL.		3	t						t	t					Platy crumb	-	Striated	Enaulic
	2	t		t		3	t			Light medium brown PPL. Medium brown with dark brown platy areas OIL.	t	3	2	t	1				t			t			Platy interspersed with crumb	-	Striated	Fine enaulic
	1	t		t		3	t			Medium brown with dark bands PPL. Medium brown with dark bands OIL.	t	3	t	1	3		t		1	t					Platy/crumb	-	Striated	Fine enaulic

Table 38: Biskupsvík Laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low Frequency	High Frequency
24	Biskupsvík H8	4.9	85.56	77.93	96.16	93.69
23	Biskupsvík H5	4.8	57.99	187.80	35.83	34.39
22	Biskupsvík H2	5.6	63.69	237.47	41.83	39.58
21	Biskupsvík H1	5.8	47.63	333.60	9.11	7.5

In the upper part of monolith 1, representing soil horizon 2, a reduction in the anthropogenic signature is noted with a drop in total P values and magnetic susceptibility. Excremental features were identified which may have an impact on structural integrity, however, the microstructure remains a platy crumb even where there were no signs of post-depositional disturbance. These were found alongside iron nodule accumulations, indicating possible exposed wetting and drying conditions. The lowest part of monolith 2 captures the upper part of soil horizon 2, and displays the same pattern of excremental features, iron accumulations, but with more in the way of plant material (Figure 128).

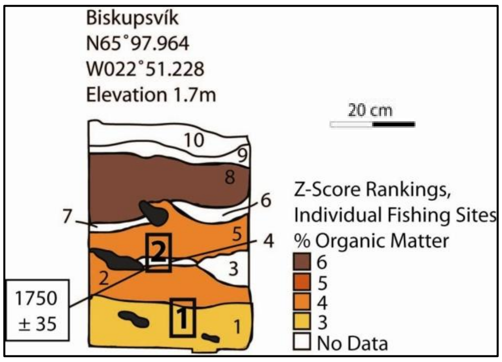


Figure 126: Biskupsvík Intra-site Stratigraphic Z-Score rankings of Percentage Organic Matter

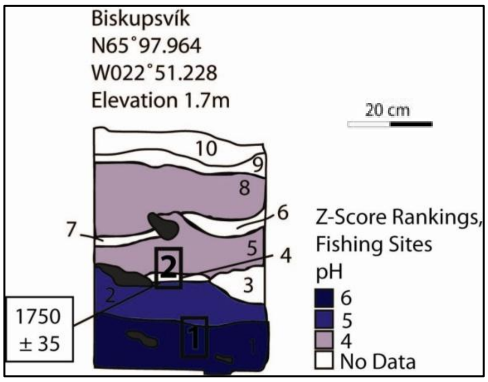


Figure 127: Biskupsvík Intra-site Stratigraphic Z-Score rankings of and pH

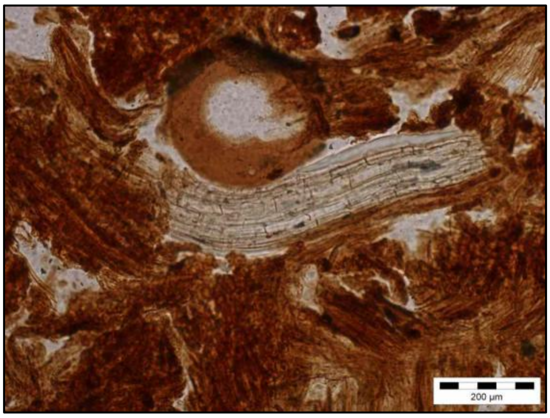


Figure 128: (Biskupsvík Figure 1) plant remains and accumulated material, 10x mag, PPL

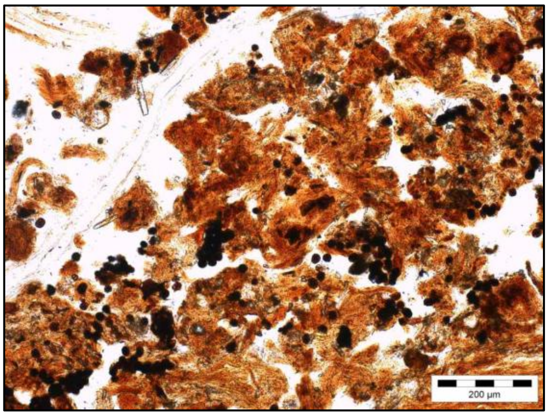


Figure 129: (Biskupsvík Figure 2) faecal material and iron nodules, 10x mag, PPL

Monolith 2 displays differing characteristics to monolith 1, in that it reveals distinct and abrupt changes at microscopic level. Despite horizon 4 not being sampled during bulk analysis, the reddish brown colours may indicate some level of direct anthropogenic influence, although this may also represent a build-up of iron material within the stratigraphy caused by the persistently wet conditions (Figure 129). Thin, distinct microstratigraphic horizons were observed, revealing alternating bands of fuel residues incorporating birchwood and turf remains, intimate mixes of bone material and fuel residues, and bands of unburnt peat material.

Where the sample represents soil horizon 5, the traces of bone material appear to be having an influence on elevating levels of total P. Magnetic susceptibility levels were close to the values found in horizon 2, suggesting a level of consistency between the two horizons. Progressing upwards in the monolith, turf residues drop in number, as the microstructure changes to subangular blocky, before returning to a crumb microstructure. The change here is very distinct, and represents rapid changes in on-site use.

Capping the stratigraphy is soil horizon 8, and despite not being represented under thin section, there is a clear drop in site use and intensity observed in the bulk soil analysis.

Here, the lowest anthropogenic influence is observed (Figure 130). Significant drops in soil magnetism and total P were observed, with the percentage of organic matter increasing to over eighty percent.

Table 39: Biskupsvík, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
24	Biskupsvík H8	0.91	48.69	32.2	14.6	3.6	130.4	63.85	2.545	7.829
23	Biskupsvík H5	0.00	45.5	28.3	16.9	9.3	192.1	75.96	2.222	4.886
22	Biskupsvík H2	0.61	45.79	30.7	14.5	8.4	178.5	72.05	2.539	6.792
21	Biskupsvík H1	0.00	48.0	29.2	15.5	7.3	164.8	68.09	2.440	6.705

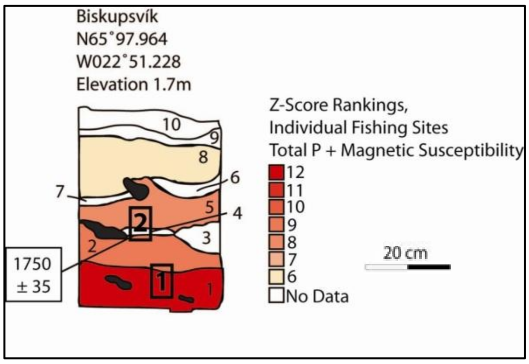


Figure 130: Biskupsvík Intra-Stratigraphic Integrated Z-Score rankings of Total P and Magnetic Susceptibility

Taking into account the similarities and consistencies between the two time frames, the findings within the stratigraphy at Biskupsvík show that site intensity was much higher prior to the AD 1715 – 1785 radiocarbon assay. After this period swift changes were observed, however, these periods of occupation were not to the same level as the earlier period.

Selvík Case Study

Selvík is a unique site as it is the only one sampled which reveals a stratigraphy rich in mollusc and shell remains. The stratigraphy is basic in that there were only four, clearly defined dark gray silty loam horizons, however, the shell midden is the dominant feature of the site. A radiocarbon age was obtained from soil horizon 2, which yields a date of AD 1310 – 1380 (Figure 131). This is the lowest horizon containing cultural material, and forms the basis for the interpretation that this site emerged in the fourteenth century.

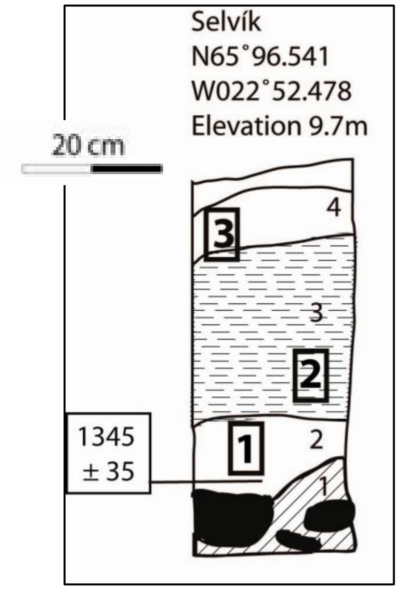


Figure 131: Selvík stratigraphy with position of C14 age

Soil horizon 2 contains the highest levels of total P and soil magnetism on site (Table 40), however, these figures were much lower than found at other fishing sites sampled. Shell material appears to have influenced the soil pH, with a mildly alkaline result obtained. Monolith 1 (Table 41), which is firmly within soil horizon 2, is an un-complex monolith dominated by unburnt organic material. The microstructure is crumb, indicating a swift period of deposition, which contains an intimate mix of iron accumulations, cellular material, plant residues, fuel residues and in some discreet areas, bone residues. The lower part of the monolith contains coated basalt grains (Figure 132), which suggest slow beginnings at the site before a prolonged period of use.

Table 40: Selvík Laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low Frequency	High Frequency
28	Selvík Horizon 2	7.4	34.10	179.10	224.39	213.11
27	Selvík Shell Horizon	7.6	27.53	152.55	196.72	188.11

Table 41: Selvík Thin Section Descriptions 1, 2 & 3

Selvík, 1-3

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures										
Section		Basalt	Feldspar	Calcite	Headed Stones	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Hyaline Dopplerites		Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
3	3	t		1		t	t	yes		Medium brown with dark brown patches PPL. Medium brown with reddish brown flecks OIL.	t	t	t	t				1	t						Subangular blocky	-	Speckled	Enaulic
	2	t	t	3			1			Medium brown with dark brown speckles PPL. medium to dark brown with red flecks OIL.		t	2	t											Crumb	Poorly sorted	Speckled	Coarse enaulic
	1	2	t	3		t	t			Medium brown but highly speckled PPL. Medium brown with pale flecks OIL.		3	2	3				1							Crumb	Unsorted	Speckled	Coarse enaulic
2	2	t	t				1	yes		Light to medium brown PPL. Dark brown with one light patch OIL.		3	2												-	-	Speckled	Poryphic
	1	t	t	3		2	2			Light to medium brown PPL. Medium to dark brown with yellow flecks OIL.	1		2	1					1			t			Crumb	-	Speckled	Poryphic
1	3	t	t			2	t			Light brown with dark brown clusters PPL. Dark brown with yellow streaks and flecks OIL.	t		t				1					t			Crumb	-	Speckled	Enaulic
	2	t	t			3	t	yes		Medium brown with light brown areas PPL. Dark brown with infrequent trace red flecks OIL.	2	t	t	1			2		t						Crumb	-	Speckled	Enaulic
	1	4	t							Medium brown with reddish brown patches PPL. Dark brown OIL.	t	t	t				1	1		t					Crumb	Well Sorted	Speckled	Enaulic

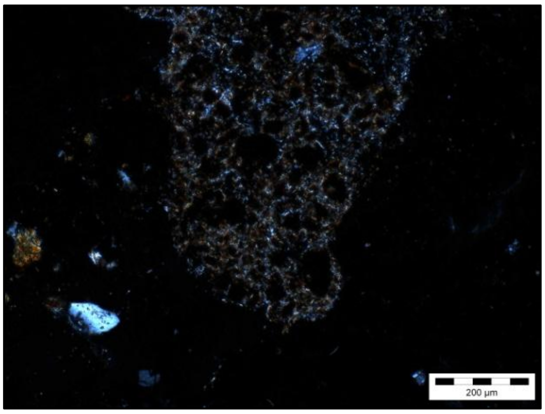


Figure 132: (Selvík Figure 1) Mineral material, 10x mag, XPL

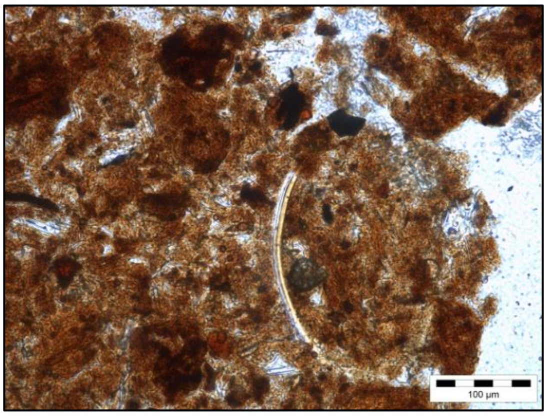


Figure 134: (Selvík Figure 3) Trace of fish bone and iron nodules, 20x, PPL

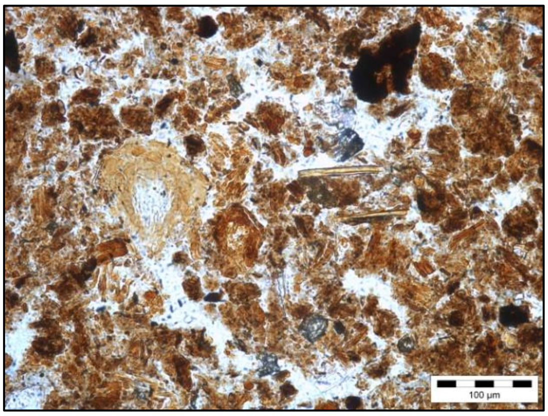


Figure 133: (Selvík Figure 2) Traces of bone in various states of degradation. 20x Mag, PPL

The shell midden, soil horizon 3, shows a reduced level of total P and soil magnetism, an above neutral pH and an elevated percentage of organic matter in comparison to the underlying horizon. The significant presence of molluscan remains is revealed in the monolith, alongside well-rounded calcareous material and traces of bone material. The void space around the shells were made up of crumbly soil material, however, there is an increased component of plant and organic remains which support the elevated organic matter figure. A few rubified flecks have found their way into the monolith, however, these were not found in a great number. The sheer volume of shell remains present suggests that during the fourteenth century, this site placed a lot of focus on obtaining molluscs for baiting.

Monolith 3 captures the uppermost part of the shell midden, and soil horizon 4 which has no bulk soil samples associated with it. Here, more in the way of bone and rubified fragments were observed (Figure 133), which ceases abruptly before a transition to an overlying organic horizon. The crumb microstructure suggests a swift deposit, before a subangular blocky microstructure takes over, indicating more in the way of prolonged periods of exposure. The organic layer which caps the anthropogenic horizon contains signatures of site abandonment, such as silicates, fungal spores, iron nodule accumulations and plant residues (Figure 134).

Table 42: Selvík, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
28	Selvík Horizon 2	1.86	69.84	28.6	0.6	0.0	50.32	36.76	1.562	2.371
27	Selvík Shell Horizon	0.00	62.2	26.2	8.9	2.7	96.37	43.77	2.815	8.053

In the absence of additional radiocarbon dates, it is not possible to temporally link the two horizons, whether they represent a continuous but changing occupation, or whether the shell midden was abandoned before re-occupation of the site at a later period. With the site at Biskupsvík, positioned within the fjord being re-occupied sometime in the eighteenth century, it may be that this site was re-occupied during times of necessity.

Vatnsfjörður Booth Case Study

The Vatnsfjörður Booth site reveals a differing stratigraphy, with distinct horizons of well-rounded shell material present at two of the four horizons. Dark reddish brown and reddish brown Munsell colours were recorded, with the soils being sandy loam and silty loam. No radiocarbon age was obtained from this site, however, a piece of wood which had been mechanically faced and had a galvanised nail through the end piece relatively dated the boundary of soil horizons 1 and 2 to sometime in the twentieth century.

Soil horizon 1, which was represented in the lower part of monolith 1 (Table 45), reveals elevated levels of total P and soil magnetism, but nothing in the way of bone material. The influence of the overlying horizon is striking, and throughout the rest of the monolith well-mixed, well-rounded calcareous material dominates alongside shell remains. Where soil fragments do appear, rubified anthropogenic material is observed in the form of fuel residues and bone material. One instance of unburnt turf is observed, with a growing representation of silicates found in the uppermost part of the monolith. This uppermost part is represented by soil horizon 2, which reveals a comparative drop in total P and soil magnetism compared to the underlying soil horizon (Table 43).

Table 43: Vatnsfjörður Fishing Booth Laboratory Results (pH, organic matter, phosphorus and magnetic susceptibility)

Bulk Sample ID	Context	pH	% Organic Matter	Total P	Mass Specific Susceptibility	
					Low Frequency	High Frequency
26	Vat Fish 2	6.8	32.66	143.85	78.59	78.00
25	Vat Fish 1	7.2	17.60	221.21	126.75	125.64

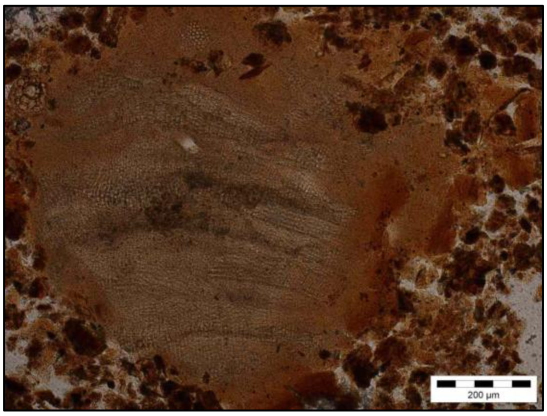


Figure 135: (Vat Booth Figure 1) patterned material converting into solution, 10x mag, PPL

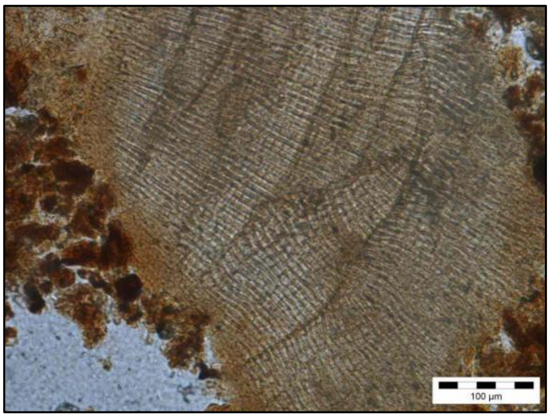


Figure 136: (Vat Booth Figure 2) shell-like material, comparable to figure 5, un-degraded, 20x mag, PPL

Monolith 2 captures the uppermost part of soil horizon 2 as well as parts of horizons 3 and 4. The lowest part is dominated once more by calcareous material (Figure 135; Figure 136), but this time more within a dark matrix of soil material. Flecks of fuel residues have found their way into the matrix, which is largely unrubified. There appears to be a greater level of site exposure, with distinct areas of subangular blocky material (Figure 137) revealing iron nodule accumulations, as well as swift crumb deposits alongside. Nematodes and excremental features reveal potential post-depositional disturbance (Figure 138).

Table 44: Vatnsfjörður Fishing Site, Particle Size Distribution

Bulk Sample ID	Context	Percentage Fraction					Mean	Median	Skew-ness	Kurtosis
		<2 µm	2-63 µm	63-212 µm	212-630 µm	630-2000 µm				
26	Vat Fish 2	0.75	58.65	24.1	9.1	7.4	155.4	44.39	3.093	9.649
25	Vat Fish 1	2.01	55.39	21.0	8.5	13.1	200.8	47.89	2.092	3.226

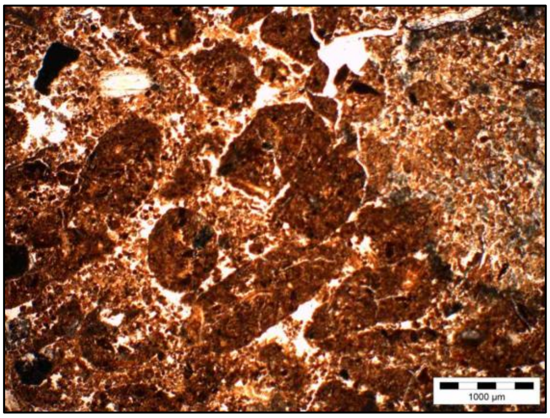


Figure 137: (Vat Booth Figure 3) subangular blocky microstructure with crumb inclusions, 2x mag, PPL

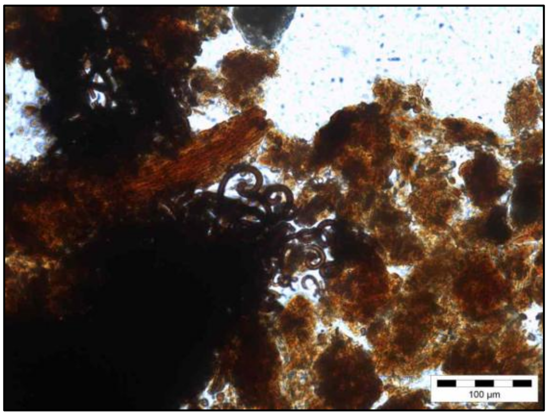


Figure 138: (Vat Booth Figure 4) nematodes amongst a darker brown matrix, 20x mag, PPL

The observed crumb areas show distinct patterns of rubification, with traces of bone and fuel residues found throughout typically amongst plant residues and silicates. The uppermost part of the monolith reveals a dominant calcareous horizon, with the occasional area of organic soil, plant material (Figure 139), unidirectional silicates and

Table 45: Vatnsfjörður Booth Thin Section Descriptions 1, 2 & 3

Vatnsfjörður Booth, 1-3

		Coarse Mineral Material									Coarse Organic Material			Fine Organic Material				Pedofeatures									
Section	Horizon	Basalt	Feldspar	Hornblende	Calcareous/Shell	Silicates	Bone	Bone Specific (Fish)	Bone Specific (Mammal)	Fine Mineral Material	Fungal Spores	Plant Material	Cell Residues	Charcoal	Amorphous (Black)	Amorphous (Brown)	Amorphous (Reddish Brown)	Textural Coatings	Iron Accumulations	Excremental Pedofeatures	Calcium-Iron-Phosphates	Yellow Infills	Nematodes	Microstructure	Coarse material arrangement	Groundmass B fabric	Related distribution
3	1	2	t		3	2	2			Medium brown with red/brown patches PPL. Dark brown with occasional red flecks OIL.	t	1	t						1		t	t		Subangular blocky	Moderate	Speckled	Enaulic
2	3	2			2	3				Medium brown PPL. Dark brown with distinct bands OIL.		2	2	t					t		t			Subangular blocky	Moderate	Speckled	Enaulic
	2	2			t	3	t			Medium brown with darker inclusions PPL. Dark brown with occasional lighter flecks OIL.		3		1					t				t	Subangular blocky	Moderate	Speckled	Enaulic/ Poryphic
	1	3	t		3	2	t			Medium to dark brown PPL. Dark brown OIL.		1	t	t					2	1		1		Angular blocky	Moderately sorted	Speckled	Enaulic
1	3	2	t		4	3	t			Medium brown PPL. Medium to dark brown with red flecks OIL.		t	t	1					t	t				Crumb	Moderately well sorted	Speckled	Enaulic
	2	3			3	3				Medium brown PPL. Dark brown OIL.		2	t	t								t		Granular	Unsorted	Speckled	Enaulic
	1	2	t	t	4	t				V. Little. Medium brown with red areas PPL. Dark brown OIL.		t	t						t					Crumb	Well Sorted	Speckled	Poryphic

iron material. These features suggest a period of prolonged abandonment and coastal activity and inundation which would have covered the site during periods of inactivity.

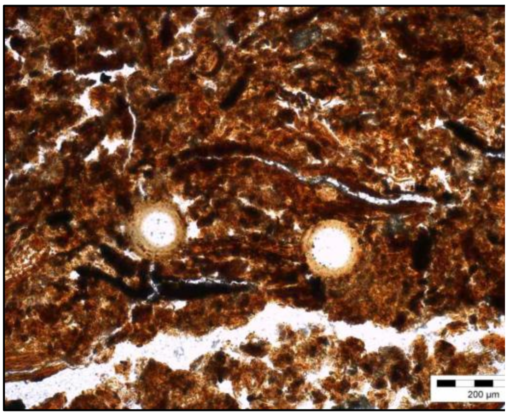


Figure 139: (Vat Booth Figure 5) nodules of P amongst plant residues

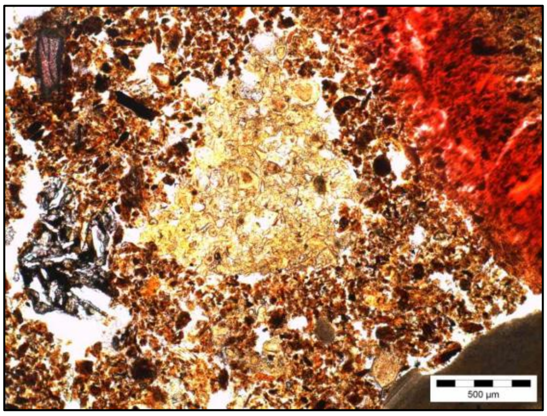


Figure 140: (Vat Booth Figure 6) P infill amongst crumb matrix

The uppermost monolith, sampling from soil horizon 4 which is not represented in the bulk soil analysis, reveals a persistent mix of calcareous material, with some plant material and shell remains throughout. The predominantly crumb microstructure indicated a period of swift deposition (Figure 140), however, areas of subangular blocky material suggest this accumulation pattern is intermittent.

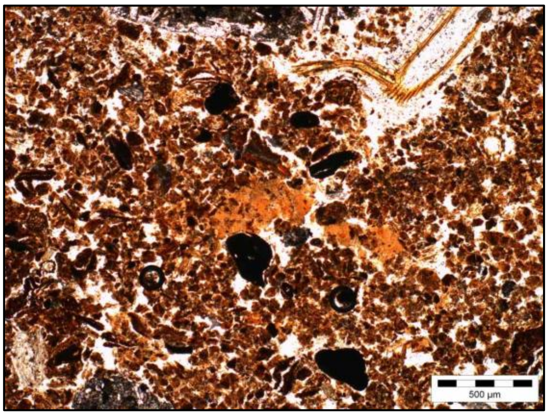


Figure 141: (Vat Booth Figure 7) iron inclusions, 4x mag, PPL

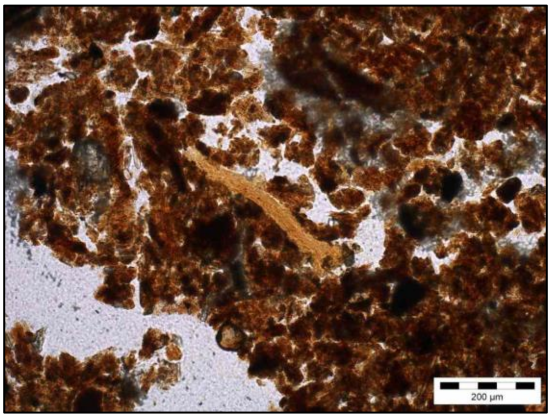


Figure 142: (Vat Booth Figure 8) fragmented bone, 10x mag, PPL.

A few iron nodules find their way into the monolith (Figure 141), as do traces of bone material in both rubified and unrubified states (Figure 142; Figure 143; Figure 144;

Figure 145; Figure 146; Figure 147; Figure 148). This would suggest a period of domestic occupation influencing the stratigraphic deposits.

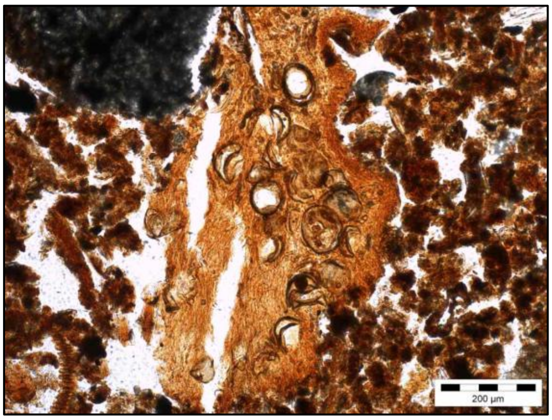


Figure 143: (Vat Booth Figure 9) Organic matter, 10x mag, PPL

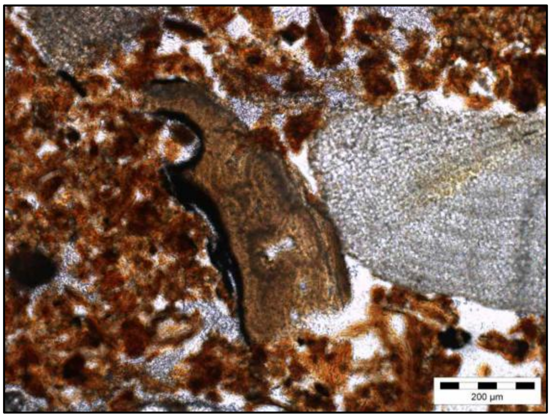


Figure 144: (Vat Booth Figure 10) burnt bone, 10x mag, PPL

Figure 145: (Vat Booth Figure 11) burnt bone, 10x mag, OIL

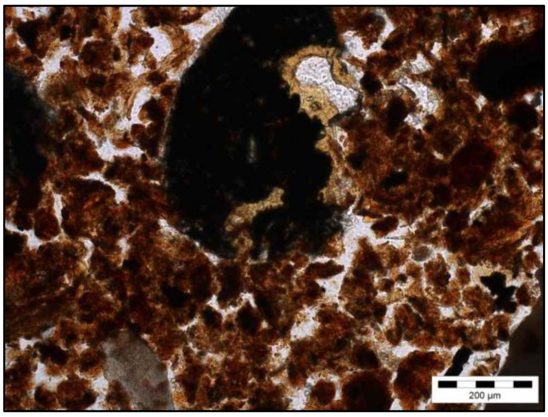


Figure 146: (Vat Booth Figure 12) burnt material with P infill, 10x mag, PPL

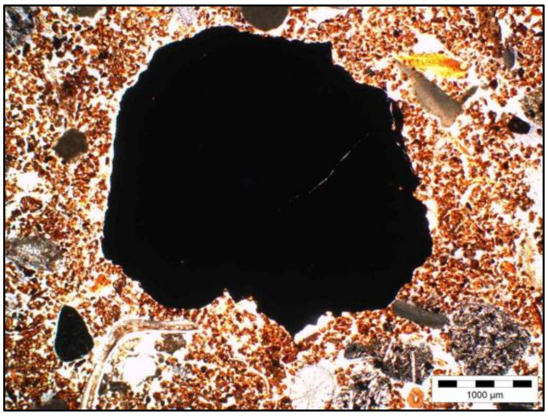


Figure 147: (Vat Booth Figure 13) burnt material, 2x mag, PPL

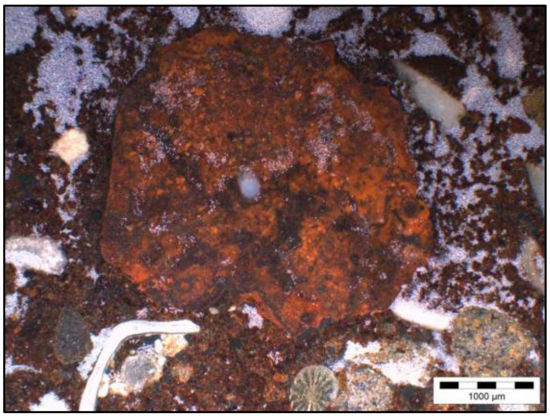


Figure 148: (Vat Booth Figure 14) burnt material, 2x mag, OIL

Fishing Sites – Group Analysis

As mentioned previously in this chapter, the fishing sites when analysed as a collective display interesting correlations between magnetic susceptibility and total P, magnetic susceptibility and organic matter, and total P and pH. By analysing the sites directly within the context of each other, it brings with it a more intimate narrative and permits stronger discriminations within values which may otherwise not have emerged when set against a different scale. The findings reveal strong associations with anthropogenic activity, and also environmental conditions which influence sites which contain elevated proportions of bone material in midden formations.

The most elevated values of total P were found predominantly at Skálavík 1, 2 and 3 (Figure 149). The most intense horizons were found around AD 1050 – 1110 at Skálavík 1, and between AD 1280 – 1340 and AD 1545 – 1605 at Skálavík 3. The lowest levels were associated with Vatnsfjörður booth and the upper horizons of Selvík and Biskupsvík, which interestingly also contain elevated values of organic material within the horizon.

The strongest signal of soil magnetism amongst all fishing sites can be found at Skálavík 1, in the horizons associated with the period of time immediately after AD 1050 – 1110 (Figure 150). This corroborates well with the findings from the thin section analysis, revealing a highly intense phase of occupation sometime in the twelfth century. The lowest values can be found at Biskupsvík, throughout the stratigraphy. This supports the documentary evidence that the site was never used in any specialist capacity, only for subsistence purposes.

Organic matter levels display their highest values at Biskupsvík (Figure 151). Once more, the role of the site as a subsistence base and the reduction in intensity would allow organic matter to grow, however, on this occasion the very high values of organic matter recorded were more than likely directly linked with topographical positioning, adjacent to a wetland plateau. Lowest values of organic matter were found in the lowest horizons of Arnardalur, which may be a reflection of the mineral material which makes up the horizon adjacent to the beach stratigraphy.

Soil pH is most neutral and mildly base at Selvík (Figure 152). The volume of calcareous material observed in the field and under thin section appears to have a strong influence on neutralising the stratigraphy. Vatnsfjörður booth also displays the same characteristics through its influence from calcareous material. The most acidic soils were recorded at Skálavík 1, loosely matching the periods of increased industrial intensity. The lower pH would assist in the degradation of bone material, elevating levels of total P and enhancing the cultural signature within the soil.

When the magnetic susceptibility and total P z-scores were integrated, there were two distinct phases of strong anthropogenic occupation (Figure 153). The first one is between horizons 5 to 9 at Skálavík 1, particularly around the period at the beginning of the twelfth century. The second one is at Skálavík 2, in a horizon positioned between the fourteenth and sixteenth century AD radiocarbon dates. The latter horizon may, however, be influenced by the iron pan feature, identified in the field. The uppermost horizon of Biskupsvík and the lowest horizons of Arnardalur and the Vatnsfjörður booth display the lowest values of anthropogenic influence. As expected, the former location comes at a period after abandonment, and the latter two base layers positioned immediately above a rocky substrate.

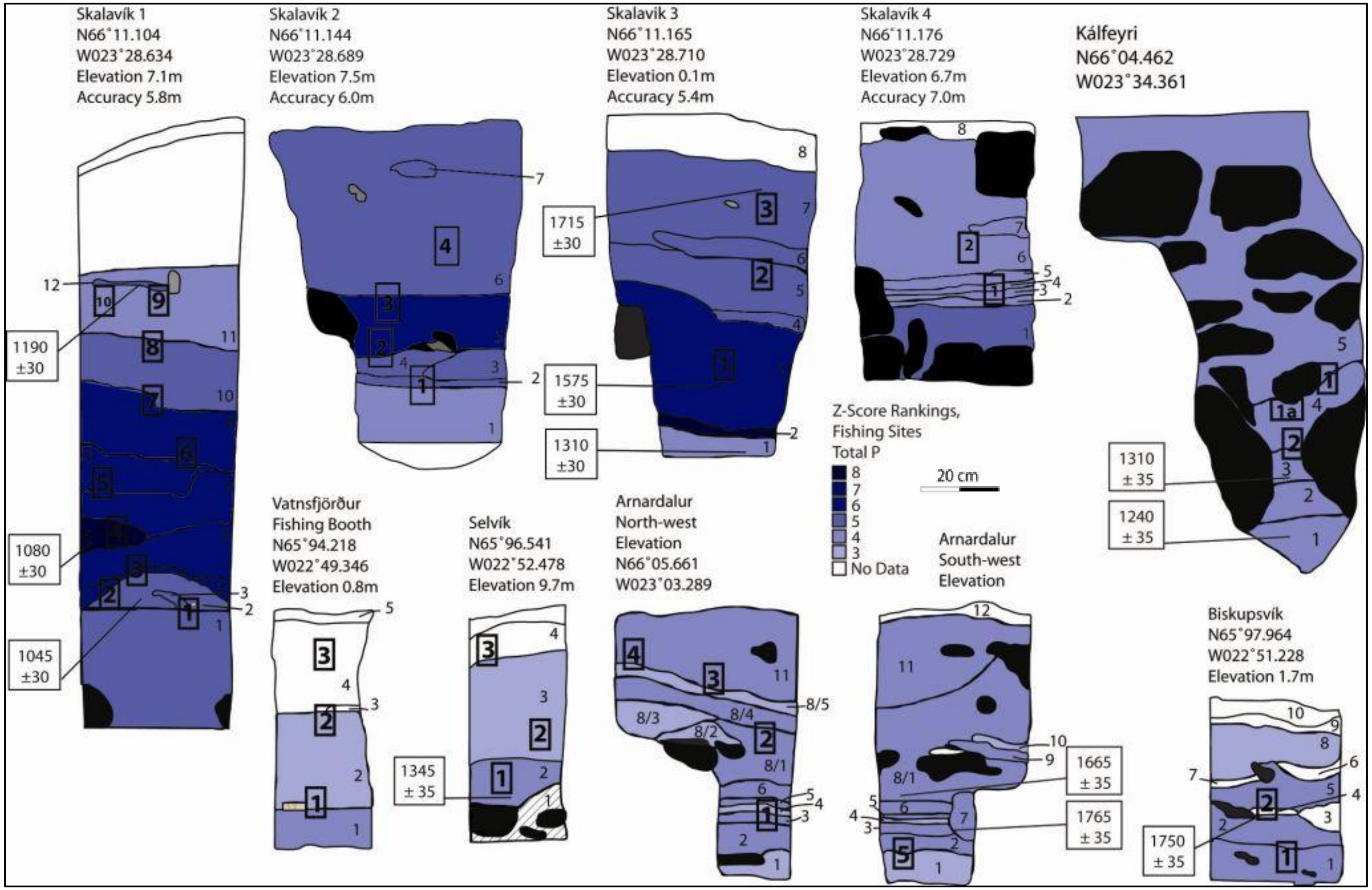


Figure 149: All Fishing Sites, Total P Comparative Analysis

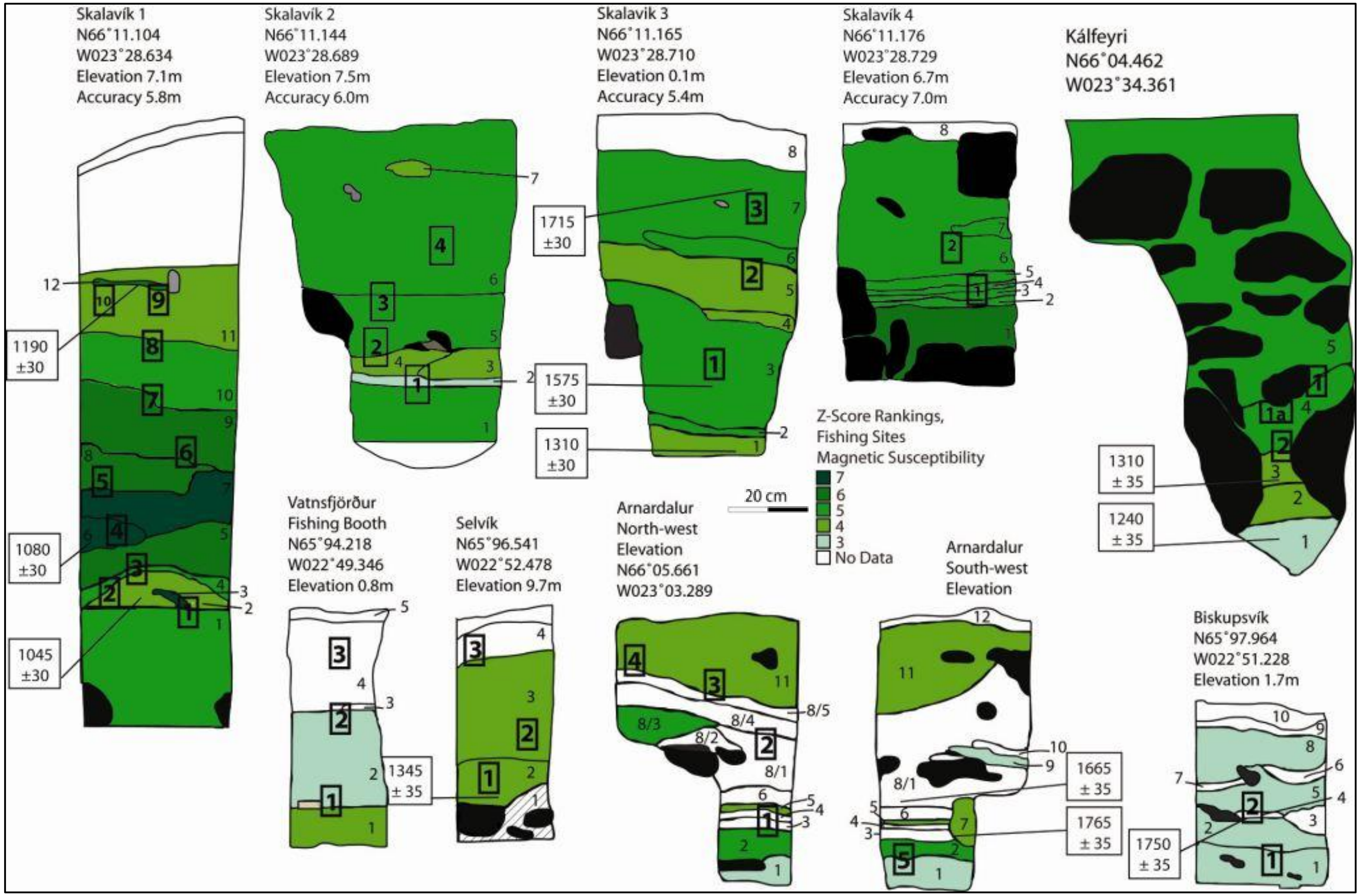


Figure 150: All Fishing Sites, Magnetic Susceptibility Comparative Analysis

Results Summary

The sites sampled share some common features as regards to some of the identified environmental and cultural features. At the most intensively occupied fishing stations, elevated levels of total P were accompanied with higher proportions of bone material under thin section, and to an extent, elevated levels of magnetic susceptibility associated with domestic wastes produced at occupied sites. During periods of site absence, the opposite of this can be observed from features such as a high presence of iron features, plant growth, single-direction silicates associated with vegetation growth and fungal spores. When sites were thought to have been abandoned for prolonged periods of time, there were greater frequencies of sand grains, associated with material being brought in from the sea. It is unknown as yet whether these accumulations can be attributed to significant coastal storm events, or whether the inundation of sand blow material is a low accumulation allowed to form when there is no activity on the site which would otherwise remove them from any future stratigraphy.

There is no one standalone variable which can be used as a proxy for a natural or environmental presence on the site given the nature and complexity of the processes which take place and the selection of methods used. Save for a rise in the proportion of sand particles in the particle size analysis, there can be no defined characteristic. The presence of abandonment features such as iron nodules, plant material, fungal spores and silicates can give an indication of site absence, however, their presence is often characterised by being sandwiched between two anthropogenically-influenced contexts.

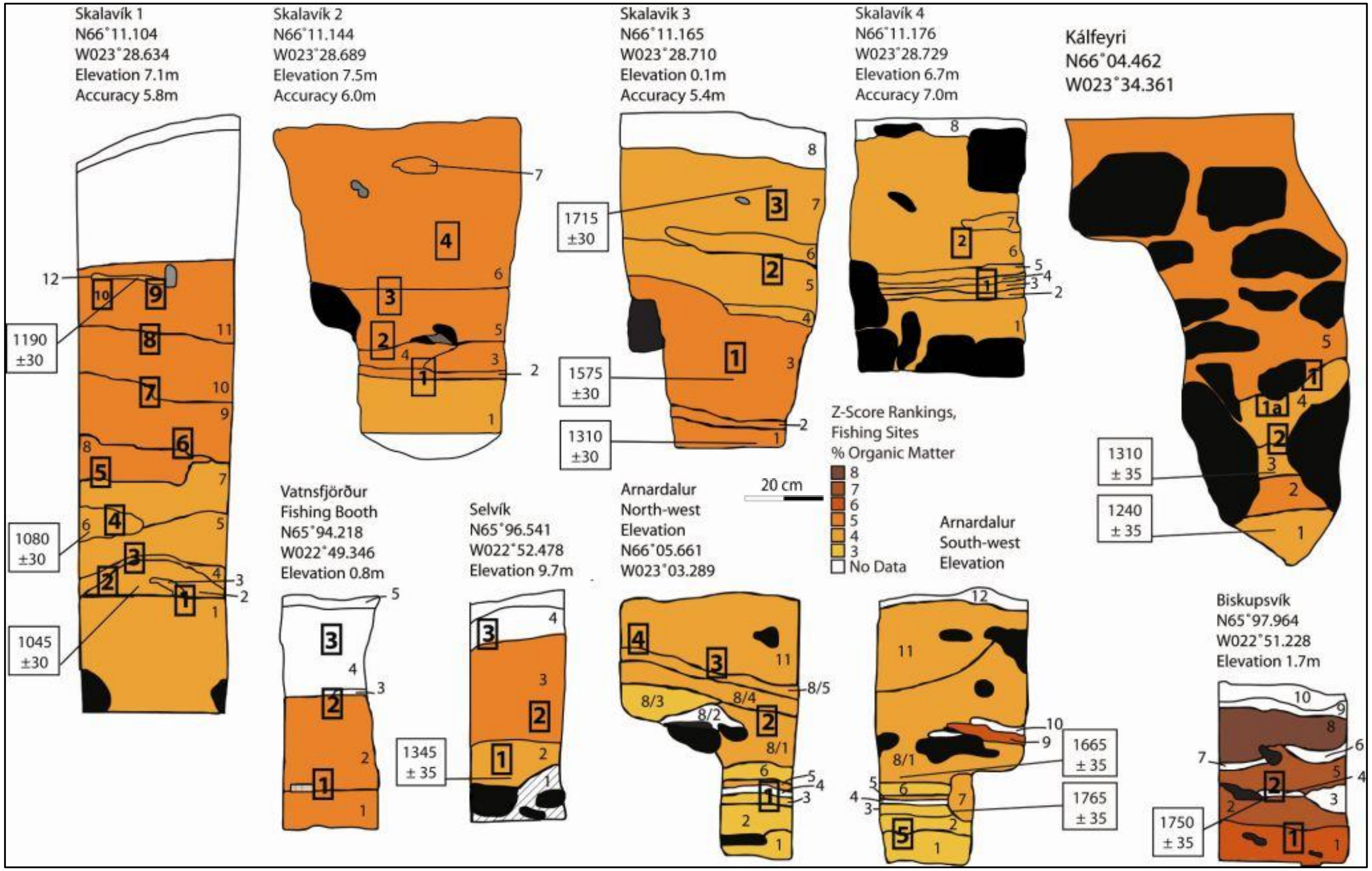


Figure 151: All Fishing Sites, Organic Matter Comparative Analysis

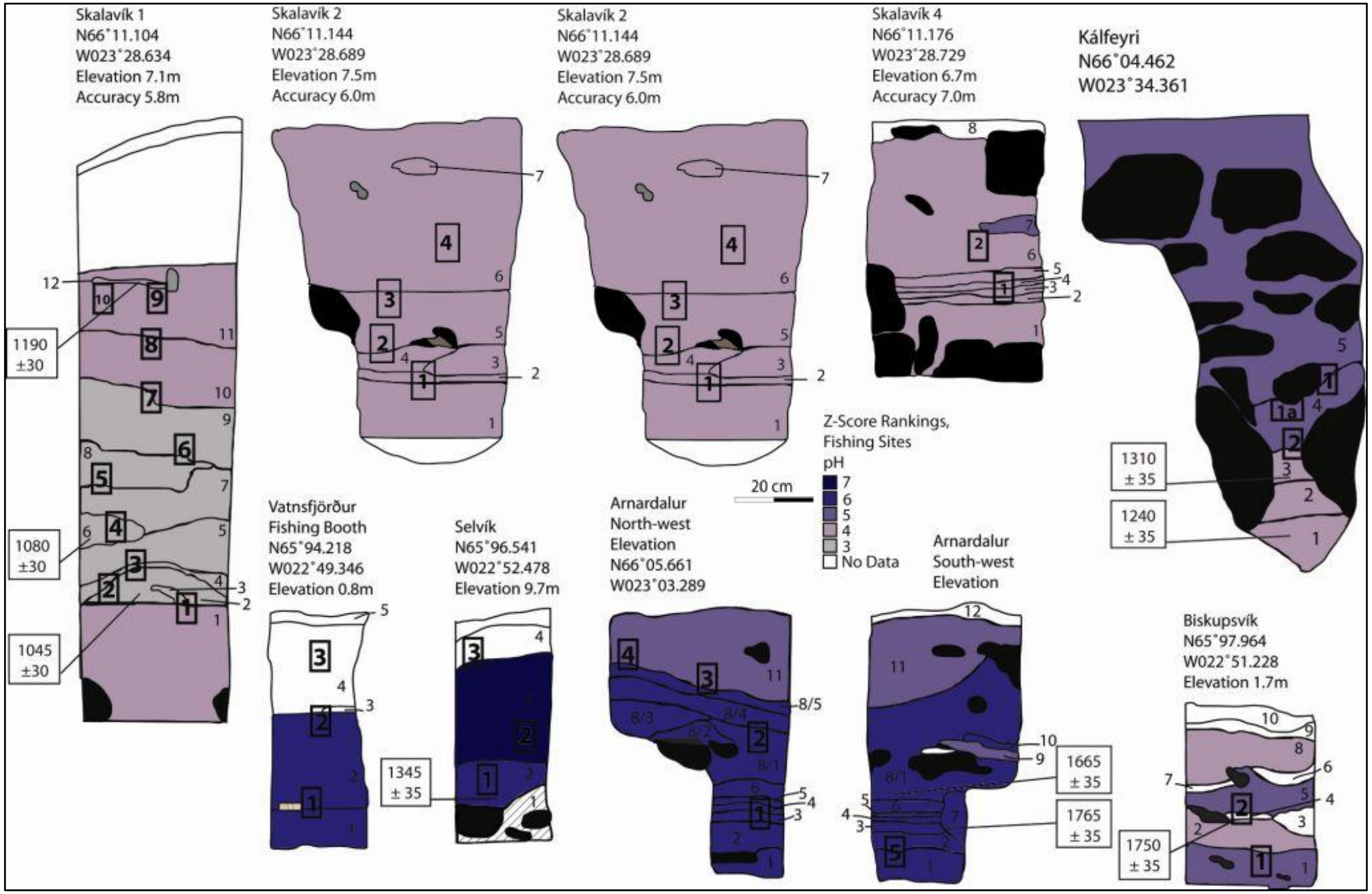


Figure 152: All Fishing Sites, pH Comparative Analysis

The important material from this chapter to take to chapter five is the patterns of occupation and degrees of intensity at particular stratigraphic areas. These can now be tied closely with the wider historiographical narrative, and generate a more relevant region-specific account of activity taking place around the coasts of Vestfirðir.

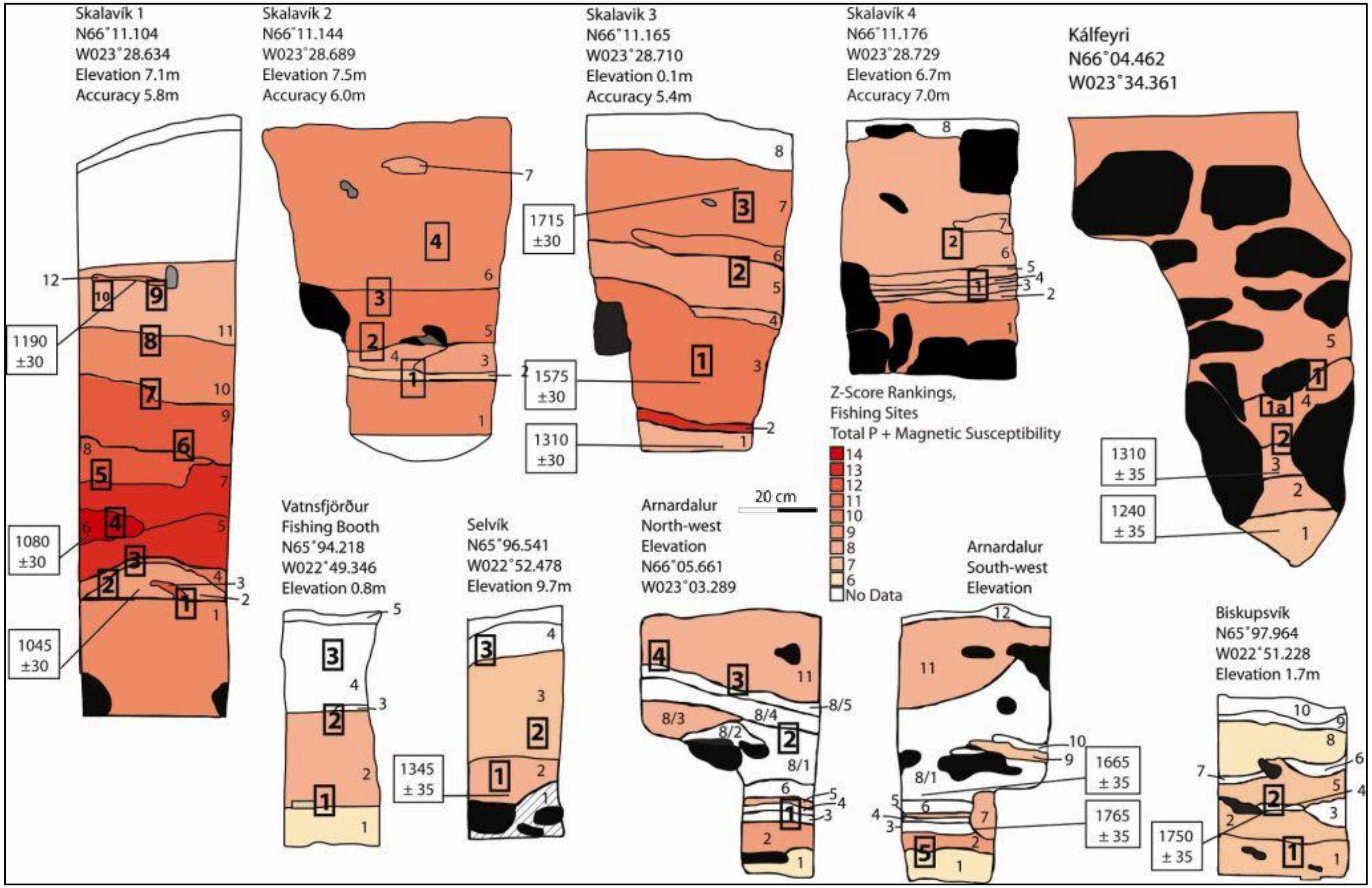


Figure 153: All Fishing Sites, Integrated Total P and Magnetic Susceptibility Comparative Analysis

Chapter Five – New Insights into Fishing Community Development in Iceland: an Integration of Historiography and Geoarchaeology

The purpose of this chapter is to chronologically integrate the historiography from chapter two and the results of the geoarchaeological investigations and assessment from chapters three and four, to generate a revised assessment of how fishing communities in Iceland emerged and evolved. Each site has already been subject to individual analysis, as well as analysed as a collective based on their interpreted use, whether this be fishing or farming. By now taking an integrated chronological approach, a new model can be developed allowing similarities and differences within sites, regardless of their temporal period or specific function, to be discussed over the course of time. The chapter begins by the establishment of a chronological framework taken from data presented in chapter four, providing a visual guideline to be taken throughout the chapter. From this position, the research and findings can be placed into the broader environmental history narrative. Chapter four provided a site-by-site narrative, and the patterns which have emerged as a result of this analysis has revealed distinct chronological phases, from which a basis for discussions relating to the historical environment, and how these phases reflect anthropogenic and environmental changes and responses over the course of time. The phases of occupation, abandonment, intensity and how they were related (or unrelated) to the historiography will be discussed in depth, with a summary at the end of the chapter. Emphasis will be placed on revealing and developing these key points and trends, particularly where there were similarities and differences with the historiography, existing environmental record and prevalent environmental themes.

By integrating the narrative in such a manner, a new and greater understanding can be obtained at a variety of levels. Firstly, a new understanding of specialist fishing sites can be obtained. The collation of material to form the historiography provides a general, almost national overview. The newly developed geoarchaeological analyses of Icelandic fishing communities can provide a perspective relating to the Vestfirðir region as well as the individual sites. By synthesising these methods, it allows for the varying degrees of information resolution to be appreciated and understood, ultimately providing a new and completely revised and more detailed narrative relating to the cultural heritage in this maritime-rich region. On a wider scale, Vestfirðir can be understood as part of a wider economic and environmental unit, however, this will benefit from expansion in the future into other regions of Iceland. The findings can be placed in a global context, and will contribute towards the understanding of responses to environmental change. The models and theories developed here can add to the growing discussion on environmental change, and how we as humans can look to the past to see how we responded to changes in the environment, and the associated impacts, consequences, successes and failures which may be related to.

The timeline below (Figure 154) reveals several distinct phases relating to periods of occupation and abandonment of fishing stations over time. First is the initial settlement period around the ninth century at Vatnsfjörður farm, second is the emergence of fishing stations from the eleventh until the fourteenth century AD, and thirdly, is the period of abandonment in the sixteenth and seventeenth centuries AD, and fourthly, after a period of inactivity, the re-emergence in the seventeenth and eighteenth centuries AD. It is from this framework that the narrative can be developed, providing additional context and dimensions to a newly constructed chronology. These distinct phases will be discussed in depth, and comparisons drawn within each of them relating to the sites involved.

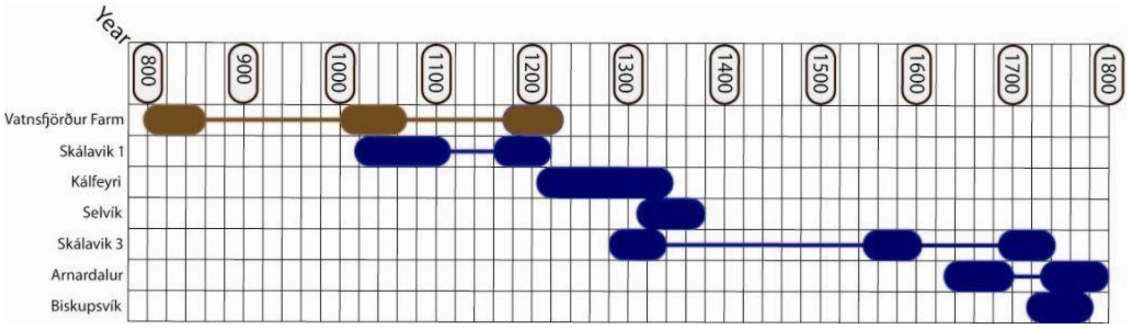


Figure 154: Timeline of Calibrated Radiocarbon Ages, All Sites

Vatnsfjörður Farm – Earliest Occupation

The earliest radiocarbon age obtained from Vatnsfjörður farm corroborates with early documentary evidence from *Landnámabók* and previous excavations of the longhouse at Vatnsfjörður that it was one of the earliest settled farm sites in Iceland.[577] These same early documentary sources often refer to Iceland as being wooded from hilltop to shoreline,[578] and despite there being an added element of exaggeration and myth regarding this statement, the fuel residues around this time and through subsequent centuries reveal that there was a change in vegetation coverage. Monolith 1a, which comes from the lowest part in the Vatnsfjörður stratigraphy, reveals a higher yet steady proportion of charcoal within the deposited wastes. Monolith 1, however, which cuts through the soil horizon dating to AD 1000 – 1070, reveals more in the way of turf residues. This, in turn, can firstly be interpreted as representing broader environmental and secondly, potential changes which were taking place within the environment of Iceland around AD 1000, possibly reflecting additional changes within society driving this modification.

577 Edvardsson & McGovern, 'Archaeological Excavations at Vatnsfjörður 2003-04'; Fornleifastofnun Íslands, 'Fornleifarannsókn í Vatnsfirði við Ísafjarðardjúp sumarið 2004'.

578 *Landnámabók*.

With more in the way of charcoal being identified lower in the stratigraphy, this suggests early access to woodland or scrub, but it is impossible to differentiate whether this reflects the abundance of combustible material through woodland clearance, or that wood was an everyday source of fuel for the inhabitants of Vatnsfjörður. Whatever the process of selection, early Icelanders were instantly modifying their contextual environment upon arrival, with the landscape combined with the resources brought with them allowing successful settlement. Bone is identified in rubified and unrubified states, indicating the butchering, processing and dumping of domestic wastes on site. With the fuel residues being intermixed with bone material, this indicates that wastes were being brought together and directly dumped on to the midden, rather than being recycled and redistributed as fertiliser within the homefields. This could potentially reflect their lower value in this new landscape. The practice of redistributing wastes back into the soil to increase the soil nutrient value was a common practice throughout Western Europe (since long before the Norse expanded westwards). Within these farm mound wastes is evidence of high and low-temperature burning,[579] revealing materials being burnt at temperatures associated with more industrial (versus domestic) temperatures mixed in with the general domestic midden deposit. These higher temperature fuel residues can be expected, as a smithy has been identified in the previous archaeological investigations at Vatnsfjörður.[580]

The early period of non-recycling of fuels may reflect the wider picture and attitudes in post-*Landnám* Iceland. Settlers would have known about the benefits of adding wastes to soils from their homelands, however, it strongly appears that wastes were just finding their way to the midden. Early Iceland was viewed as a land of plenty. There is one Saga

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[579] Simpson *et al.*, 'Fuel Resource Utilisation in Landscapes of Settlement'.

[580] Edvardsson & McGovern, 'Archaeological Excavations at Vatnsfjörður 2003-04'.

tale of livestock perishing during their first winter as the individual concerned was too busy fishing.[581] By having an abundance of naturally available resources within the island and plenty fish around its coasts, as well as having the benefit of allowing the imported livestock to flourish and graze on the newly cleared areas of the landscape, there may have been no immediate need to add to the nutrition of the land and fertilise the homefields given the sufficient availability of resources. The absence of a requirement for adjustment of the landscape fertility would indicate a society living within the threshold and capacity found within Iceland, and any degradation or shortfall was made up from elsewhere.

The change in types of fuel being burnt after a short period of time could reflect a change in both the society and environment concerning Vatnsfjörður. The transition from charcoal to turf and the occasional use of peat sometime in the ninth and tenth centuries could reveal the absence of access to woodland to acquire material for burning. Interpretation of this may be complex, as there may have been woodland available, but not for the use of those occupying the site or not for the purpose of burning. Given that Vatnsfjörður was one of the richest sites in early Iceland,[582] this may not be the case. It is more likely that the change in fuel being burnt was a shift in the availability of resources. Pollen evidence shows shifts in the vegetation composition in Iceland shortly after *Landnám*,[583] with woodland resources declining sharply.

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581 *Landnámabók*.

582 Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland'.*

583 R. Barclay, E. Tisdall, R. McCulloch & I. Simpson, *Pollen Analysis of the Wet Meadow at Vatnsfjörður, in* Milek, K. (ed.) Vatnsfjörður 2009: Interim Reports, Fornleifastofnun Íslands FS499-03099, (Reykjavík, 2009).

Archaeological evidence reveals that Vatnsfjörður underwent a period of structural modification and possible site reorganisation sometime in the tenth century.[584] This structural transition may have induced, or have been induced by, wider changes taking place across environment and society. There is an architectural trend across Iceland around AD 1000 which suggests larger structures were being phased out and replaced by smaller designs, thought to have been driven by practical reasons;[585] it is a lot easier to heat a small structure than a fifty metre longhouse which in turn would require less fuel for burning and less material for maintenance. Turf structures were generally required to be replaced every seven to ten years,[586] meaning the change to smaller dwellings would have been a progressive decision and not a case of instantaneous destruction and reconstruction of a new, smaller dwelling. With changing fuel resource use and availability, reflected in both the pollen and micromorphological record, this theory brings with it justification.

The correlation diagram in chapter four shows a highly significant association between soil magnetism and total phosphorus. High levels of total phosphorus in the lowest horizons alongside comparatively lower levels of soil magnetism indicate that this elevated value did not solely originate from the remains of burnt material. This may reflect the early availability of marine resources and the subsequent dumping of associated wastes on to the midden, however, with preservation conditions far from ideal, only fragments of bone material remain. The association demonstrates that this methodology can be used to establish levels of bone input into the soil stratigraphies.

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[584] Edvardsson, '*The role of marine resources in the medieval economy of Vestfirðir, Iceland'.*

[585] G. Lucas, '*Hofstaðir; Excavations of a Viking Age Feasting Hall in North-Eastern Iceland',* (Reykjavík, 2009).

[586] Oram, personal communication.

Depositional patterns change in the temporal period between AD 790 – 860 and AD 1000 – 1070, where there begins to be distinct bands of material appearing on the midden. Standstill features which have been identified may represent movement across the midden in terms of deposition patterns and the location of deposited material on the surface, rather than an absence of material being generated and deposited. Fuel residues have by this time changed from the dominant charcoal to a mixture of charcoal, willow wood, peat and turf. The soil chemical records display an interesting transition towards the end of this temporal period, with a proportional increase in soil magnetism and reduction in total phosphorus. With the pH being more acidic, it would be expected that any bone material contained within the soil horizon would undergo greater degradation and conversion to solution, enhancing the total phosphorus levels. Whatever was enhancing the total phosphorus levels lower in the stratigraphy is no longer present in the same quantity. Fuel residues were making up a greater proportion, suggesting that debris from marine sources is no longer being added to the stratigraphy at the same level, with the sharp change implying a swift transition. The proportional absence would suggest a change in the routine which previously created high levels of total phosphorus and soil magnetism. It is at this point the first specialist fishing stations in this study emerge, implying a level of association between the two. The changes appear to have been driven by environmental conditions, as well as the manner in which society was organised and the wider economies of Europe growing.

The First Maritime Expansion – The Eleventh Century

The idea of a transition in maritime processing activity away from Vatnsfjörður around AD 1000 fits well with the development and expansion of sites elsewhere in the region, closer to deep-water fishing grounds. Skálavík 1 yields a radiocarbon age of AD 1015 – 1075 from the second-lowest horizon in the stratigraphy, with the monolith representing the underlying horizon revealing evidence of occupation prior to this date. Above-average values of soil magnetism and total phosphorus reveal a concentrated phase of occupation that can be associated with a temporal period prior to AD 1000. The degraded nature of the bone remains may be associated with the more acidic soil conditions, however, the enhanced total phosphorus levels indicate a distinct period of occupation most likely related to maritime resource exploitation.

The temporal period capping this lower phase reveals a distinct difference. Dating from AD 1015 – 1075 to AD 1050 – 1110, there were distinct periods of occupation and abandonment identified through the presence of clear and distinct horizontal bands. Values of soil magnetism and total phosphorus increase sharply, indicating a change in the intensity of occupation. Bone material is intimately mixed with domestic and industrial-temperature fuel residues, which were predominantly of turf origin. Bands of unrubified peat suggest natural encroachment during periods of abandonment, which were overlain with the same turf and domestic debris mixture. These unburnt peat bands can be found with anthropogenic inclusions embedded within them, indicative of a surface that has been walked upon after re-occupation has commenced, or had existing anthropogenic fragments washed into void spaces within the stratigraphy. As the temporal phase progresses upwards in the stratigraphy, the abandonment features previously identified reduce in frequency and become less noticeable as levels of total phosphorus continue to rise, representing a change once more revealing an increasingly intense occupational phase.

The increase in total phosphorus is matched under thin section by an increase in bone material, coupled with increasingly acidic conditions. Given that the increased acidity would have contributed to higher levels of bone degradation, and that the frequency of bone is actually elevated, this suggests a period of very high intensity towards the end of the eleventh century AD. By far this is the period which contains the largest proportion and representation of bone material.

At Vatnsfjörður, the farm mound stratigraphy reveals changes in deposition characteristics, including distinct bands of bone material. This bone component fades and returns once more, sandwiching a period of standstill within the midden. Levels of total phosphorus drop, which coincides with a rise in soil magnetism, indicating a greater component of fuel residues being present. These residues were largely of turf origin. This pattern changes in one horizon made up largely of bone material, which shows a dramatic increase in total phosphorus values, reiterating the close relationship between the two. The nature of this bone deposit and its contextual exclusivity may be related to the availability of marine resources. With specialist sites emerging elsewhere in the region, a trading network may be opening up, providing Vatnsfjörður with a more consistent supply of marine produce. Being a major landowner in the region, rental payments would have largely been made in fish, suggesting that the resource was not difficult to acquire.

The radiocarbon ages reveal that the farm mound sampled at Vatnsfjörður was acquiring more marine material roughly at the same time Skálavík 1 was occupied. Even though there may not have been a direct association between the two sites, it is likely that given the suggestion that there was a vibrant internal trading network in place in Iceland in the centuries following *Landnám*, Skálavík was not the only location emerging in the eleventh century. Nearby Akurvík was functioning as a fishing station by the eleventh century,[587] reflecting the possibility of a collective effort to acquire marine resources.

[587] Amundsen *et al.*, 'A 15th Century Archaeofauna from Akurvík'.

The findings here reflect a wider trend of coastal emergence driven by a movement away from freshwater species and disruption to the immediate environment.

Transitions were clear within both Vatnsfjörður farm mound and Skálavík 1, from which suggestions emerge attributing the reasons behind them which can be tied in with the constructed narrative. Around AD 1000, marine species began to dominate zooarchaeological assemblages throughout Europe as societies underwent a transition.[588] Within Iceland, marine resources were growing in importance as they made up an increasing proportion of zooarchaeological assemblages within the country.[589] The drivers for this can be viewed as primarily environmental but conditioned by social factors; around the AD 1050s, Iceland endured several seasons of food shortage in succession, and there is also famine and hardship in AD 1095 where the elite begin grain hoarding. The protection of resources to sustain a way of life may be reflected in the fisheries; the transition from freshwater to saltwater species in the zooarchaeological assemblages may reflect the elite's control over resource access. By hoarding grain and enforcing restrictions concerning the consumption of freshwater fish regarded to have a higher status, the chieftain-style (and standard) of living can be maintained by differentiating between classes controlling the resource availability over the lower classes and utilising luxury goods which have been 'ring-fenced' and made exclusive. The growing power the elite had over the rest of Iceland is demonstrated here. Whereas before, society may have responded to hardships by turning to reserve stocks of fish, with this option removed through the elite demonstrating their control, the buffer of insurance is removed as the reserve became a core resource. The resulting conclusion is a shortage of foodstuffs and associated episodes of dearth.

[588] Barrett *et al.,* 'Dark Age economics'.

[589] McGovern, *et al.,* 'Coastal connections, local fishing, and sustainable egg harvesting'.

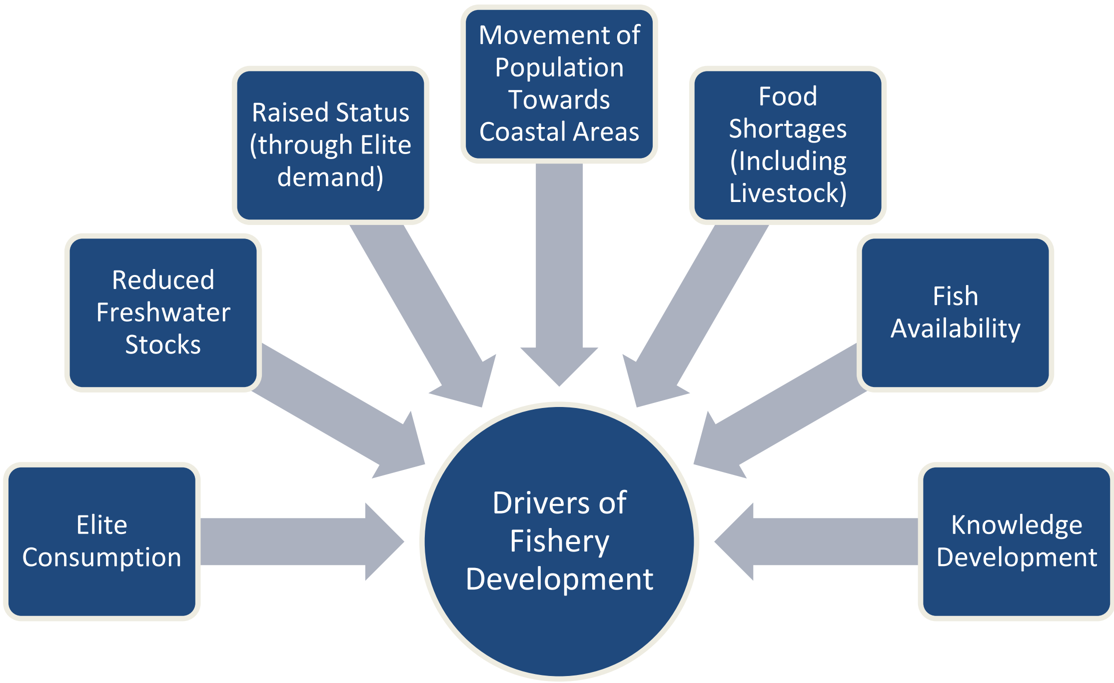

Figure 155: Model Outlining the Potential Drivers behind Specialist Fishery Development

These food shortages may also have played a part in the movement towards the coasts to secure maritime produce for domestic consumption. Icelanders were demonstrating their willingness and ability to respond to some of the hardships presented to them. Marine sediment records show an increase in sediment inundation around this time, adding weight to the freshwater to saltwater species transition.[590] This would have suited the elite; as freshwater stocks dwindled, the status and exclusivity of this catch would increase significantly. Pressures on existing resources towards the end of the eleventh century would have been growing. The dearth and famine reported in Icelandic historiography may have been representing other areas away from Vestfirðir, as Skálavík 1 appears to be reaching an occupational peak. The reduction of abandonment indicators at Skálavík 1, however, may be an indication of the increasing time spent at the site; with pressures growing through environmental deterioration and food shortages, there may have been greater frequency of site utilisation, undergoing a

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590 Geirsdóttir *et al.*, 'A 2000 year record of climate'.

transition from occasional provider of marine produce to a core seasonal activity supplying a growingly dependent internal trade network. What is being represented here is the role maritime produce is playing in a society which is struggling for alternative resources. There is clearly a growing episode of maritime produce consumption, followed by an increase in intensification. Although it appears the site emerged as (partly) a result of market demand, it demonstrated its resilience in playing a key role as a resource provider during times of hardship.

The next temporal phase at Skálavík, AD 1050 – 1110 to AD 1160 – 1220, is almost a continuation of the previous temporal phase; distinct bands of fuel residues and a growing presence of bone between progressively shorter phases of standstill. The fuel residues do, however, show change, with evidence of peat being burnt alongside charcoal material. This change indicates a transition in fuel use, and may be closely linked with inclement environmental conditions reducing the availability of turf for fuel.[591] Reduced availability of turf may have called for the extraction of peat, which would have added to problems of landscape degradation through the removal of vegetation cover and underlying material.

There is one distinct episode of standstill during this chronological phase which stands out amongst this part of the stratigraphy in that it is more prominent and suggests a longer than normal period of time away from the site. This subangular blocky area, indicating prolonged surface exposure, is a contrast to the encompassing crumb microstructure associated with the anthropogenic deposits. The latter part of the twelfth

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[591] The role of turf within society is somewhat unclear in parts. It is unknown whether the turf for fuel, was performing a secondary function as in material formerly used in construction, or if it was freshly cut for purpose. If it was used in construction, this would suggest a potential cyclical pattern of deposition, as turf would be burnt when it was made available, reflecting a recycling strategy rather than differing environmental and fuel pressures.

century was said to mark the end of the Little Climatic Optimum, with the onset of poorer environmental conditions. Progressive and repetitive shocks to systems and processes would have been a likely contribution towards the widespread, later period hardships of the 1200s, where famine and hunger was present at a previously never-before seen level. During previous hardships, the seas presented an opportunity for providing resources which could be turned to in times of terrestrial failure, but they too were determined by over-riding environmental conditions. The standstill observed may be pinpointed, possibly to the succession of famines experienced in the AD 1050s, or possibly the famine of AD 1095 where the peasantry were said to be eating plant roots.[592] This level of hardship reflects a widespread shortage of foodstuffs on and off-shore, with this standstill reflecting the impact it was having on Vestfirðir. The changes in environmental conditions may have been a factor in the modifying fish migration patterns, as a later period example from Ísafjarðardjúp in AD 1236 highlights the potential of this problem; farmers at this time nearly succumbed to hunger before the fish arrived in the fjord. With fish not arriving at the expected fishing grounds, hardship is likely to have followed. Cod are a notoriously fickle species, and a series of years impacting and modifying sea temperatures would have an over-riding impact on their migration. With this risk and ability to reflect on previous forecasts and experiences, there may have been a calculated response driving an investment in infrastructure which would ultimately produce a more reliable source of maritime resources.

Aside from the aforementioned prolonged single period of standstill, patterns of anthropogenic occupation progressively grow as there were an increasing proportion of bone remains present. Much like in previously observed horizons, the high volume of bone is found alongside a low pH, giving an insight into the proportion and significance

[592] Vasey, 'Population, Agriculture and Famine'.

of material that must have been deposited for it to have a neutralising effect. The intensity of total phosphate continues as the stratigraphy progresses into the twelfth century AD, reflecting one of the most periods of on-site activity represented in the geoarchaeological record.

Into the twelfth century AD, there is the return of occasional abandonment features, including the presence of basalt grains, indicating an increase in coastal storm activity. This correlates well with the decline in environmental conditions recorded in the historiographical and published environmental record around this time. Progressing upwards in the stratigraphy, the presence of bone material begins to reduce, as do the values of total phosphate, but these were often coupled with a reduction in abandonment features. Industrial activity is still taking place with the presence of high temperature fuel remains, which maintains the higher soil magnetism levels. These features begin to find themselves intimately mixed with abandonment features in a crumb deposit further up the profile, as presence and abandonment indicators alternate. Charcoal is now seldom present in the stratigraphy, which could possibly reflect environmental conditions and fuel resource availability. Charcoal is found in reduced quantities within the Vatnsfjörður farm mound stratigraphy, reflecting issues related with the wider availability of the resource in the region at this time.

Progressing to the top of the AD 1050 – 1110 to AD 1160 – 1220 temporal phase at Skálavík 1, anthropogenic indicators show a reduction in their presence, but abandonment features were also less frequent. Occupation may not have been as intense, but the stratigraphy suggests that use was regular and to some degree stable, with periods of time spent away from the site not as prolonged. Fuel residues tend to show characteristics of more domestic temperatures, and were often found as a mix of peat and turf with the occasional charcoal fragment present. At the uppermost part of the temporal period in the stratigraphy is a return to an intimate mix of bone and charcoal, before a significant period of standstill represented by coated basalt grains. Circumstances were changing at Skálavík 1, which may have been dictated by the environmental conditions. The increase in the proportion of sand correlates with increased storm activity towards the end of the twelfth century. Over the course of the twelfth century temporal period there were clear and distinct changes in the deposition patterns, particularly in comparison to the previous century.

Thirteenth Century Expansion of the Fisheries

The change of intensity at Skálavík 1 appears to be related to expansion in the fisheries elsewhere in Vestfirðir. Kálfeyri, yielding a lowest radiocarbon date of AD 1205 – 1275, would have been an additional fishing station responding with the rising demand for marine produce. The reduction in intensity at Skálavík 1 may have made it necessary for other sites within the region to develop, and possibly be related to a drop in species availability or through overfishing and changing environmental conditions altering cod migration patterns. Differently positioned fishing stations throughout the region would have targeted different fishing grounds and the additional diversity would have provided flexibility when faced with lower returns at individual sites. The years around AD 1200 saw widespread famine experienced in Iceland, with many people reported to have died at Hólar in AD 1204.[593] For a site of such national and ecclesiastical importance to undergo such hardships indicates difficulties regardless of social status. Aside from domestic demand, there is a growing call from Europe for fish. Cod isotope evidence suggests that during the thirteenth century AD, the long-distance trade in fisheries was

[593] Vidfússon, 'Biskupa Sögur'.

expanding.[594] Akurvík also reveals a transition in the zooarchaeological assemblages around AD 1200, from subsistence to specialist levels of exploitation, targeting specific species.[595] This shows that the development of sites around this time was part of a broader regional phenomenon, responding to external demand and intra-regional failures.

The development of activity at other sites, and the drop in intensity at the end of the eleventh century suggests that Skálavík 1 reached a peak around AD 1100, as a key site in the internal, domestic fish trade in Iceland. With this peak coming prior to the thirteenth century expansion, and in reference to the hypothesis of Zori, it may reflect the role of Skálavík 1 in early Icelandic society. Zori notes that domestic consumption of fish in Iceland is strong from the post-*Landnám* period but drops after the thirteenth century,[596] which would indicate that Skálavík 1 was provisioning an internal market from its earliest period.

It is unknown *who* the initial occupiers of these thirteenth century sites were. It is known that dwindling availability of resources were causing problems in Iceland. Wood for boat building was becoming scarce, and more and more of the fishing industry was falling into the hands of foreigners.[597] This may have caused a demographic transition, altering the activity taking place.

The signature at Vatnsfjörður farm from the twelfth century reveal thick seams of bone material intimately mixed with fuel residues, including charcoal indicating a domestic

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[594] Barrett *et al.,* 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

[595] Amundsen *et al.,* 'Fishing Booths and Fishing Strategies in Medieval Iceland'.

[596] Zori, *From Viking Chiefdoms to Medieval State in Iceland.*

[597] Gardner & Mehler, 'English and Hanseatic Trading and Fishing Sites'.

origin for these residues. Peat material is growing in proportion, suggesting a further change in fuel resource availability. The thick bone material is most definitely of marine origin, and well preserved in the more neutral pH conditions. Deposits on the farm mound were intermittent, however, as mentioned previously, this may be related to the depositional pattern rather than time spent away from the site. The proportional increase of this material is significant, supporting the idea that Iceland was consuming more fish during the twelfth century. Terrestrial failures and widespread degradation would have enforced a transition to alternative resources for nutrition, with produce from the seas filling the void.

One highly unique feature within the farm mound is a gravel deposit positioned below the AD 1160 – 1220 radiocarbon age. Varying between ten and fifteen centimetres thick, this well-rounded (and obviously influenced by water) deposit may be a result of the dredging of a river channel close to the farm mound. The high levels of total phosphorus and soil magnetism reveal a strong anthropogenic influence, and the presence of fuel residues within parts of the deposit suggest a level of mixing within the midden, possibly related to later material percolating through the void space within the gravel. It strongly suggests a period of landscape improvement sometime during the twelfth century AD, reflecting a conscious change in land management at Vatnsfjörður. It is unknown whether this channel was to drain and mobilise the movement of water away from the site, or perhaps to irrigate and control the flow of water to be used as and when required, something which has been identified in Norse Greenland.[598] With difficulties growing in terrestrial environment, what may be being observed here is a response to the changing environment and resource pressure in Iceland. Icelanders were now consciously

[598] W.P. Adderley & I.A. Simpson, 'Soils and palaeo-climate based evidence for irrigation requirements in Norse Greenland', *Journal of Archaeological Science,* 33 (2006), p.1666-679.

modifying their contexts in a way previously never seen. Capping this gravel deposit is a horizon rich in bone and fuel residues, of turf and wood origins. Micro-layering of turf material is present suggesting a series of deposits.

Overlying this soil horizon is a thick seam of charcoal, a stark contrast to the underlying horizons which sees a dwindling proportion of charcoal material as the stratigraphy progresses upwards. Dating to AD 1185 – 1255, this phase of deposition appears to be constant with little or no standstill features recorded. Traces of turf and intimately-mixed bone can be found throughout suggesting a domestic origin, however, the scale of this deposit would suggest something associated with industrial levels of waste. The lower soil magnetism levels would suggest that charcoal does not contain the same value of magnetism as peat and turf residues.

The charcoal horizon is of birch sources, which strongly suggests that around the beginning of the thirteenth century, wood was somehow readily available for the occupants of Vatnsfjörður and being burnt as fuel. This begins to raise questions of its origins and subsequent wider socioeconomic implications. Was this wood imported or was there a dramatic increase in driftwood freeing up domestic sources, or was it a result of a systematically managed process of woodland management? This would challenge the age-old interpretation that Iceland was devoid of wood swiftly after *Landnám*.[599] The micromorphological record reveals charcoal being present, albeit at a reduced scale prior to this deposit, but clearly not to the same scale. Is there a possibility of this deposit reflecting a new supply of fuel being made available? There does appear to be a distinct change, and this may reflect the way in which Vatnsfjörður was being

[599] S.K.T.S. Wärmländer, D. Zori, J. Byock & D.A. Scott, 'Metallurgical findings from a Viking Age chieftain's farm in Iceland', *Journal of Archaeological Science* (2010), DOI: 10.1016/j.jas.2010.04.001

managed. May it have reflected social attitudes, a change to a 'live for the moment' attitude, or perhaps a response to the sea providing the majority of the needs for society, and no need to provide their domestic wood sources? Could it be that charcoal on its own was previously utilised in another way, possibly as fertiliser, but there was a change in its value and neither worthwhile nor possible to redistribute charcoal on to the homefields, possibly as a result of a labour force moving to the coasts? Future micromorphological investigations on to the homefields may give insight into this theory. The movement of labour from the terrestrial to maritime economies was recognised as something of a problem in early Iceland, and attempts to control this are mentioned in the lawbook *Grágás*.[600] It may also have been a period of crisis within the agricultural economy of Iceland, and like elsewhere, degradation was becoming more widespread and problematic leading to the movement away from farming as the primary economic activity.[601]

The soil chemistry results identified so far may provide a theory into the transition of nutritional inputs into soil. Horizons which were rich in bone and marine wastes were revealing higher levels of total phosphorus than a charcoal rich deposit. Phosphorus is one of the key elements required for vegetation to grow, with higher levels associated with greater yields. Could it be that this nutritional value has been identified, and wastes generated by fishing stations under the control of major farms such as Vatnsfjörður were sufficient enough in quantity and finding their way into the farming system to be used as fertiliser? A sharp growth in fishing stations, like that observed in the thirteenth century, would make these wastes readily available and their redistribution economically more worthwhile than would have been previously. If this was indeed a method used to

[600] Byock, *Viking Age Iceland*; Karlsson, *Iceland's 1000 Years*.

[601] Simpson *et al.,*'Crossing the thresholds'.

fertilise homefields, it would explain the sudden introduction of a significant deposit of charcoal in the farm mound stratigraphy; it was no longer required for its original 'secondary' function. It is known that in Scotland, fish wastes were a popular way of fertilising the farming landscape and significant efforts were made to mobilise wastes from processing locations back into the terrestrial landscape.[602] There is a future requirement to investigate Icelandic sources to establish whether fish wastes were ever recycled in this manner, or merely discarded.

The charcoal deposit identified at Vatnsfjörður correlates with the drop in intensification at Skálavík 1, and the emergence at Kálfeyri, dating to AD 1205 – 1275. At Kálfeyri, there were initially comparatively low levels of total phosphorus, but elevated levels of soil magnetism, indicating mainly fuel-based wastes. It was not possible to obtain a Kubiëna tin from this stratigraphic context, so it is difficult to interpret whether this fits in with the previously mentioned waste recycling theory. The overlying horizon contains a sharp rise in total phosphorus, suggesting that between AD 1205 – 1275 and AD 1280 – 1340, there was a significant presence on the site exploiting marine resources, supporting the historiography that there was significant growth in the Icelandic fisheries during the thirteenth century. This site fits in with the historiography, in that the economy is said to have taken off in the AD 1260s, driven by overseas demand, however, by contrasting the earlier and later periods in the geoarchaeological record across the relevant sites, the earlier period by far shows stronger and more distinct periods of occupational intensity. Fish is growing increasingly important to Iceland's export economy, as would be demonstrated in the following century.

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[602] R.D. Oram, 'Waste management and peri-urban agriculture in the early modern Scottish burgh' *Agricultural History Review*, 59 (2011), p.1-17; E.B. Guttmann, I.A. Simpson, D.A. Davidson & S.J. Dockrill, 'The management of arable land in prehistory: case studies from the Northern Isles of Scotland', *Geoarchaeology,* 21 (2006), p.61-92.

The uppermost horizons from Vatnsfjörður, dating to the period post-AD 1205 – 1275, show a change in fuel residues with peat and wood ash the most prominent. There is a growing peat component, with the first instance of evidence of herbivore activity present through the identification of a calcitic indicator, a proxy for material which has been through the digestion tract of an animal. Coated basalt grains and other abandonment indicators suggest that this area of the midden is falling out of favour, with intensity and deposition becoming reduced. The increase in peat would indicate a pressure on resources and growing hardships and that the thick charcoal episode from earlier in the century was a one-off. This transition was in some way driven by climate, as there are records from the AD 1270s commenting on the increase in sea ice, and that it was only possible to get out fishing in a few particular locations.[603] In the late AD 1200s, dearth was present throughout the country, reflected in King Eiríkr's decision in AD 1294 to prohibit the export of fish from Iceland. Climatic pressures were not exclusive to Iceland, as Europe was also feeling the impacts of this inclement episode. The climatic optimum and associated favourable conditions experienced from the post-*Landnám* period to around the AD 1150s was now completely over.

Further Expansion in the Fourteenth Century

With the reduction of intensity at Skálavík 1, the fourteenth century saw development at Kálfeyri and now also Skálavík 3. Radiocarbon evidence indicates development here from AD 1280 – 1310 onwards coinciding with terrestrial problems within Iceland as well as pressing overseas demand. In addition to this, supplementing the theory of expansion in the fisheries is the emergence of Selvík in AD 1310 – 1380 as a baiting

[603] Dawson, personal communication; Þ. Thoroddsen, '*Árferði á Íslandi í þúsund ár*'. Hið íslenska fræðafélag, Kaupmannahöfn 1916-1917. (1917). p.364-65.

station. These on-site transitions appear to be reflecting a wider phenomenon being experienced in Iceland.

Kálfeyri from AD 1280 – 1340 onwards displays characteristics of bone material intimately mixed with fuel residues. The fuel being burnt is mainly turf but also peat. Abandonment indicators were present but only in trace amounts. Despite monoliths revealing significant bone components, total phosphorus values actually drop, suggesting a drop in intensity compared to the earlier period, before a resurgence and strong anthropogenic phase in overlying horizons. Fuel residues were becoming paler, indicating more intense burning as the phosphorus levels drop. Charcoal is noted throughout the parts of the stratigraphy, highlighting the availability of wood as a combustible resource at this time, as it was found at Vatnsfjörður in vast quantities. At Skálavík 3, the evidence suggests a period of activity around the AD 1280 – 1340 radiocarbon date. The absence of micromorphological evidence limits the volume of information, however, the reduced total phosphorus levels and soil magnetism indicates that this was not as intense as later periods. It may be the case that the catch is more widely distributed amongst a greater number of landing sites, rather than all activity taking place at one location.

The emergence of these sites correlates with a period when Norway became a key exporter of fish, accounting for eighty percent of export earnings.[604] Iceland was also becoming part of a wider European network, and as a response, fishermen changed the season in which they primarily fished. It was now a winter activity, which coincided with more favourable cod migration periods, as well as being able to provide more in the way of efficient, mobile seasonal labour which could migrate from farms to coasts during the

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[604] Barrett *et al.,* 'Dark Age economics'.

terrestrial slack season. The reaction to expand the fisheries was a response to wider economic conditions, which were driven by social expansion and environmental change throughout Europe, as well as growing pressures experienced within Iceland itself.

Unique to the collection of sites surveyed is Selvík, which emerges around AD 1310 – 1380. Field observations and micromorphological evidence indicate that this was most likely a baiting station, however, this can be debated. The lowest part of the stratigraphy is an organic-rich deposit with few traces of anthropogenic material. This is capped by the shell midden, almost exclusively containing molluscan remains, with little soil accumulation within the horizon. There is no doubt that this site and the sharp transition shown in the stratigraphy represents a strategic yet sudden effort in the fourteenth century to collect molluscs.

The reason this accumulation of shell remains can be debated is that molluscs can be captured both for bait and also for human consumption, and can be regarded as a proxy for population growth and resource pressure, as well as being a suitable indicator of wider socioeconomic conditions[605] The same question emerged at Eýri, which revealed a significant proportion of shell fragments with no distinction being made between their use as food or bait.[606] Clarity regarding this question would lie with whoever is occupying the site at the time. During the fourteenth century, foreign fishermen were said to be arriving on Iceland's coasts and setting up seasonal camps. What may be observed here is a location focussed on collecting bait. Small fish as well as molluscs and

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[605] N. Milner, J. Barrett & J. Welsh, 'Marine resource identification in Viking Age Europe: the molluscan evidence from Quoygrey, Orkney', *Journal of Archaeological Science*, 24 (2007), p.1461-472.

[606] Harrison, 'Preliminary Assessment of the faunal remains'.

birds were in widespread use for this purpose,[607] which is also evident through recent excavations in Orkney given the chronological relationship between the generation of the shell midden at Quoygrew and a period of growth in the eleventh and twelfth century fisheries.[608] Baiting may also have been undertaken by Icelanders, and it may be that with the maritime growth developing slowly from the eleventh century AD, but more widespread intensity from the thirteenth century onwards as demonstrated at Kálfeyri, specialist baiting locations may have been necessary. The development ties in well chronologically with the transition from *vaðmal* to *skreið* as Iceland's principal export product, with more effort being placed in the capture of fish.[609] It was customary for fishermen to supply their own bait, but if it was provided by someone else, he would claim his share of the lot, known as the 'bait lot'.[610]

The focus on the role of this site as a possible baiting location is one suggestion, with its role during times of food shortage being another. Terrestrially, Iceland in the fourteenth century was struggling, with landscapes becoming progressively degraded and increasingly large areas of land being blown or washed away. Environmental pressures were increasing not only in Iceland but throughout Europe with the Great European Famine, as well as the deteriorating environmental conditions within Iceland itself. The sharp cooling of the sea surface temperatures experienced from the AD 1350s onwards[611] would have reduced terrestrial biomass productivity by influencing

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[607] Jónsson, 'Fisheries off Iceland, 1600-1900'; A.H. Pálsdóttir, '*The Tjarnargata 3c Archaeofauna: The Fishing industry and the rise of urbanism in early modern Iceland*', XiVth iCAZ Fish Remains Working Group Meeting, (2008).

[608] Milner *et al.,* 'Marine resource identification in Viking Age Europe'.

[609] Byock, *Viking Age Iceland*, p.44.

[610] Jónsson, 'Fisheries off Iceland, 1600-1900'. Could it be that in order to guarantee a share of someone's catch that bait stations were monopolised by the landowner, forcing fishermen to get their bait from them?

[611] Sicre *et al.,* 'Decadal variability of sea surface temperatures'.

terrestrial surface temperatures, as well as changing oceanic conditions and fish migration patterns. A few concurrent seasons of dearth and shortage may have forced a short but intense period where molluscs were captured not for bait but for human consumption. It was a relatively low-risk strategy which required minimal investment, and the gathering of molluscs was an activity which could be undertaken by children and the elderly.[612] In Britain particularly in the centuries prior to the twentieth century AD, shellfish such as limpets were a 'famine food', which could be turned to during times of hardship and actually contained twice as much nutritional value as oysters.[613] The same definition of shellfish being a low-yielding 'famine food' was held through many areas of pre-modern Iceland.[614]

The shell horizon is overlain by a dark organic deposit associated with abandonment. Soil chemical analyses confirm a swift drop in site intensity. These observations suggest that there was a period of change in the later part of the fourteenth century AD leading to the abandonment of the site. The fourteenth century abandonment may have been part of a wider north Atlantic collapse, as an episode of this nature swept through Norway and Greenland around this time. It is unknown whether this episode was associated in any way to the dearth sweeping through Europe at this time, difficult to do without a wider national study on fishing stations.

Selvík appears to encapsulate a period of swift development and change, for whatever reason, which took place around the Icelandic coasts only during the fourteenth century. The possibility that it was a site turned to in times of hardship is very plausible, or even a

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612 Edvardsson *et al.,* 'Coping with hard times in NW Iceland'.

613 C. Wickham-Jones,'The Tale of the Limpet', *British Archaeology,* 71 (2003); Edvardsson *et al.,* 'Coping with hard times in NW Iceland'; Milner *et al.,* 'Marine resource identification in Viking Age Europe'.

614 Edvardsson *et al.,* 'Coping with hard times in NW Iceland'.

dual-function of baiting station turned nutritional hub or vice-versa, but given the correlation with developments of specialist locations elsewhere in the region, it is most likely this was a baiting station facilitating the growing demand for fish, assisting the growing number of people assisted in this industry. After this short period of occupation, it appears the site was abandoned, and never occupied to the same level again.

As the stratigraphy at Kálfeyri progresses, dating to the later fourteenth century, abandonment indicators increase in frequency, including an increase in the presence of basalt grains. It would appear that coastal storm episodes were increasing in number. With the intermittent presence of anthropogenic features, it would appear that occupation on the site was taking place but becoming more erratic as time progressed forward. The sporadic periods of occupation may be related to the levels of competition experienced. From the fourteenth century onwards, foreign fleets were visiting Icelandic waters for their fish and returning home, whilst in the fifteenth century, some were basing themselves on the Icelandic shore. This change in occupational pattern by foreign fishermen may be related to internal social change within Iceland. After AD 1350, there was also said to be an increase in the Norwegian share of the European fish market, contributing to a collapse in the foreign fisheries in Iceland; it was easier for traders to visit Norway than the more distant Iceland for their produce. Fewer ships were sailing to Iceland, which contributed to a period of isolation away from the wider European network. It is this isolation which may have protected the country from one of the worst environmental disasters in global history, but for only around fifty years.

The plague which swept through Europe in the mid-AD 1300s finally arrived in Iceland in AD 1402 and lasted for two years.[615] This event can be directly associated with the transitions observed in the fisheries. Widespread death would have created a shortage of labour, and with the landed elite favouring terrestrial economies,[616] what is being witnessed here is an occupational shift from the coasts to inland locations, occupying vacant farms. With the population reduced, so was the demand for fish.[617] The plague only killed humans and spared livestock, meaning there were more terrestrial-based foodstuffs to go round. This was an opportunity for the landless labour class to distance themselves from the 'squalid' fishing villages and pull themselves up the social ladder, driving the change from a social perspective. The shift in labour would have developed a void, which could have been filled by overseas fishermen without much direct confrontation. Any reference in the historical narrative to any conflict regarding marine resources tended to involve, or be instigated by, foreign fishermen as the active participants and perpetrators. It could be argued that those landowners owning the fishing stations would have accepted anyone, as without any fish being landed, rents would not have been generated. After the collapse of the North Sea fisheries in AD 1415, fishermen who formerly used that area would be looking for a suitable replacement, and Iceland became a viable option.

Kálfeyri was a fishing station used very intensely from the thirteenth century onwards, with a steady presence of occupation with few indicators of abandonment. A higher frequency of absence associated with the following century suggests a change on what was happening in the century previous. The thirteenth century emergence of Kálfeyri

[615] Jóhannesson & Bessason, '*Íslendinga Saga'.*

[616] D.A. Foote & R. Perkins, *Grágás II. Laws of Early Iceland*. (Manitoba, 2000).

[617] Woolgar, 'Food and the Middle Ages'.

fits in well with the theory that long-distance trade and globalisation was in place to fulfil the nutritional demands of Europe. Kálfeyri could well have been one of these sites which were part of this expansion.[618] This expansion of sites also coincides well with the change in fishing seasonality, from a summer to a winter activity. This transition allowed for a more mobile labour force, which was allowed to work on the landscape during the summer, and work on the seascape during the winter.

With no further material remaining in the Kálfeyri stratigraphy, and no indication of site occupation until the construction of stone booths in the eighteenth century, it is an assumption to suggest there was no activity taking place on site after the later part of the fourteenth century or the fifteenth century (based on the accumulation rates within the soil stratigraphy) until the construction of these stone booths. This theory gains strength in the fact that the shell midden at Selvík was abandoned, and Skálavík 3, which contains a stratigraphy dating from the early fourteenth century to the eighteenth century, displays a prolonged period of abandonment associated with the fifteenth and sixteenth centuries AD. The phenomena which were influencing sites were not restricted to one location; impacts were region-wide.

Prolonged Phases of Abandonment

The Icelandic fisheries may have been booming during the fifteenth century, but from an Icelander's perspective, this claim is one of foreign fishermen in Icelandic waters and not necessarily the claim of those native to the country. The geoarchaeological record from the sites investigated show prolonged periods of abandonment taking place in possibly the fourteenth and fifteenth centuries but most certainly in the sixteenth century.

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[618] Barrett *et al.,* 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

Skálavík 3 reveals a phase between AD 1280 – 1340 and AD 1545 – 1605 with little in the way of accumulation of cultural material. The absence of material coincides with the post-plague period, where Iceland underwent a period of reorganisation. Coincidentally, the documentary record from Iceland during this period is also lacking, reflecting not only a drop in literary output but also lack of shoreline activity in the surveyed sites. The soil horizon at Skálavík 3 contains the radiocarbon age indicating that during the sixteenth century there is evidence for intense periods of marine activity taking place. The soil horizons between the AD 1545 – 1605 and AD 1685 – 1745 reveal a different story. The soil chemistry results show a drop in intensification with reductions in soil magnetism and total phosphorus. The associated soil thin section reveals a prolonged period of standstill, with a thick seam of abandonment features alongside peaks in sand material inclusions indicating sand blow and coastal storminess.

From the late AD 1400s, there was a growing trade connection between Europe and Newfoundland, flooding the markets of Europe with cheaper fish. The historiography reveals a collapse in the Icelandic fisheries after AD 1550, with demand and price both dropping and subsequent processing crashing, directly related to the Newfoundland enterprises. It is at this time that power is said to have moved away from Vestfirðir, reflecting a contraction in demand, and reverting back to a demand last witnessed many centuries previous. With no activity revealing itself at Skálavík 1, Kálfeyri and Selvík after this period, as well as the abandonment of Akurvík after AD 1600,[619] there is a definite change taking place in the sixteenth and seventeenth centuries. The presence of sand grains may suggest an environmental perspective to this abandonment in additional to the socioeconomic changes. The seventeenth century AD saw poor climatic conditions in Iceland, and the later decades were associated with widespread hardship

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[619] Amundsen *et al.,* 'Fishing Booths and Fishing Strategies in Medieval Iceland'.

throughout Europe. Increases in coastal storminess may be describing the wider picture of generally inclement and difficult environmental conditions. That said, there is a period in the mid-AD 1600s when coastal sea ice is absent around Iceland's coasts, indicating a period of respite in a century of sustained hardship.[620] Despite this, there is not a surge in the geoarchaeological record at these sites as demonstrated during earlier periods.

Thór describes the scale of the fisheries in Iceland between the AD 1560s and AD 1700s as constant, a consequence of the Danish monopoly. This does not shed any light on regional variance, environmental impacts, the pursuit of resilience by Icelandic elites or any other influential variable. Jónsson suggests that the first half of the seventeenth century was one where output from the fisheries increased, which matches well with the drop in environmental hardship. These signs of stability and growth were not represented in the geoarchaeological record for any of the sites investigated here, suggesting that the Vestfirðir was indeed unique, and the wider historiography may not be considering regional variance and differences which may be in place. There may have been striking differences in the culture between Vestfirðir and other coastal regions of Iceland such as the southwest. This clear difference reaffirms more than ever the need for regional-based narratives to be constructed to give the differing pattern of activities across Iceland. The shift in power away from Vestfirðir transferred to the southwest, and the historiography may be describing the economic conditions in this region given the revision in focus. Investment was being received primarily from German sources, facilitating this development. Environmental conditions in the northwest were particularly unfavourable at times. Between AD 1600 and the AD 1630s, the increase in coastal sea ice may have been keeping fishermen on shore. The eruption of Hekla would

[620] Dawson, personal communication; Lamb, '*Climate: Present, Past and Future*'.

have placed additional pressure on any available resources, however, in the second half of the century the weather began to be more favourable, making fishing conditions in the more extreme areas increasingly possible.

Eighteenth Century Resurgence in the Fisheries

In contrast to Skálavík 1, Kálfeyri and Selvík, there was a return made to Skálavík 3 sometime in the eighteenth century. In the late AD 1600s, catch numbers in the North Sea were dropping, pushing fishermen back to Icelandic waters, predominantly Dutch fishermen. The monolith associated with the AD 1685 – 1745 radiocarbon age at Skálavík 3 reveals a sharp contrast to the underlying horizons. The presence of bone increases amongst a turf and birchwood fuel residue matrix, with a growth in the frequency of charcoal also observed. This intense horizon is capped off by a sharp, abandonment horizon, and it appears there was a short period of reoccupation prior to another phase of abandonment.

The eighteenth century was one of widespread difficulty for Icelanders, with forty-three years of the century said to have contained some form of hardship.[621] Climatically, the century was very poor. Volcanically, Iceland was very active and famine was an overly-frequent occurrence. These pressures brought about a higher demand for marine produce, and the re-visitation of Skálavík 3 may be one example of a site reoccupation during times of increased hardship or trade expansion. With the absence of competing socioeconomic factors, Icelanders may have been allowed to develop their own coastal activity, before it was incorporated into the wider European economy once more.

[621] Tomasson, 'A Millennium of Misery: The Demography of the Icelanders'.

Two other sites emerge in Vestfirðir during this time; Arnardalur and Biskupsvík. These are two contrasting sites, which reveal differing purposes in the documentary sources relating to their wider function; Arnardalur was for commercial purposes, with Biskupsvík for subsistence needs and not of commercial importance.[622] The radiocarbon age positioned lowest in the Arnardalur stratigraphy, dating to AD 1730 – 1800 is used here, with the AD 1630 – 1700 age regarded as material containing a residual date given that it was found higher up the stratigraphy. Biskupsvík yields a date of AD 1715 – 1785 from the middle of the stratigraphy.

Pre-AD 1730 – 1800, reveals Arnardalur to be a site built on beach gravel. Soon after occupation, deposits consisting of mainly charcoal and peat can be found, associated with a rise in the value of soil magnetism. These anthropogenic layers were often capped with abandonment features, suggesting extended time was spent away from the site at specific periods. The corresponding site at Biskupsvík reveals a different picture. This is a site with a very high anthropogenic footprint from its earliest period, dating to the early eighteenth century. Soil magnetism is also elevated, but the remains of bone material appear significantly higher. The acidic conditions of the peaty soil would have contributed to bone degradation, however, the acidity appears fairly constant throughout the profile permitting comparison in context. This strong anthropogenic signal at Biskupsvík may reveal an episode of occupation, which was driven by the inclement environmental conditions of the late AD 1600s. With widespread tenantry, terrestrial degradation increasing and there being concurrent years of hardship through adverse climate, farmers were returning to the shoreline to fulfil their dietary requirements. With the anthropogenic signal progressively dropping as the stratigraphy moves upwards, this would indicate that activity on the site never reached the same level

[622] Magnússon, & Vídalíns, '*Jarðabók*'.

again, emphasising the level of occupation after first development and the key role fish played as a resource provider at this time. Poor catches in the AD 1740s and AD 1750 brought about the closure of the fishing grounds in the early AD 1750s, with a famine (swiftly following the AD 1755-56 inclement weather episode) in AD 1756-58, indicating the widespread hardships impacting the whole of Iceland. After the AD 1770s, fortunes began to change in Iceland with the fisheries undergoing a boom period, relieving some of the nutritional pressures witnessed earlier in the century. These changes were driven by foreigners, who were now permitted to fish in Icelandic waters.[623]

Arnardalur reveals a contrasting story in the geoarchaeological record. After the AD 1730 – 1800 radiocarbon date, there were distinct phases of intense occupation followed by abandonment with bone material found in linear bands intermixed with turf residues and the occasional use of peat. The occurrence of charcoal is a rarity, suggesting that by the eighteenth century, it was a prized and not widely available resource, particularly in a lower-status occupational site associated with fishing. As much as the sites display occupational characteristics, they were generally revealing lower values than stratigraphies elsewhere in the region dating to the earlier period. Total phosphorus levels were reduced, whilst fuel residues present a moderate degree of consistency. This may be related to the changing behaviour of fishermen from the late eighteenth century AD onwards. From the AD 1790s, decked vessels become a common sight off the coasts of Iceland. The processing of fish was now done on deck, at sea, meaning that wastes would be dumped at sea or taken to the trading post associated with the fishermen. Fishing booths were now almost like a residential starting point for the fishermen. With wastes no longer being generated on site to the same degree as earlier occupation, this

[623] Eggertsson, 'No experiments, monumental disasters: Why it took a thousand years to develop a specialized fishing industry in Iceland'.

would reduce the levels of material contributing to the sheet midden accumulation. What possibly being observed here were remnants of purely domestic activities and little in the way of industrial debris. With fuel intimately mixed with some bone material, this appears to be the case.

The commercial fisheries in Iceland underwent a clear expansion period during the eighteenth century. These appear to have been driven by the four decades of hardship experienced throughout society as well as foreign demand. The inability of the fishermen to obtain cod was a problem early in the AD 1700s; with terrestrial failures driven by the climate, the presence of ice meant fishing was difficult if not impossible, further compounding the problem. In addition to this, even when the fisheries were successful, catches were still subject to climatic conditions. In AD 1769, processing failed due to unfavourable weather conditions, causing many inhabitants of Reykjavík to fall into destitution.[624] The reduced anthropogenic signature at Arnardalur corresponding to this period echoes these possible scenarios. After the AD 1760s, good fisheries were increasingly reported, although often punctuated by poor climatic events. The upper part of the Arnardalur stratigraphy corresponds well with this, where anthropogenic material is found alternated with standstill features. Dependence on the fisheries at this time may have been higher due to increasing rains impacting terrestrial productivity and the twenty year sheep epidemic which lasted until AD 1780.[625]

The arrival of decked vessels heralded the beginning of modernisation of the Icelandic fisheries. As equipment became more efficient, turf structures were replaced by stone constructions, and with an ever-increasing vessel size, fish could now be 'hunted down' in more distant waters. Saltfish were now the preferred product, which meant no longer

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[624] Pálsdóttir, '*The Tjarnargata 3c Archaeofauna'.*

[625] Þ. Óskarsson, '*Saga Reykjavíkur – í úsund ár 870-1870'*, (Reykjavík, 2002).

was there a dependence on favourable weather to process dried *skreið*. This transition may have been assisted not only by economic conditions, but the hardships of the late AD 1760s caused by a heavy reliance on the environment as a means of preservation which may have been fresh in the mind. Iceland was not necessarily exempt from the pressures and hardships encountered over the previous centuries, however, these events provided some level of contribution to the foundations of the modern fishing industry we have today. As experienced in the past, it is the environment which largely dictates the problems facing the fishing industry, however, instead of changing migration patterns, volcanic activity and sea ice, today's problem is the actual population of the valued resource. The fishing industry globally has perfected the ability to hunt fish down and evolved at a scale and rate much faster than the can regenerate, and as a consequence, our and future generations are paying for the ambition, dedication and skill of previous generations who captured as many fish as technologically possible. Since the *Landnám* of Iceland in the ninth century, the environment has always presented itself complete with challenges, and the dwindling level of fish stocks in the present day is another challenge which needs to be overcome if society wishes to progress or endure.

The sites surveyed reflect how Icelandic society has responded to the demand for marine resources. The records show the versatility and role Iceland's coasts played in responding to a multitude of demands caused by a wide-ranging set of scenarios. These ranged from internal needs to the market demands of mainland Europe, themselves responding to their own unique set of social, economic and environmental circumstances. Iceland faced the same problems as other famous fishing areas such as the Mediterranean and North Sea in the form of stock collapse, but given the lower population of Iceland, it may have been the geographical marginality, the same isolation which left the island undiscovered until the ninth century, which worked to its advantage and gave additional preservation to its fish stocks to take into the modern era. Global impacts of the post-mechanisation era took place around the same time, however, Iceland appears to in a much healthier position. Transitions have been numerous, and reasons behind change varied, but the manner in which society responded to the challenges in front of it helped maintain a society which has evolved into the one we see today. A timeline of key events detailing environmental, historical, social and economic narratives can be found below (Figure 156).

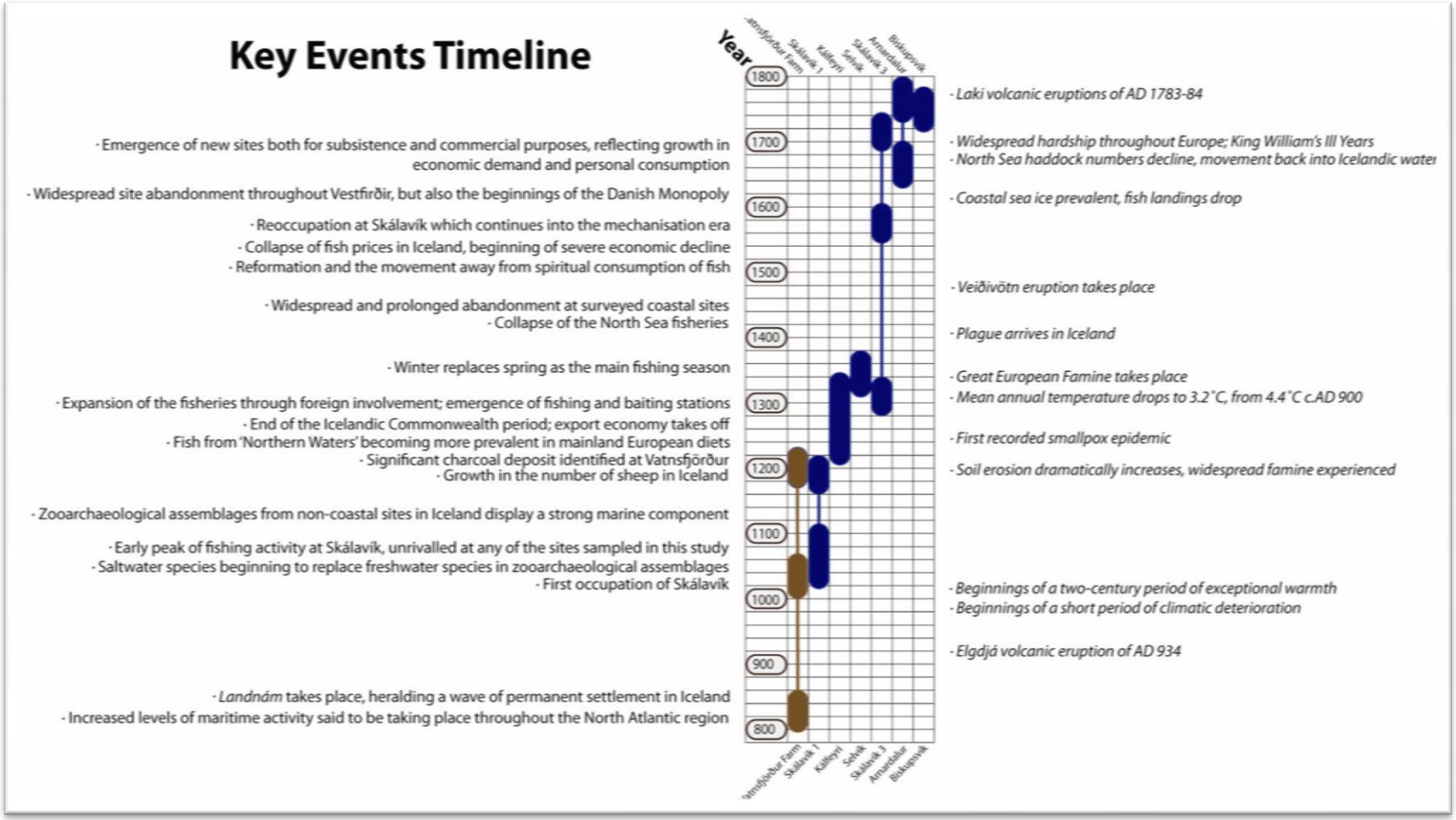

Figure 156: Timeline of Key Events

Chapter Six – Conclusions

The following chapter brings together the findings of the research process and aims to answer the research questions outlined in Chapter One. Whereas previously the narratives have been chronological (particularly in the historiographical discussion in chapter two) and site-based (field research and geoarchaeology, chapters three and four), this chapter will provide a thematic discussion oriented around specific research questions, ultimately contributing to the generation of an integrated environmental model. This discussion will be followed by suggestions for future research.

Research Question One – *When did specialist fishing locations first emerge in Vestfirðir, and are there observations within the geoarchaeological record to suggest a subsistence to specialist transition?*

The site at Skálavík, trench 1, is the earliest evidence suggesting occupation around or before AD 1015-1075. The presence of bone residues and elevated levels of total phosphorus in contrast to the Vatnsfjörður farm mound, alongside the absence of farming indicators such as dung residues, gives a strong indication that this was a site used for fishing. The soil horizon positioned beneath the measured radiocarbon age indicates site occupation on a subsistence level which was relatively continuous. These subsistence characteristics of fuel residues mixed with domestic material and few abandonment indicators (see Chapter Four) swiftly change around AD 1100, when the site reveals a peak on intensification reflecting continual or near-continual occupation, before becoming reduced and demonstrating stronger seasonal and specialist characteristics as it progresses into the thirteenth century AD.

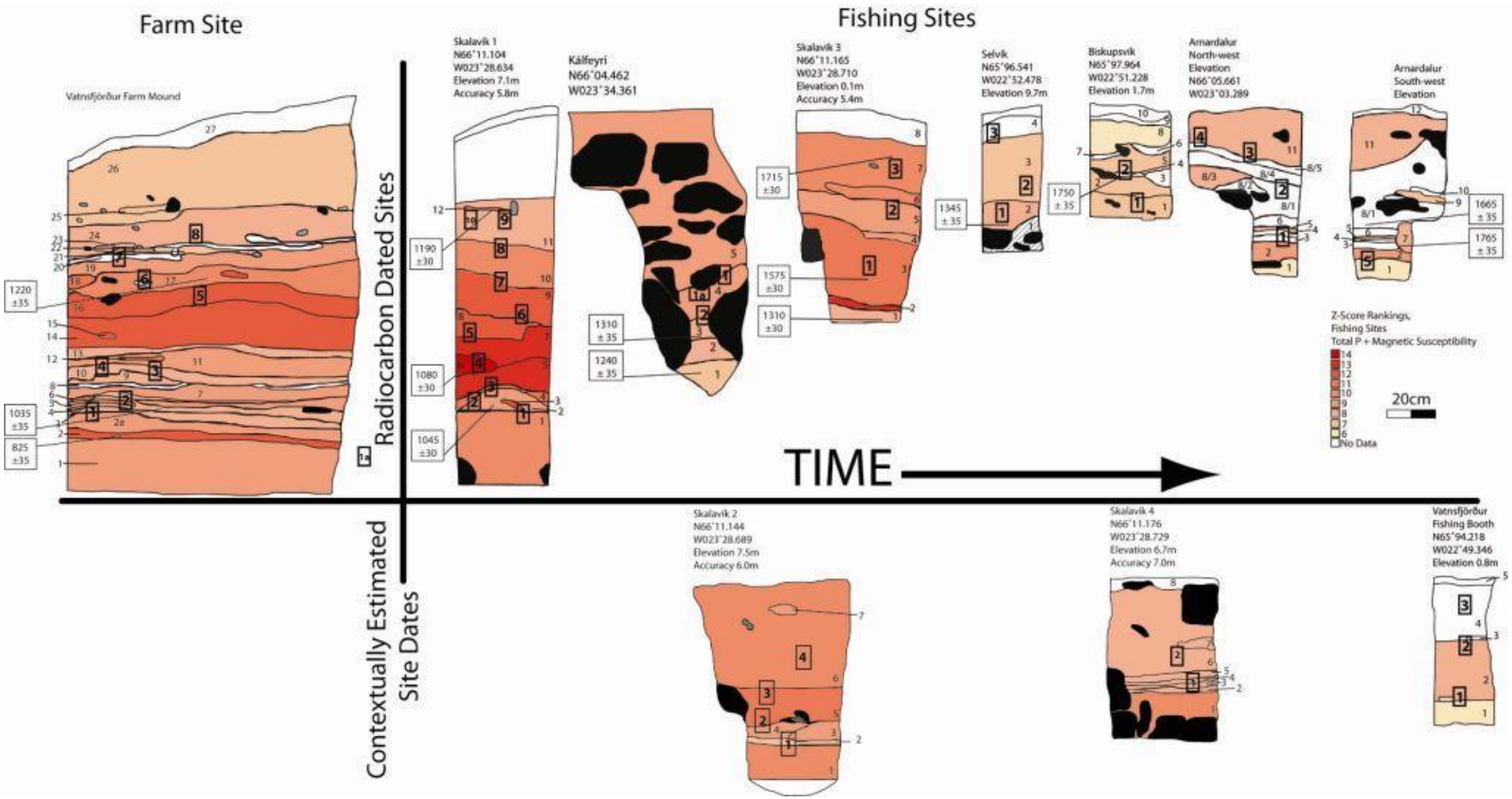

Figure 157: Illustration of site occupation over time

These changes evident in the soil record reflect the beginning of a period of change in economic activity around Iceland's coasts; Skálavík underwent a transition in site activity towards more intermittent occupation. This transition is perhaps consequent on the emergence of other sites indicating specialist maritime resource use in the thirteenth and fourteenth centuries. As the activity pattern became intermittent, however, the Skálavík site expanded in size in the late AD 1200s/early AD 1300s, as demonstrated by the findings from Skálavík trench 3. Kálfeyri first came into occupation slightly earlier, sometime between AD 1205 and AD 1275, but the same intermittent characteristics were observable there. A baiting location at Selvík dating to the fourteenth century, coupled with the emergence of specialist sites strongly supports the idea that this particular region of Iceland was fully-functioning in exploiting its surrounding marine resources.

Skálavík 1 can be split into two temporal phases (for the purpose of this observation), the latter correlating with the emergence of Skálavík 3 and Kálfeyri. The characteristics between the earlier and later periods differ enormously, as demonstrated in chapter four, revealing that a transition did take place. The difficulty is in interpreting whether this transition represents a growth in specialist exploitation and a regional expansion, or whether this is an indication of a previously existing subsistence strategy being superseded, evolving into something more commercially driven. It is difficult to ascertain what socio-economic process this transition represents, however, it does underscore that a change was occurring. It has been suggested recently by Zori that immediately after *Landnám*, marine resources were a fundamental part of the earliest Icelandic economy whilst livestock numbers grew, and once target stock levels were reached, the country could turn its attentions to its terrestrial resources. The pattern of a reduction in the proportion of marine species found in zooarchaeological assemblages after AD 1200 echoes this theory.[626] This change could have happened in tandem, or completely independent of, the growth in European long-distance trade. After AD 1200, northern marine resources were increasingly finding their way into European diets. Isotope analysis reveals zooarchaeological assemblages in Europe containing a growing proportion of fish bone from more distant, 'northern' waters. These initially revealed fish bones from prominently local sources between the ninth and twelfth centuries AD, before undergoing a transition to the more distant catch after the thirteenth century.[627] It is unclear whether European traders were fishing in these 'northern waters', or if Scandinavian or Icelandic traders were making their way south from Iceland with the stocks. The growth in seasonal occupation at certain sites which occurred after AD 1200 could represent both a change in the economic importance of fish within Iceland, and also the increasing mainland European demand for, amongst other things, dried cod. Whether the loss of one opportunity allowed another to flourish, or whether this transition was enforced by incoming groups or individuals, is still unclear.

Research Question Two – *Were specialist fishing locations occupied seasonally, or occupied throughout the year?*

Occupation of the sites would have been overwhelmingly determined by fish migration and spawning patterns; if fish were not there to be caught, there would have been little point in the site being occupied, unless there were other economic activities taking place during otherwise slack periods. Few sites around the Icelandic coast had access to year-

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[626] Zori, *From Viking Chiefdoms to Medieval State in Iceland*; A. Pálsdóttir & T. McGovern, 'Preliminary Report on Faunal Remains from Vatnsfjörður 2003-2006', in K. Milek, (ed.). 'Vatnsfjörður 2006, Interim Report. FS356-03096', (Reykjavík, 2007).

[627] Barrett *et al.,* 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

round fishing grounds, and even these were only really accessible after the advent of engine-powered vessels in the nineteenth century.[628]

On the basis of the signatures and characteristics which have been identified, outlying fishing station locations appear only to have been occupied during the fishing seasons. The geoarchaeological approach seeks to identify textural pedofeatures associated with abandonment within the stratigraphy as periods of prolonged human absence from sites. The very nature of the sites and how they operate means that annual or near-annual laminations are simply not possible. If we accept that, then any signatures of abandonment indicate not simply seasonal absence of activity but sustained episodes of inactivity across a number of seasons.

In the site where pre-AD 1100 samples were obtained, Skálavík 1, few signatures associated with abandonment were present; cultural material has been allowed to accumulate with a degree of continuity. These signatures were viewed in comparison with later periods both in the same site and at other outer fjord sites, which show indicators of both strong presence and absence. It would suggest that the Skálavík 1 site, during its earliest phase, was being occupied season after season, with longer periods of absence associated with the later periods of occupation. The exact duration of these abandonment periods can only be estimated as several years or more at present. This factor, in turn, raises the question about the transition observed in the stratigraphy, and the reason behind these abandonment signatures suddenly appearing? Is it a question of ownership, or resource availability? At present, all that can be done is to recognise the changes which were happening within Icelandic society in terms of resource use,[629] and

[628] Bolungarvík is one example of a shore base with year-round access to fishing grounds.
[629] Zori, *From Viking Chiefdoms to Medieval State in Iceland.*

acknowledge that trade with Europe was having a greater impact in more distant regions.[630]

Research Question Three – *Is there any evidence within the cultural record of the soils and sediments to suggest that activities other than fishing were taking place?*

There were no indicators within the cultural record of the soils to suggest that other economic activities, such as pastoral farming, were taking place. It would not be unduly speculative to suggest that these outlying locations also had a secondary function, perhaps as summer shieling grounds. The seasonal migration to locations far from the home farm was a common practice in Iceland, and may have been a viable solution for obtaining additional biomass for livestock during an era when landscape degradation was a pressing issue and the availability of good quality pasture land was reducing. Like the traders and fishermen of thirteenth century Europe, it may have been necessary to travel further to maintain access to resources. The trace signatures of herbivore material which have been identified can be attributed to the possibility of livestock being present at the location during fishing seasons. Fishermen were known to take supplies and livestock with them during the season for their dairy produce. The residues representing high-temperature burning of fuel, found in trace amounts at Kálfeyri and Skálavík, can be attributed to metalworking, processes closely related to fishing activity in the preparation of equipment. If the fuel residue and animal waste signatures were found in greater abundance, there would be a necessity to raise doubt on the idea that these were solely fishing stations. Activity other than fishing has to be expected as day to day living involved activities which were found on a greater scale elsewhere. These

[630] Barrett *et al.,* 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

observations reaffirm the idea that the sites investigated were solely for the purpose of exploiting marine resources.

Research Question Four – *What events, if any, were driving the development of specialist fish exploitation?*

No single cause can be said to have contributed to the development of specialist fish exploitation in Iceland. So many social and environmental factors driven from within and beyond Iceland can all be said to have had a determining influence on the outcome. There are, however, key developments which perhaps influenced development more than others, taking place at various times through Iceland's history. Key phases and transitions have been identified which will be briefly discussed; the emergence of specialist fishing communities, the AD 1100s transition, AD 1300/1400 development, abandonment in the Middle Ages, and the seventeenth and eighteenth century resurgence.

The initial development of marine exploitation appears to have been driven by an internal demand within Iceland. Zooarchaeological assemblages at inland sites demonstrate strong marine signals prior to the AD 1100s.[631] The nature of the initial settlement of Iceland and the need to build up livestock numbers to a level capable of sustaining a Scandinavian-style agricultural regime would have required the colonists first to turn to foraging of Iceland's natural resources. With little in the way of a wild terrestrial mammal population, birds, eggs, berries, and the resources of the sea would have been the focus of attentions. As human population numbers increased, the fish resources of inland waterways may have been insufficient to meet demand, triggering

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[631] Zori, *From Viking Chiefdoms to Medieval State in Iceland*; Pálsdóttir & McGovern, 'Preliminary Report on Faunal Remains from Vatnsfjörður 2003-2006'.

development at more outlying locations with easier access to deepwater marine fishing grounds. Such a progression from interior waterways to the coast may explain the more than two century gap between *Landnám*, and the earliest date (Skálavík 1, AD 1015-1075) obtained from one of the fishing locations.

The AD 1100s transition is less clear. The aforementioned zooarchaeological assemblages show a reduction in the marine signal, which might indicate that terrestrial resources were, for whatever reason, playing a greater part in the diet of Icelanders at this time.[632] Concurrently, traders and fishermen from mainland Europe were travelling greater distances for their marine produce in order to meet the demand from a growing population.[633] How these two possible factors interact is unclear. Did Icelanders leave an opportunity open, or did Europeans impose themselves on to the Icelandic landscape? It may simply be a case of opportunistic commercialism, that the circumstances were favourable in the growing search for reliable marine resources. Icelanders were in a promising position, as they had both terrestrial resources and maritime resources at their disposal, and it is possible that a deal was struck that allowed fishermen from overseas to exploit the resources, while returning a percentage to Icelanders. That way, Icelanders could supplement their terrestrial diet with fish and not need to subject themselves to the dangers of the seas.

The transition through the AD 1200s and into the AD 1300s to more specialist levels of exploitation can be attributed more confidently to the growing role Iceland was playing as a provider of fish to European markets. This interpretation tallies with the theories of

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632 Zori, *From Viking Chiefdoms to Medieval State in Iceland.*

633 Barrett *et al.,* 'Interpreting the Expansion of Sea Fishing in Medieval Europe Using Stable Isotope Analysis of Archaeological Cod Bones'.

Thór.[634] The economy of Iceland was expanding at this time, not contracting.[635] A transition from *klipfisk* to *skreið* production at Akurvík shows a response to meet overseas demand,[636] and a change in the value of fish from a subsistence product with a labour value, to a product with a monetary value.[637] After AD 1350, winter was replacing spring as the main fishing season. This may have been to keep up with demand, and also reflecting the fish migration patterns in the more preferred fishing grounds. New fishing-station sites were established, and geoarchaeological evidence from their earliest period reveals strong exploitation characteristics (Skálavík 3, Kálfeyri, Selvík), and no further period of growth and development. These sites were swiftly imposed on to the landscape, supported by investment which would have yielded favourable levels of profit. Periods of apparent absence of activity on the sites were growing. Such abandonment episodes possibly reflects the nature of the end product, in that *klipfisk* can be produced for more months of the year than *skreið,* or signal the impact of deteriorating environmental conditions which brought events such as widespread sea ice around the coasts. Even with a recognition that demand from overseas was increasing, there were mounting pressures from within Iceland; cold spells from AD 1180 to AD 1220 would have reduced the year-on-year returns of fish. This cold episode appears to have coincided with a change in site use at Skálavík 1. Environmental conditions were deteriorating progressively in Iceland, forcing greater reliance on marine resources. The ruling prohibiting the export of fish around AD 1294 is testimony to a significant trade being in place (in order for it to be suspended and warrant mention by the king), as well as underscoring widespread supply problems within the country.

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[634] Thór, 'Icelandic Fisheries, c.900-1900'.

[635] Byock, 'The Age of the Sturlungs'.

[636] Amundsen *et al.,* 'Fishing Booths and Fishing Strategies in Medieval Iceland'.

[637] This is part of Cronon's *Order of Nature*. For further explanation, see W. Cronon, *Nature's Metropolis: Chicago and the Great West,* (New York, 1992).

During the later Middle Ages, particularly between AD 1430 and the AD 1490s, a prolonged episode of absence of evidence for processing activity can be observed at the sample sites. This episode coincides with disruptive environmental impacts from pestilence and volcanic activity, which had an overwhelmingly detrimental impact on Icelandic society. Particularly visible at Skálavík 3 were signatures which suggest that fishing was not taking place, and when it was, that the scale of operation was reduced in comparison to earlier periods. Labour may have been focussed on inland activities, with the lower classes who survived the plagues and famines of this period taking up residence in one of the growing numbers of unoccupied farms. Politically, Iceland was under the rule of the Danish crown, and it may have been that the Icelandic fisheries were deliberately suppressed in order to keep the price of Scandinavian fish inflated. The sixteenth century saw a reduced demand for fish through a change in Lenten observance principally as a result of the Protestant Reformation, with fewer people adhering to pre-Reformation obligations to consume fish on holy days. Environmentally, it was also a time of change, with stormier seas recorded. The fickle nature of cod as a species may have meant that because the polar front shifted to such an extent, fish simply were not in the fishing grounds where they used to be found. Even with this period of decline, it was to make a comeback once more.

During the seventeenth and eighteenth centuries AD, further developments in the fisheries can be observed with new sites emerging (Biskupsvík, Arnardalur). These new locations were different in nature to those of earlier periods. The fisheries were entering a new technological age and played a different role in a struggling society, which meant that the soil signatures of activity had different characteristics to those of earlier phases. Biskupsvík was developed to meet basic subsistence demands; this is a period when widespread degradation had affected the Icelandic landscape, reducing both the carrying capacity and output of the land. Weather events were also becoming more extreme, resulting in landowners investing in places such as Biskupsvík in order to supplement their existing resources. Volcanic activity was also becoming more frequent which made the colder decades even harsher. It was not, however, all about subsistence, as the growth of Arnardalur demonstrates. This was a new age of decked vessels, and the present, weaker land-use characteristics (of lower soil chemistry levels and fewer waste remains) found within the stratigraphy at that site represents this transition. Processing was no longer a land-based activity but one carried out at sea on these decked vessels. *Skreið* was making way for *saltfish* as people's tastes changed, which would have stimulated demand.

Research Question Five – *Of all the sites surveyed, at what point in the geoarchaeological record can the most intense period of occupation be observed, and what can be observed during specific temporal phases?*

The period around AD 1100, before the transition towards a more specialist occupational period, revealed itself to be very intense. This intensity was possibly caused by the year-on-year (or close to it) occupation of the site. Constant deposition created a series of signatures reflecting growth over time. This reflects a progression of growing demand over time catering to an internal market.

The period from the AD 1200s to the AD 1400s is where various sites reveal their most intense periods of occupation. This intensification was caused by Iceland's role in the wider European fisheries market. Occupational periods reveal more intensive activity at this time, with continuing growth in some areas into the fifteenth century AD.

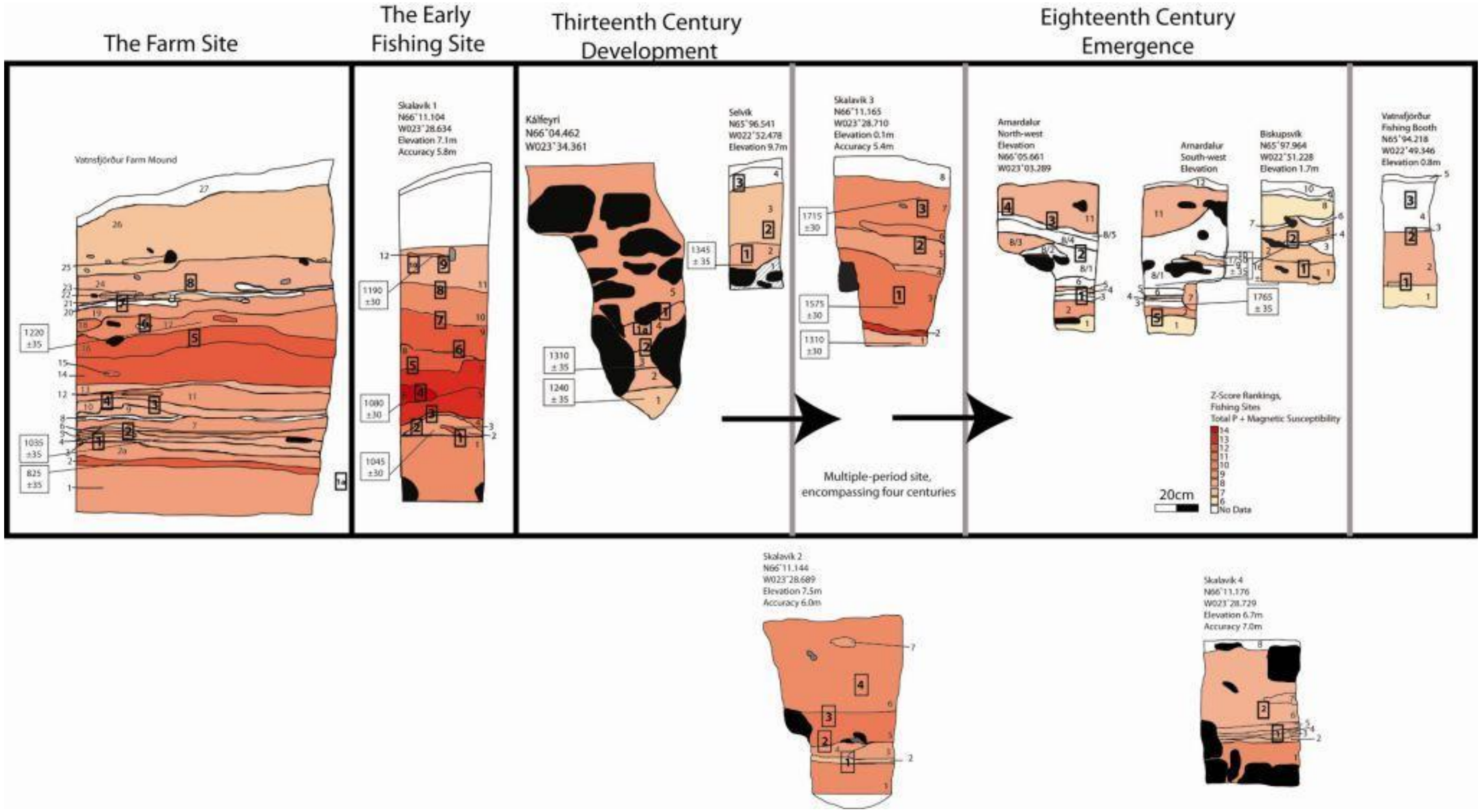

Figure 158: Temporal and functional classification of surveyed sites

During periods of occupation what is observed were bone and fuel residue materials, as well as elevated levels of phosphorus and soil magnetism. During periods of abandonment, indicators were iron accumulations, fungal spores, coated mineral grains and evidence for plant material which represents vegetation being allowed to grow over the site. In addition to this, phosphorus and soil magnetism levels become comparatively reduced. Where there were elevated levels of particle size, these were generally to be found during temporal phases which were associated with stormier seas and detrimental environmental conditions, where sand has been washed upon the site with a higher frequency. This characteristic is most clearly observable in the post-medieval phases.

Research Question Six – *On the evidence provided, can this research support the theory of previous research which attributes the wealth found in the archaeological record at Vatnsfjörður to the exploitation and control of the maritime environment?*

Clearly, there were periods where the marine resources have been systematically exploited, which would ultimately bring with it economic rewards. The economic complexity of the region is something which was not fully appreciated at the start of this research. Vatnsfjörður demonstrates wealth within its archaeological record, but it is just one of many farms within Vestfirðir which were said to have been powerful and owned fishing stations (or the rights to fishing stations), but it is the only one which has been subject to extensive archaeological investigation.

If the findings from the sites surveyed as part of this research are to be used as a proxy for suggesting that the earliest wealth was derived from the exploitation of the maritime economy at outlying locations, the answer has to be no. More than two centuries passed from *Landnám* to the earliest radiocarbon age of a specialist site (Skálavík 1), suggesting that wealth may have come from other sources. Terrestrial resources were said to have been limited in Vestfirðir, which has given rise to the theory that the wealth represented within the archaeological record may have been derived from elsewhere in the Norse world.[638] This, however, does not consider the exploitation of marine resources as an evolving economy. As suggested earlier in this chapter, this may have been the case, where fishing grounds closer to land may have been exploited first. If so, further investigations into specialist fishing locations further into the fjord and closer to the power centres may be essential.

Research Question Seven – *Can the establishment of Iceland be regarded as a Scandinavian trading post and an economic extension, or was it settled by people who intended to continue their chieftain-based lifestyle and live by subsistence means which so happened to evolve into a major provider of specialist marine products?*

This question is closely related to the one above, in the acknowledgement of the years which passed before systematic exploitation began to take place. In the absence of further investigations into inner fjord areas, the current evidence has to be used as a baseline to answer this question. Such a gap in the timeframe would suggest that the *Landnámsmen* were content living within their means and having little or no specialist trade connections with the rest of the Norse territories. The systematic manner in which marine species were targeted after the AD 1100s is said to be identical to that of western Norway in the early centuries AD.[639]

The debate regarding *Landnámsmen* is still current, and there is a growing volume of evidence to suggest that they were not so much persecuted individuals wanting to maintain their chieftain-based lifestyles, but working with powerful individuals in

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[638] Byock, 'The Age of the Sturlungs'.

[639] Simpson *et al.,* 'Cultural sediment analyses and transitions'.

Norway which helped develop an economy within Iceland. It is unlikely that there was a strong intent to have Iceland as a direct economic extension to Scandinavian kingdoms. It appears to be the establishment of opportunistic individuals settling on a distant landscape, conditioned by a unique set of circumstances, which so happened to take advantage of burgeoning demand. The ultimate result of this was Iceland becoming part of the wider European economy over subsequent centuries.

A degree of detachment of Iceland from the Norse kingdom exists until around the thirteenth century AD, when the loss of independence and incorporation into a broader European network takes place. When circumstances cause a greater isolation in Iceland during the fifteenth century, the characteristics in the cultural record do not show a return to what was experienced prior to the thirteenth century development. In this context, it would suggest that circumstances behind this isolation were different to before, and it was increasingly difficult for Icelanders to be more sustainable during later periods as a result of the modifications which had taken place in their environment. The benefits of a low population finding its way on a pristine landscape were no longer replicable, nor the same outcomes achievable.

Research Question Eight – *Are the sites surveyed comparable, does the geoarchaeological record correlate well with the documentary and climate history record, and what material can now be expected to be found within the geoarchaeological record at specialist fishing locations in the light of this research?*

In the context in which they were sampled, and in reference to the context of the historical and environmental record, these sites to a degree appear to be comparable. The significant transitions and key events which were represented in these records, broadly speaking, are echoed in the findings from this research. Events were found to closely fit in with the drivers behind developments. A chronology has been developed which provides a close and logical narrative, further enhancing knowledge in an attempt to explain the development of specialist fishing communities in Iceland. Where the temporal periods of sites overlap, the same broad activities can be observed across the sites, revealing that the findings obtained can be used (with limitations) to explain broader scale activities across the region, reflecting the wider social and environmental context. Where differences were observed, this can be attributed to regional variance and the individuality of Vestfirðir in the broader historiographical context of Iceland.

In light of the research, elevated levels of specific elements and characteristics as well as distinct micromorphological observations can show what is to be expected in the geoarchaeological record at specialist fishing locations. The main element is phosphorus; elevated levels, particularly in acidic environmental conditions reflect a deposition and decomposition of bone material derived from the processing of fish. Elevated levels of soil magnetism can be used as a proxy for on-site presence, with fuel residues indicative of the processes which were going on. These have been shown in this research to correlate very strongly, reflecting their association. Distinct bands of bone material as well as areas of fuel residues are indicative of specialist activity. Time spent away from the site is as much of a characteristic, with the microstructure and biological matter representing the phases of standstill providing an insight into overriding market demands and environmental conditions as much as occupational indicators.

What was expected to be found in abundance was not identified in great numbers in any of the Icelandic sites. Calcium-iron-phosphate features were found in abundance in Vesterålen,[640] and were expected to be widespread throughout fishing sites. This was

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[640] Ibid.

not the case in the sites sampled here, with their presence found in only trace amounts in very few stratigraphic horizons. Their absence may be related to the wider environmental conditions, as the enhanced levels of phosphorus and the highly fragmented bone component identified under the microscope shows that conditions were hardly ideal. The sampling from a sheet midden rather than a designated midden deposit may have contributed in the lower frequency of this characteristic. This did not hinder the ability to evaluate the site in regards to the maritime activity which was being undertaken, and permits the observation that in an Icelandic context the absence of calcium-iron-phosphate features does not mean an absence of on-site maritime activity. As demonstrated, the adoption of a multi-proxy alternative can be used as a replacement methodology to determine on-site activities, and the absence of calcium-iron-phosphate features must not be used solely as a way of determining on-site fishing activity, particularly in the context of Iceland.

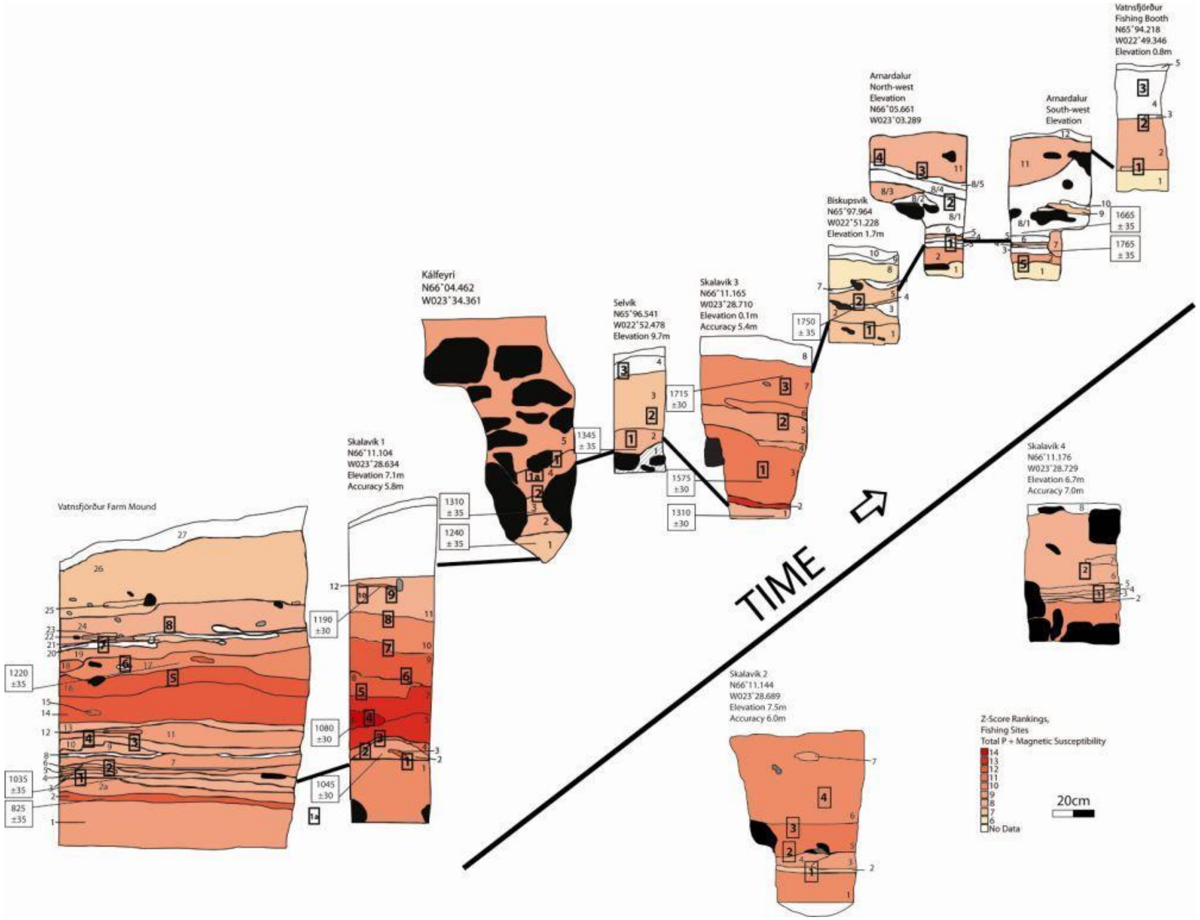

Figure 159: Diagonal alignment of site stratigraphies

Chapter Summary

These research questions demonstrate the manner in which maritime resources were utilised in Iceland, and showing that without any doubt, they were essential not only in the centuries following *Landnám,* but essential in allowing the country to become part of a vibrant and wide economic area. The internal trading and exchanging, and the systematic exploitation of the resource, can almost be viewed as a pre-requisite to becoming part of this trade. However, amongst the commercial activity, trade in fish retained an important place within Icelandic society, supporting the terrestrial economy. Being a society on the margins and more susceptible to environmental pressures, it was essential for Icelanders to have access to additional natural resources during times of need. Even during later periods, long after the foreign-led fisheries had left their imprint on the Icelandic shoreline, they still had a role to play in the subsistence economy in Iceland. This research has exposed a resource which has such versatility that it has played such a key role in all aspects of life; across Iceland, Europe and the world, and it is hoped that this role can continue long into the future.

This research has provided a context of social, cultural and environmental change relating to pre-modern fishing communities in Vestfirðir, Iceland, providing not only a regional context but also the role of fishing in a North Atlantic context. Spanning just under a millennium, this research has provided evidence behind the reasons behind transitions relating to maritime activity in Iceland. Through the integration of historical and environmental data, it has been possible to supplement and enhance the findings from different research arenas and bring them together to enhance their value and in turn, enhance our knowledge of fishing communities in pre-modern Iceland. The in-depth analysis of coastal sites has developed the work by Edvardsson, which was a wider survey of coastal activity, but without a strong chronological foundation. It integrates well with the research undertaken at Akurvík and Gjögur, and moves these sites from standalone locations to understanding their role in a wider regional landscape. More recently, the excavations at Snæfellsnes have supported the strong maritime episodes found in this research, and there is no doubt more will emerge in coming years.

The collation of historiographical material has allowed a newly revised and critiqued narrative to be constructed and place the events and episodes in an environmental context. The same can be said for the environmental data, which can be interpreted with a greater degree of confidence when cross-referenced with historical sources. Together, this methodology has allowed the construction of an environmental history, which can allow this research to be placed in a broader environmental framework associated with themes prevalent in today's society; sustainability, resource management and resilience. Lessons can be learned when we look at the past in order to find a solution to the problems we face today. Environment and society are regarded as being considerably more complex, but the fundamental core themes are the same as they were over 1,000 years ago.

Resource exploitation in Iceland during the post-*Landnám* period can be regarded as being sustainable, given that it allowed a population to continually grow without the pressing need for imported resources. The country lived comfortably within its means until about 300 years after *Landnám*, when changing environmental conditions meant the carrying capacity of the land could no longer tolerate the existing landscape practices, causing widespread degradation and abandonment. It is around this time that there is a growth in the maritime economy (both internally and externally), however, after AD 1300, changing environmental conditions brought hardships to the Icelandic population, who were now subject to resources being exported and terrestrial carrying capacity ever-reducing.

Pressures in the AD 1400s were mounting, and it could be argued that if the plague did not kill off a significant proportion of the population, there may have been a resource crisis in the Middle Ages much like that experienced four centuries later. Fortunately (or unfortunately if you were one of the forty to fifty percent killed by the plague), crisis this time was averted, and society was given the chance to reorganise itself into something more sustainable. This example, although coincidental at the time and rather extreme, shows that given the opportunity, we should be willing to revise the context in which we live our life and reorganise ourselves to ensure the protection and prolonged availability of valued resources.

Being resilient means there needs to be something to fall back on in times of need. Iceland, despite its crises has been fortunate enough to be able to turn to its rivers and seas, even though they were far from readily available resources at all times. When this resource, turned to in times of hardship, becomes the core resource in the economy, there no longer is this resource to turn to in times of need. It may be the case that in the fourteenth century, the Selvík site and its molluscan remains may be reflecting a site turned to in hardship. The stratigraphies here have shown differing instances when the fisheries reflect wider crises, such as the eleventh century hardships reflected in Skálavík 1, and the eighteenth century hardships expressed in the emergence of Biskupsvík. At Skálavík, the wider environmental problems caused a cessation of occupation at a vibrant site during one of its peak periods, and Biskupsvík shows a new emergence of a site during a time of national hardship. These differing responses show the flexibility of the fisheries, and demonstrate that it was susceptible to wider changes but could also be turned to during times of need. In the present day context, we should be willing to adopt flexibility in our day-to-day approach in order to succeed, as well as being innovative and have a desire to attempt something not necessarily new, but different to the existing regime.

Given the examples of resilience, the chronological history of the Icelandic fisheries is marked by a prolonged period of collapse and inactivity. The social and environmental changes which took place in Iceland and throughout the North Atlantic from the fourteenth century onwards had repercussions which were reflected in the prolonged absence at the fishing locations investigated here. This inactivity at these sites can be observed as a response to social changes in Iceland, rather than collapse within the society. Opportunities presented themselves in the terrestrial economy, and due to leadership favourability of this economy, it was the preferred option. Fishing still continued offshore, largely by foreign fishermen, who would have left a minimal imprint on the Icelandic shoreline as they caught their share and left for home.

In summary, the specialist exploitation of marine resources allowed early Iceland to flourish, facilitated the country to become part of a wider European trading network, and was a resource to be turned to in times of hardship. The chronological narrative of Iceland's fisheries are far from uniform, however, the similarities and patterns which were expressed in the environmental and historical narrative show a degree of consistency which reflects the role it has played in allowing this society to develop. The recognition of the value of this resource has been clear for over a millennium, something which continues right through to the present day, shown in the level of protection it continues to receive.

Fish has always been more than a resource for Iceland. It is also a symbol of the country, an identifiable character and something which brings with it a sense of national pride and international recognition. It is hoped, that by adopting a unique multi-disciplined approach, a new and more detailed narrative has been outlined regarding the history of fishing in Iceland. *Felix qui potuit rerum cognoscere causas.*

There were several developments which could be made in future research on the basis of what has been identified in this study. These suggestions can not only develop this study to the next level, but also help broaden the wider narrative and of the country in terms of maritime resource exploitation and the associated wider economic framework.

Future studies may benefit from further investigations into the regional economy of Vestfirðir; establishing how different sites were connected and how they interacted with one another, from both historical and also geoarchaeological perspectives. Within such a study, there is value in seeking to establish whether different land use signatures can be found between sites used by Icelanders and sites used by foreign fishermen. Evidence for this may be provided by geoarchaeological investigations, and the development of a rigorous typography would be beneficial for future research.

During the course of this research, the site at Eýri was investigated, revealing zooarchaeological assemblages relating to a 'non-specialist' economy, neither fishing or farming, and not likely beyond a subsistence level. Remains here were mixed, and the opportunity to undertake geoarchaeological investigations here should be seized in order to take these findings into a broader economic context.

The template used in this present research project can also be extended across Iceland. Vestfirðir is only one region, and is known to have been interconnected socially and economically with other areas. It would be a significant step forward if it was possible to determine (i) who the early trading partners were and (ii) whether the transitions observed here are also echoed in other parts of Iceland. The southwest of the country became its power centre during the eighteenth century, and it would be interesting to establish how much – if at all - fishing played in this development in the context of earlier periods. Before this time, power centres were found at the ecclesiastical centres elsewhere in Iceland.

The most readily achievable study would be to maintain a research focus on Vestfirðir, but with a wider sample of sites. The aim of this would be to substantiate the findings obtained from this research, and also understand the context of economic development. If the early economy evolved and developed from an internal economy fulfilling subsistence requirements to one which targeted specific species from outlying locations before the baseline date obtained at Skálavík, there should be evidence contained within the site records of locations further into the fjord. This would be able to link together a chronological narrative between earliest post-*Landnám* farm site dates and the AD 1015-1075 date at the outlying site of Skálavík which specialised in the exploitation of marine resources. In addition to this, it would be essential to consider other maritime activities such as shark hunting and whaling, and establish what impacts these activities had on the terrestrial record. These activities were known to have taken place in later periods, so a potential starting point would be to conduct a geoarchaeological and historical analysis on a later site where shark- and whale-hunting were known to have occurred, which could be cross-referenced with sites from an earlier period.

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