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Insular Interconnectivity in the Viking Age: A Geospatial View from Norse Jarlshof

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Insular Interconnectivity in the Viking Age: A Geospatial View from Norse Jarlshof

By

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During the Viking Age, settlements and trading centers were often located near lakes, seas, waterways, and sailing routes. As such, access to other locations was facilitated, whether for the purpose of settlement, trade, resource acquisition, or conflict, by some form of seafaring vessel or watercraft. Over the course of the Scandinavian Diaspora, a level of cultural and economic interconnectedness was maintained between mainland Scandinavia and the settlements in the North Atlantic region. This shared link with Scandinavia contributed to the development of local connections between insular and coastal sites within the broader diasporic network. This thesis considers the archaeological evidence for insular interconnectivity during the Viking Age ca. 790-1066 CE in the British Isles and North Atlantic, as well as the potential for using a GIS-based joint visibility and mobility model that depicts the experiential use of, and interaction between, past landscapes and seascapes while maintaining a quantitative approach. This is considered through the evaluation of intervisibility between a mobile sailing ship entering the mouth of Grutness Voe and the occupants of the Norse farmstead at the Jarlshof archaeological site, Mainland, Shetland over the course of its occupation ca.850-1200 CE. The results of this research support the argument that the investigation of the diasporic maritime communities of the Viking Age can benefit from the use geospatial technology to evaluate insular interconnectivity and to better conceptualize broader patterns within those extensive maritime networks. Broadly speaking, these findings can also inform our understanding of coastal and

insular populations in the past, and the way that they have engaged with their environment, both aqueous and terrestrial.

“The dust dreams of the world it had once been. But the dust, alas, does not command the wind.” (Erikson, 2008, p.430)

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CHAPTER 1: INTRODUCTION

Westerdahl (2006) notes, the root of the English word ‘isolation’ can be found in the Italian word for island: ‘isola’. However, as Fitzpatrick and Erlandson (2018) also note, with the arrival of human populations, the ecological isolation of previously model ecosystems is often irreversibly disrupted; that the settlement of human populations on islands effectively terminates their geographic isolation. Each voyage that is undertaken to and from that island, whether for residential, logistical, or tactical pursuits, results in some form of interaction between the seafarers and the broader world outside (Crouch, 2010; Farr, 2006; Terrell, 2010; Westerdahl, 2006).

In recent years, researchers have been engaging with the concept of centrality as it relates to maritime networks (Crouch, 2010; Farr, 2006; Terrell, 2010). They have found that centrality in maritime networks is intimately linked to the number of sailing routes between insular destinations, and their relative nearness to other islands, or coastal settlements within those social, cultural, and economic networks (Crouch, 2010; Farr, 2006; Terrell, 2010; Westerdahl, 2006). Terrell (2010) developed the term ‘social seascapes’ to describe the multi-level, and multi-purpose web of sea-based pathways that enable maritime communities to maintain contact with one another.

Westerdahl (2006) suggests that amongst past maritime societies, insular and coastal settlements may have been more readily accessible, and in fact less isolated, (both in terms of social interaction and physically accessibility) than many contemporary inland settlements. Sailing routes enabled far flung communities to remain enmeshed in broader social, economic, and political spheres (Crouch, 2010; Farr, 2006; Terrell, 2010). Sailing vessels enabled maritime societies to engage in trade, resource acquisition, conflict, exploration, and settlement (Barrett, 2019; Cooney, 2003). Thus, enabling far flung communities to remain enmeshed in broader social, economic, and political spheres (Barrett, 2019; Crouch, 2010; Farr, 2006; Terrell, 2010).

Building on this line of thought, we cannot hope to understand the manner in which past peoples have inhabited coastal and insular localities if we focus solely on the terrestrial landscapes on which their settlements were constructed and ignore the non-tangible networks that bound them together. It is for this reason that, one primary concern of this research was the development of a joint visibility and mobility GIS-based model that could more readily depict the experiential use of past landscapes and seascapes by maritime societies in the past. By joining mobility and visibility analyses to encompass both landscapes and seascapes, a more holistic investigation of maritime environments of the past can be pursued.

Maritime societies have been identified in northern Europe since the Bronze Age and these various cultures have had a wide variety of cultural expressions both typologically and chronologically (Kobyliński & Rabiega, 2018; Skoglund, 2008; Westerdahl, 2019). These various expressions span nearly 3,000 years, beginning with early Bronze Age stone carvings (Bradley et al., 2010; Kobyliński & Rabiega, 2018; Kristiansen, 2010; Soggnes, 2008), and stone-ship burials that span both the Bronze- and Iron Ages (Bradley et al., 2010; Kobyliński & Rabiega, 2018; Skoglund, 2008), Gotlandic picture stones erected during the Iron Age and into the Viking Age (Oehrl, 2017; Westerdahl, 2019) and the use of ships and boats in the burial practices of both Iron Age and Viking Age peoples of Northern Europe (Bonde & Christensen, 1993; Bonde & Stylegar, 2016; Price et al., 2016). These depictions span some 3,000 years of pre-history and beyond, suggesting a lasting cultural importance of maritime activity to the peoples of Northern Europe (Skoglund, 2008).

With the onset of the Viking Age, we see the diaspora of a maritime society into new geographic areas which provides an opportunity to consider how initial expansion into, and continued occupation of those areas may have been facilitated by the maintenance of sailing routes (Jesch, 2015; 2016). As mentioned above, centrality in maritime networks has been linked to the number of sailing routes between a given location and its proximity to other points within a still broader series of maritime networks (Crouch, 2010; Farr, 2006; Terrell, 2010; Westerdahl, 2006). Jesch's (2015; 2016) arguments for the diasporic expansion of Scandinavians during the Viking Age are intimately connected to both Terrell's (2010) concept of social seascapes and Farr's, (2006) interpretation of seafaring as social action.

The multiperiod site at Jarlshof in south Mainland, Shetland was selected for this research, because it not only represents an ideal case study for the investigation of insular interconnectivity overtime, as evidenced by the archaeological record at the site as it relates to both local and long-distance trade and exchange throughout the Viking Age (Fanning,1994 Hamilton,1956; Hansen, 1993; 2003; Harrison, 2013; Hunter, 2008; Sindbæk, 2012; 2019; Wallace, 2016), but also because the initial settlement of the Shetland Islands, and Scotland in general in this period is not well understood historically, chronologically, or archaeology (Barrett, 2003; 2010; 2012a; Bond and Dockrill, 2016; Downham, 2007b; Ó Corráin, 2001).

Given the lack of primary historical records for the region, place name evidence is one of the primary indicators of Scandinavian settlement in the region (Downham, 2007b; Fellows - Jensen, 2012; Gammeltoft, 2010; Nicolaisen, 1969). Placename evidence for Scandinavian settlement in the British Isles is particularly saturated in the Danelaw as well as in the Northen and Western Isles of Scotland, with the evidence from Shetland and Orkney being the most extensive, eradicating all evidence of earlier Pictish place names there (Fellows -Jensen, 2012;

Gammeltoft, 2010; Nicolaisen, 1969). These names include both environmentally descriptive terms (Fellows -Jensen, 2012; Gammeltoft, 2010) and habitation-oriented place names (Fellows - Jensen, 2012; Nicolaisen, 1969). Given this general dearth of information for the region, reinvestigation of existing sites using new methodologies, such as geospatial technologies, is warranted.

A series of geospatial analyses were conducted using ArcGIS Desktop 10.8.1 in order to investigate a number of research questions that were raised over the course of the initial research process. The analyses included a Cumulative Viewshed Analysis from the perspective of the Norse settlement at Jarlshof, a Maritime Least Cost Path Analysis (MLCPA) from three archaeological sites in the Orkney Islands, and a Fuzzy Cumulative Viewshed Analysis, intended to represent a ship sailing towards the settlement, that was based off the results of the MLCPA. These three overarching analyses were rerun a number of times (CVA =5, MLCPA = 9, FCVA = 5) to account for a number of different variables that were of particular interest to this research.

The questions to be addressed by these analyses can be divided into three categories: settlement-based visibility, ship-based mobility, and ship-based visibility. The questions related to settlement-based visibility included: Would an observer standing at any of the doorways within the settlement have the ability to observe the sea lanes surrounding the site? Does the site's orientation and organization facilitate or hinder this? Do structural changes at the site impact those viewsheds through time? The questions associated with ship-based mobility included: Would all the modeled sailing routes conform to similar paths? What factors might influence substantial variation in the path/route results? Questions corresponding to ship-based visibility included: Does the site's placement on the slope of a settlement mound enable it to be seen by an observer arriving from the sea? If so, does the prominence of the site change over time as structures at the settlement are decommissioned and new ones are erected?

The hypotheses formulated in response to the questions of settlement-based visibility are as follows: It was hypothesized that the placement of the site within the built and natural landscape would offer enhanced observation ability to its occupants due to the site's increased elevation in relation to its immediate surroundings. Thus, as the site continued to grow in affluence and scale, it was hypothesized that overall visibility from the site would increase with time as more structures, and thus additional observation points appeared. Despite the decommissioning of old structures and the erection of new ones, throughout the course of the site's occupation, it was hypothesized that the ability to view sea lanes from the settlement would not be adversely impacted by those changes. These hypotheses would suggest a potential correlation, although not a direct one, between visibility, occupational continuity, and connectivity with other sites over the course of the Viking Age.

The hypotheses related to sea-based mobility included: The hypothesis that all the modeled sailing routes would, generally, conform to the same path when the points of origin were accounted for, because it was assumed that a relatively direct route would be the most economical in terms of energy expenditure. The second research question led to the development of the cost friction surfaces detailed in Chapter 7 and 8 of this work. The hypotheses linked to ship-based visibility are detailed here: It was hypothesized that the placement of the Norse settlement on the slope of an archaeological mound would result in the increased visual prominence of the site from the sea, as Harrison, (2013) argued, that many of these archaeological mounds in the Northern Iles of Scotland were located at 'visually dominate' locations. It was therefore also hypothesized, that as the settlement increased in scale through time, its visual prominence from the sea would also increase.

The overall layout of this thesis is detailed below. The chapter topics briefly outlined in this introduction include, Chapter 2 which considers the cultural conception of seascapes as extensions of lived environments among maritime societies of the past, and the importance of reevaluating the way we think about the dichotomy of land and sea. Chapter 3: considers the various cultural expressions of maritime societies of northern Europe from the Bronze Age into the Iron Age with particular attention to iconographic depictions of watercraft as they relate to cosmology and technological changes, as well as the use of watercraft both real and symbolic in mortuary practice. An overview of the Viking Age, the Viking Diaspora, and their impact on Europe and other geographic regions follows in Chapter 4. Chapter 5 involves the consideration of a number of diagnostic artifacts and the presence of Scandinavian vernacular architectural styles abroad as expressions of interconnectivity. This precedes the discussion of the case study in Chapter 6. Chapter 7 covers the methodologies employed in this research while Chapter 8 focuses on outlining the results of the analyses detailed in Chapter 7. Chapter 9 is dedicated to the dissemination of the results of the analyses as well as the consideration of the potential implications of those findings and the author's interpretations. Chapter 10 focuses on the history of investigations into the Viking Age and how historical events have had lasting impacts on the way we perceive Vikings today. The 11th and final chapter summarizes this research and discusses future research opportunities and closing remarks.

This thesis does not aim to advocate for the primacy of a singular methodology, as a number of other methods have the potential to return comparable results. Rather, it is intended to highlight the potential benefits of shifting our perspectives and taking time to reassess and reevaluate what new information can be gained by investigating ‘the usual subjects’ from new angles and to provide new insights on the diasporic maritime communities of the Viking Age as well as our understanding of coastal and insular populations in the past more broadly, and the way that those communities might have engaged with their environment, both aqueous and terrestrial.

A note on terminology

I have employed several different terms throughout the course of this work in reference to Viking Age individuals of Scandinavian descent. When possible, I have sought to remain somewhat ambiguous in my use of ethnic terms, given that identity, whether ethnic or socially based, is situational and fluid by nature. Terms such as ‘Norse’ were utilized when referring to regions where recent genetic evidence suggests the presence of individuals of Norwegian descent, Danes for individuals of Danish ancestry, and Rus for those of Swedish descent. When the regional origin of a group of people is more ambiguous, I use the term Scandinavian. In instances involving historical records or archaeological evidence that indicate the presence of Vikings, that is seafaring raiders and warriors, I use the term ‘Viking’ to stand in, not as an indication of ethnicity, but as a job description. To clarify, not all individuals from Scandinavia during the Viking Age engaged in raiding, warfare, pillaging, and piracy, and not all those who went on a raid, or military expedition overseas alongside other Vikings were genetically Scandinavian (Brink, 2012; Margaryan et al., 2020). This allows for further ambiguity in terms of an individual’s origins, but clearly indicates the perceived purpose behind their presence in a given location. Any erroneous errors or mistakes in this arena are unintentional, but nonetheless, are attributable solely to the author.

CHAPTER 2: MARITIME ARCHAEOLOGY AND THE INVESTIGATION OF MARITIME SOCIETIES

The following chapter delves further into the discussion of the spatial, cultural, and conceptual aspects of maritime environments, and the traditional investigative methods employed by archaeologists in order to draw attention to some of the issues surrounding the traditional characterization of maritime societies. Specifically, how to determine the geographic extent of a maritime society, when said society makes extensive use of watercraft in a variety of aquatic environments but does not reside exclusively in coastal or insular areas. It is argued here that the conception of maritime societies as residing, by definition, in coastal and insular areas does not fully encompass the lived experience of Scandinavian seafarers during the Viking Age.

In order to fully understand the interconnected nature of aquatic and terrestrial environments, we must first acknowledge the role watercraft play in keeping the members of these societies connected. That watercraft serve to connect far flung localities, regardless of the relative scale of a given site, be it a fishing village, trading post, or harbor, it is the sailing routes that link those seemingly disparate riverine, lacustrine, coastal, and insular sites into broader societal networks. The placement of these various maritime-oriented archaeological sites often facilitate access to both aquatic and terrestrial environments. These sites straddle the transition between maritime and terrestrial environments, but shorelines should be seen not as a boundary these dichotic environments, but as a connecting point. I will advocate for an integrated approach that considers coastal and insular environments alongside the seascapes that seemingly isolate them.

Maritime archaeology is a sub-discipline within archaeological practice that studies maritime cultures in the past; it is divided into two main specializations: nautical archaeology and coastal archaeology (Bass, 2011). Nautical archaeology is the archaeology watercraft regardless of its age, method of construction, or location when discovered, as well as their links to land (e.g., harbors, ports, and landing points), while coastal archaeology focuses more generally on past peoples who lived in maritime regions (Bass, 2011). When we consider Northern Europe during the Viking Age it can be difficult to draw a clear line between riverine, lacustrine, and maritime archaeology, particularly when considering trading hubs be they regional, local, or long distance. This is in part, because urbanism did not take hold in Scandinavia until the onset of the Viking Age (Sindbæk, 2007; 2012; Skre, 2012a). During the Viking Age, these pre-existing trade hubs and central places that have been understood in terms of long-distance trade, economic and social control, power, and production, in addition to sacred or spiritual significance, developed into embryotic urban centers (Hedeager, 2002; Skre, 2012a).

The seasonal crafting center, trading post, and possible cult site located at the Magnate's Hall on the west bank of Lake Tissø in west Zealand, Denmark is one such example. Tissø translates to Týr's Lake or Lake of the Gods; Týr was one of the Norse gods of warfare. The magnate's hall and seasonal trade center was in use from the mid- 6th century until the 11th century CE (Albris, 2015; Jørgensen, 2012). Although it could be considered a lacustrine archaeological site, sea-based access to the magnate's hall on Lake Tissø, and its associated market (which is six kilometers from the coast) would have been facilitated by river access via the Halleby Å River (Jørgensen, 2012). Other rivers connected to the lake also enabled access to the site from further inland areas of West Zealand (Jørgensen, 2012).

In much the same way, the major Swedish long distance trade hub of Birka provides a similarly ambiguous example. Birka was established on the isle of Björko, in what is now Lake Mälaren, Sweden in the 790s CE (Ambrosani, 2012). The hinterlands surrounding Birka provided the trade town with furs, raw mineral deposits, lumber, and agricultural produce that supported the town and served as trade goods (Ambrosani, 2012; Linderholm et al. 2008). When it was founded, Birka was an integral part of the trade networks along the shores of the Baltic Sea which in turn had connections to other networks reaching as far as the Mediterranean and Friesland (Hedenstierna-Jonson, 2015). Over time these connections changed so that by the end of the 9th century Birka had become the western-most stop on direct trade routes with the East, bringing trade goods from the eastern Caliphates and Byzantium as well. (Ambrosani, 2012). Evidence from strontium isotope analysis and stable isotopic analysis along with comparative grave goods conforms to these findings indicating that Birka had become a multicultural melting pot (Ambrosani, 2012; Hedenstierna-Jonson, 2015; Linderholm et al. 2008). However, Birka's role in trade declined when the sailing routes to Birka from the south and east became too shallow, due to glacial isostatic rebound and river silting (Ambrosani, 2012). Around 1000-1300 CE Birka was gradually cut off from the Baltic Sea isolating Lake Mälaren and its settlements (Ambrosani, 2012; Risberg et al., 2002; Skre, 2011; 2012a; 2012b). In this case, archaeological investigation of what was once a major center for maritime trade, is conducted in a lake that no longer has direct access to the sea. According to sediment sequences associated with the occupation of Birka, the most intense period of human activity at the site was identified immediately prior to its abandonment (Risberg et al., 2002). These examples reflect that the development of trade centers is a complex process involving potentially longstanding patterns of interregional connections and the actions taken directly by traders, craftspeople, and the political elite to varying degrees at each respective location and at different times (Callmer, 2002; Jørgensen, 2010; Sindæk, 2007; 2012).

The two sites discussed above as well as other major Viking Age trade emporiums such Kaupang, Norway, and Dublin, Ireland make it obvious how integral water-based travel was to the development and maintenance of long-distance trade, local and regional politics, and communication regardless of whether they ever were, or still remain in a maritime environment. Harbors can be of varying size and importance to local communities or broader regions the various sizes of these localities are often a function of their significance to the communities that rely upon them. For example, a fishing villages or coastal insular settlements that relied on the sea for subsistence can be found in high frequency all throughout Viking World from the west along the coast of the North Sea, Irish Seam and into the North Atlantic such as the Islands of Scotland including the Hebrides, Orkneys, and Shetland, as well as to the east along the coasts of the Baltic Sea and islands such as Gotland at its center. The study of smaller harbor or landing sites was carried out by Dan Carlsson (1992) on the island of Gotland, Sweden where he aimed to identify local coastal harbors and their frequency (see Figure 2.1). He managed with a surprising degree of success to identify harbor sites in locations across the whole island. This indicates that although major trade hubs boasting harbors and ports are easier to identify archaeologically, they are also far less numerous that the more mundane, but equally important coastal landing sites and harbors located in inlets and bays that were utilized by coastal societies for subsistence.

Figure 2.1: Viking Age harbors on the island of Gotland, Sweden. Larger dots indicate sites associated with important trade and manufacturing connections while smaller dots primarily indicate fishing harbors. (Adapted from Carlsson, 2002).

Recognizing that so many sites could potentially exist in other coastal areas from the period raises questions about how to approach their discovery, identification, and investigation. If we turn our attention westward, early Scandinavian settlement sites in Orkney, Shetland, and the Faore Islands, many of them farmsteads, were primarily located in close proximity to the coast (Bond & Dockrill, 2016; Hansen, 2003; Larsen, 2016). The placement of coastal sites allowed past occupants to more readily utilize both marine and terrestrial environments in their daily lives. With the significance of coastal settlements in mind, it might be helpful to view the occupation of maritime zones from yet another angle.

Crouch (2010) has suggested that ocean-going vessels might be viewed as mobile places, even arguing that they might be seen as mobile sites. Crouch compares the way the crews of sailing vessels experience their environment while in motion is more akin to modern day automobile travel than to pedestrian locomotion; they are a location that is, by its very nature, intended to be mobile (Crouch, 2010). He points out that the actions performed by a ship's crew may leave behind traces on the vessel itself that can be identified if a sudden catastrophic event lead to its submersion. It is then possible that evidence of these activities could be identified if the ship's wreckage can be discovered at a later date. Details such as the cargo or the way the vessel itself was constructed as two such examples what can be learned from ship wrecks. Often times, cargo or other supplies can provide some inkling as to the duration or purpose of the journey. On longer voyages in particular, sailing vessels would server not only as a means of transportation, but also as a form of shelter and as a location for younger or unskilled occupants to learn and develop skills associated with sailing, fishing, or other relevant activities (Crouch, 2010; Ingold, 1993).

To summarize, maritime societies can occupy sites that exist in a wide variety of ecological zones including maritime coastal, insular, riverine, lacustrine, and even exclusively maritime zones (if we prescribe to Crouch's (2010) argument that ocean going vessels can be viewed as mobile sites). So, how can we hope to better conceptualize and examine such sites and the societies that created and inhabited them? When we consider the ambiguity of identifying just what can or should be considered a maritime site, or just when or where a site must be to be considered part of a maritime zone it presents several issues when operating out of traditional perspectives. The investigation of maritime societies using a broader semantic brush may serve to better encompass the quantity and diverse nature of maritime-oriented cultural sites in these regions.

Boundary or Connecting Point? Coastal Conditions and their Impacts on Archaeological Practice

The acclaimed Finnish geographer J. G. Granö (1929-1997) saw the landscape as a constantly changing environment that consisted of both seemingly permanent features, as well as those that were clearly ephemeral, which could be perceived bodily (Palang et al., 2005). This dichotomy can be clearly seen in coastal areas where volatile aquatic environments meet terrestrial landmasses. Coastal archaeology is the archaeological investigation of past peoples who lived in maritime zones, whether their habitation sites are currently found on dry land, under water, or due to geologic and coastal forces, somewhere in between (Bass, 2011). I contend that the meeting of these environments is not necessarily the stark dichotic boundary it first appears but rather; it should be seen as an inextricable connecting point between terrestrial and maritime environments.

Let us look first at natural recurring processes experienced in maritime and coastal regions, including the relationship between oceanic currents and atmospheric processes and the consistent ebb and flow of the tides. Climatology, seasonality, and weather patterns are impacted by the movements and nature of oceanic currents; this is especially the case for small ocean-bound landmasses such as small islands or archipelagoes (Bigelow et al., 2005). For example, if we look at the islands of the North Atlantic such as the Shetland- and Faroe Islands, we find that the Shelf Edge Current (SEC) as well as the North Atlantic Current (NAC) flow between these two island chains (Bigelow et al., 2005; Hansen & Osterhus 2000). The SEC and NAC are the not only the warmest, but also the most saline of the Atlantic currents that flow into the Nordic Seas (Norwegian Sea, Greenland Sea, and Iceland Sea); as a result, they exert a strong influence over northern European climate as well as the maritime and terrestrial ecologies of that region (Bigelow et al., 2005; Hansen & Osterhus 2000; Rowland, 2010). From these circumstances it is clear that temporal and climatological variation on land is intrinsically tied to the nature of the sea. In addition to oceanic currents, tidal forces also play a role in the environmental and physical conditions in coastal and insular zones.

Tides are a constant erosional force on coastal environments that, upon initial observation may appear to be almost imperceptible, but overtime these processes lead to the development of beaches, sand blows, and other major erosional events such as the crumbling of a cliff face (Biglow et al., 2005; Cunliffe, 2001). Oceanic currents can have an impact on local and regional atmospheric climactic changes, as was seen during the Little Ice Age, which lasted from roughly lasting from1300-1860 CE, resulting in regional increases in the violence and frequency of storms and storm surges (Bigelow et al., 2005; Rowland, 2010). McKirdy (2010) draws attention to the erosive power exerted by the sea and wind and the degree to which it has shaped the rocky coastlines of the Shetland Islands and Orkney Island groups since their formation almost three billion years ago.

This is in part due to the NAC and SEC discussed above, as well as the North Atlantic Oscillation (NOA), an oceanic circulatory pattern that occurs when the waters of the artic ocean mix with warmer southern waters in the North Atlantic and North Sea region (Bigelow et al., 2005). These processes contribute to the formation of palimpsests, which can develop quite easily in fragile coastal and insular environments where spikes in storm frequency and intensity are felt more strongly than inland locations (Bigelow et al., 2005). The term palimpsest refers to instances in the archaeological record in which successive events, -be they depositional, erosional, or both- contaminate or mar preexisting occupation layer(s) after initial deposition (Bailey, 2007). The following quote by Anschuetz et al. (2001) expresses the assertion of Wandsnider (1998, p. 87, 90) that, "…the archaeological landscape is a palimpsest of cultural residue that results from both natural and cultural processes operating at different spatial and temporal scales" (p.188). From this we can begin to grasp at least some of the challenges facing archaeologists as they try to piece together what has occurred in the past.

If we take a glass-half-full approach, coastal palimpsests can offer archaeologists a unique perspective on the interconnected nature of land and sea. Of course, it also offers up innumerable methodological and theoretical challenges. One such challenge is when the physical contents of what would spatially be considered the 'site' exists both on land and beneath the waves, what Westerdahl, (1992) and Ford, (2011) refer to as the maritime cultural landscape. The challenge with maritime cultural landscapes being that, due to the erosional forces of tidal flows, the specific context of archaeological material is lost once the land on which it rested in the past crumbles into the sea. As if that were not enough, the archaeological remains impacted by these events impacted by various depositional and erosional processes at different rates. This makes the identification of a clear dividing line between land and sea an impossibility, because the point of connection between these environments is constantly changing.

Joining Landscapes and Seascapes

In recent years, there has been a shift towards the investigation of coastal landscapes, and islands, alongside the investigation of seascapes using the concepts such as 'maritime cultural landscapes' (Westerdahl, 1992), 'social seascapes' (Terrell, 2010), or 'seascapes as spiritscapes' (McNiven, 2010). These terms and other similar definitions were developed to more concretely conceptualize and structure the way that past peoples perceived, experienced, understood, altered, and exploited the dynamic coastal, insular, and maritime environments in which they lived (Barrett, 2012b; Barrett, 2019; Biglow et al., 2005; Broodbank, 2000; Crouch, 2010; Harrison, 2013; McNiven, 2010; O'Sullivan & Breen, 2007; Palang, 2005; Terrell, 2010; Westerdahl, 1992). The purpose here is not to deny the cognitive dualism surrounding our conceptions of land and sea. Rather, the goal is to draw attention to their shared aspects and the similarities in their use by past people. After all, even a casual observer could point out countless differences between an imposing mountain range or windswept moorland and a raging, stormy sea, but these two seemingly dichotic spaces - one that appears to be relatively stable, and another that is visibly and morphologically dynamic and fluid- have much more in common that one might first perceive at the outset.

Anschuetz et al. (2001) maintain that, as archaeologists, it is vital that we consider the physical spaces that surround built residential centers as neither natural nor exclusively as a part of nature because of the impacts on those areas caused by human alteration and entanglement. I would argue that for coastal and insular settlements, particularly among maritime communities, seascapes are an integral part of their physical environment that they engage with regularly in order to take part in economic, social, and subsistence activities. For this reason, the past environments in which maritime communities developed, or re-settled should be looked at not only in terms of the terrestrial landscapes on which these communities rest, but also in terms of the associated bodies of water, or 'seascapes' on which the past populations who occupied those centers have relied on for their existence. Rather than viewing these seemingly dichotic environments as separate from one another -land and sea- we should instead recognize them as physically variable aspects of the same physical space inhabited by past peoples. Ford (2011) postulates that for past peoples each aspect of these variable landscapes, be they the physical and environmental conditions or the culturally constructed meanings and associations, are interrelated and cannot be fully understood without reference to the others.

When we consider the terms landscapes and seascapes, we find that they are both imbued with inherently visual meaning and significance; however, there is much more to past land- and seascapes than stunning vistas and enchanting views of the land and sea. As we will see in the following chapter, these are places imbedded with cosmological, cultural, social, and political meaning (Crumley & Marquardt 1990; Ford, 2011; McNiven, 2010). It has been argued in recent years that seascapes are an integral part of local identity formation and association (Barrett, 2012b; 2019; Cooney, 2003; Cordell, 1989; Cunliffe, 2001; Ford, 2011; McNiven, 2010). One simply cannot hope to understand, in any tangible way, the manner in which people have inhabited these regions if they only focus on the terrestrial landscapes on which their settlements were constructed.

As John Cordell discusses in *A Sea of Small Boats* (1989), seascapes are suffused with history and imbued with names, myths, and legends; they can even be partitioned and claimed as territory by those who travel through and use it, not unlike property on land. Cunliffe, (2001) surmises that it is no wonder that past people sought to understand such an imposing and unpredictable force; it is in the nature of the sea to be constantly changing, at times placid and calm, at others, volatile and destructive. Even so, for the past inhabitants of these coastal landscapes, and even the sea itself would have been familiar surroundings that resonated with personal memories, emotions, and deeply symbolic and culturally constructed meaning, as well as being associated with learned behaviors and activities (Ingold, 1993; McNiven, 2010).

Ford (2011) argues that in order to aid in the development of new and more holistic perspectives and approaches to landscape studies in coastal regions it is necessary to extend the study of maritime cultures beyond the shoreline. Ford's (2011) insistence that every aspect of the landscape, including human settlements in those localities, are related to one another falls in line with the arguments proposed by Gregory Bateson (1978) in his discussion of community interactions with the environment. Bateson (1978) describes landscapes as 'the pattern which connects'; I view this pattern of interacting and interdependent parts as human societies' entanglement with one another and with their environment, be that aqueous, terrestrial, or an amalgam.

Terrell (2010) utilized the term ‘social seascapes’ to describe the web of inter-connecting, multi-level, and multi-purpose pathways that enable insular and coastal locations, within a given region, to maintain contact with one another. Each voyage that is undertaken, whether for residential, logistical, or tactical pursuits, results in some form of interaction between the seafarers and the broader world. Each of those interactions in turn must be understood in relations to one another and to the broader system of ‘entanglement’ with both terrestrial and aquatic environments (Ford, 2011; Terrell, 2010). It has been suggested by Broodbank (2000) that we should view islands and their surroundings in terms of ‘patchworks’ of land and sea. To maritime societies, seascapes are not barren, empty expanses of water, devoid of significance, but realms of socio-cultural interaction as well as locations for resource acquisition and other activities.

Westerdahl (2006) argues that the function of roadways for land-based transport and communication have clear parallels in sea lanes when it comes to the transport and communication with coastal roadways often mirroring sea routes. Despite being physically distinct from solid land, aquatic environments can be shown to serve a similar function for the communities that transverse their surface and become enmeshed with them as a way of life. When we think of terms like isolated or central it can be difficult to see islands as anything but marginal in both their environmental and social aspects; the word *isola,* Italian for island, can be found in the English word isolation (Westerdahl 2006). Despite this linguistic predisposition, centrality in maritime networks has been linked to the number of trade routes between insular destinations, and their relative nearness to other islands or coastal settlements within those networks (Crouch, 2010; Farr, 2006; Terrell, 2010).

In fact, Westerdahl (2006) postulates that in the past, island and coastal settlements may have been more readily accessible, and in fact less isolated, than many contemporary inland settlements. Sailing routes permitted seemingly isolated island communities to remain enmeshed in social, economic, and political activities within their socio-cultural spheres (Crouch, 2010; Farr, 2006; Terrell, 2010). Sailing vessels enable crossing vast expanses of aqueous territory between terrestrial sites in order to facilitate engagement, either environmental or social, for a variety of purposes including, but not limited to trade, resource acquisition, conflict, exploration, and settlement. At times, these actions may have been either distinct from, or in tandem with similarly conducted terrestrially bounded activities such as commerce, farming, hunting, foraging, or herding (Barrett, 2019; Cooney, 2003).

This section has posited that past terrestrial and maritime environments can be shown to demonstrate human engagements and entanglements therein, and as such, these variable regions can be understood to represent a unified cultural 'landscape;' one that is composed of both terrestrial and aquatic environments. The inextricable nature of these land- and seascapes begs the investigation of the archaeological aspects of the past maritime cultures who engaged with them in a similarly holistic manner. If we should hope to develop a better understand of maritime cultures in the past, isolating specific site types as directly related or unrelated to maritime activities, based on the presence or absence of a harbor or the wreckage of a ship, is ineffective. Afterall, as our discussion of the issues inherent in the identification of ship burials as well as harbor sites demonstrated, absence of evidence, particularly in the field of archaeology, is not synonymous with evidence of absence. To better facilitate the investigation of these dynamic regions, and thereby gain a greater understanding of the significance of the sea to past peoples, a more inclusive approach will be necessary. The following chapter delves more deeply into the significance of seascapes to the maritime societies of Northern Europe by considering iconographic depictions of watercraft as well as their use in mortuary practice from the Bronze Age (1750 CE) to the end of the Viking Age (1066 CE) across Northern Europe.

CHAPTER 3: MARITIME SOCIETIES OF NORTHERN EUROPE AND THE DEPICTION OF SHIPS IN THE PAST: COSMOLOGY, FUNCTIONALITY, AND BURIAL

This chapter argues that recurring depiction of watercraft, as well as the use of watercraft, both actual craft and symbolic representations, in multiple different burial practices, is indicative of a lasting and close connection between Northern European peoples in the past and the sea. It considers the use of watercraft, both the vessels themselves, or representations of them, in spiritual iconography, and as cenotaphs, grave markers, and tombs in Northern Europe spanning from ca.1750 BCE to 1066 CE. Outside of their intended use in burial or spiritual practice, some of these forms of iconography have been found to depict technological changes in ship construction such as the adoption of the sail (Sognnes, 2008; Westerdahl, 2019). Westerdahl, (2019) correlates the adoption of the sail with the development of new social strategies, which focused on the concept of being seen as way of communicating conspicuous displays of wealth, organization, and power. Similar displays of wealth and status in this period can also be seen in the Iron Age boat burials of Sutton Hoo, Gokstad, and Osberg (Bonde & Christensen, 1993). Skoglund (2008) has suggested that these various representations across both time and space were, at least in part, symbolic in that they were intended to remind viewers not simply of real ships, but of what ships represented to these communities. This view is shared by Westerdahl (1992; 2006), who describes the archaeology of maritime societies as intimately linked to their use of watercraft, which they used to engage with their physical environment.

The significance of human interaction and engagement with maritime environments cannot be understated. Afterall, our ‘blue planet’ is approximately 71 percent water and of that roughly 96 percent can be found in our oceans, seas, and bays (Shiklomanov, 1993). As a result, there are areas of our planet that never would have been accessed, explored, or settled without the development of watercraft, or, for the sake of argument, aircraft. For maritime societies seascapes are integral to the development and expression of community identity (Cordell, 1989; Cooney, 2003; Cunliffe, 2001; Ford, 2011; McNiven, 2010; Barrett, 2012b; 2019). Maritime societies have their livelihoods and often their spiritual and cultural identities inextricably bound to the sea (Crumley & Marquardt 1990; Ford, 2011; McNiven, 2010).

Although many times, the discussion of maritime societies invokes images of the wayfarers who colonized the islands of the Pacific, Micronesia, and Australia, (Anderson, 1991, 2005; Anderson et al., 2006; Anderson & O’ Connor, 2008; Borreggine et al., 2022) maritime societies have existed in other regions of the world. The following section discusses the depiction and utilization of ships in various contexts throughout Northern Europe, but with a particular focus on Scandinavia. It isargued that the presence of these cultural expressions, spanning nearly 3,000 years, demonstrates the lasting cultural importance of maritime activity to the peoples of Northern Europe from the Bronze Age (ca.1750 BCE – ca. 500 BCE) through the Viking Age (ca. 790 CE- ca. 1066 CE) and arguably into the present.

The main lines of evidence that support this assertion are listed here chronologically: Bronze Age rock art depictions of watercraft in stone carvings (Bradley et al., 2010; Kobyliński & Rabiega, 2018; Kristiansen, 2010; Soggnes, 2008), the presence of stone-ship burials throughout the Bronze Age and and Iron Age (Bradley et al., 2010; Kobyliński & Rabiega, 2018; Skoglund, 2008) and depictions of watercraft, both with and without sails, on Gotlandic picture stones dated to the Iron Age and Viking Age (Oehrl, 2017; Westerdahl, 2019) and lastly, discussion of the more widely known Iron Age ship burial practices as championed by the famous burials at Sutton Hoo, Gokstad, and Oseberg (Bonde & Christensen, 1993; Bonde & Stylegar, 2016; Price et al. 2016).

Material cultural can be seen as a reflection of a given societies' daily lives and spiritual beliefs; in the case of burial contexts these two realms can become intertwined. Various depictions of maritime themes, specifically ships, boats, and sailing vessels, across Northern Europe demonstrate the longstanding significance that seascapes and the vessels that allow for engagement with then have held significance for northern European peoples. As Westerdahl (2019) argues, the Viking Age does not mark a sudden shift in the frequency or an increased reliance on watercraft amongst Iron Age Scandinavian populations. Instead, Jesch (2015; 2016) postulates that it is the process of diaspora, the exodus of a maritime society into new regions that signifies this transitional period between the Iron Age and the Medieval Period.

Rock Art

Rock art in Scandinavia is primarially linked to two major temporally distinct traditions in the Stone Age and Bronze Age traditions, although some later finds are attributed to the early Ion Age as well (Soggnes, 2008). Interestingly one common motif found in both traditions is that of the boat, although there is statistical evidence that the boat becomes the primary motif depicted in the Bronze Age and later periods (Soggnes, 2008). Kristansen in his analysis of all published evidence in Scandinavia, found that some of these Bronze Age carvings, specifically those depicting images of twin ships, or of a ship carrying the sun or suns (see figure 3.1), can be linked to broader Indo-European mythological beliefs (Kristiansen, 2010).

The particular story being depicted is believed to be that of the sun maiden and her shape shifting twin brothers -the Divine Twins- who transform from human forms to that of horses and again into ships (Kristiansen, 2010). In many of these rock art pannels horses are depicted aiding the pasage of the ship. While Kristiansen (2010) found that the depictions of sailing vessels in Scandinavia in the Bronze Age rock art can be linked to the mythological journey of the sun, Sognnes (2008) has shown that the phyiscal depiction of ships in Scandinavian rock art changes overtime from the Bronze Age to the Pre-Roman Iron Age. Sognnes (2008) suggests that these changes are indicative of actual typological change such as the presence of side rudders, the elongated nature of the prows, or the presence of animal head terminals on the vessels. The actual existance of some of these vessel types has been confirmed with the recovery of a buried vessel from Hjortspring, Denmark that matches Gjessing's (1936 as

Figure 3.1: Selected examples of Bronze Age rock art from across Scandinavia (compiled by Kristiansen, 2010). These examples show scenes where the sun or 'suns' are being carried on a ship or pair of ships. The directionality indicating whether the ship represents 'day' or 'night'.

cited by Sognnes, 2008) type III rock art typology (Bradley et al., 2010; Sognnes, 2008). Type III refers to a Pre-Roman Iron Age vessel type dated to ca. 500-1 BCE (Sognnes, 2008; Bradley et al., 2010). Bradley et al. (2010) followed a similar line of inquiry suggesting that the absence of oars and rowers on some of these vessels carved in stonecould suggest that they are inteneded to represent burial practices similar to the stone ship setting found contemporaniously on the Island of Gotland rather than actual ships.

Stone Ship Settings

Although we see a decrease in the production of rock art in Southern Scandinavia around the start of the Iron Age, the use of stone as a medium for cultural and artistic expression does not decline (Bradley et al., 2010; Oehrl, 2017; Skoglund, 2008; Sognnes, 2008). Stone-ship burials are found throughout Norway, Sweden, and Denmark, as well as other parts of Northern Europe, including the Baltic and Northern Germany, from the Bronze Age into the Viking Age,

Figure 3.2: Tjevars grav' or Tjelvar's grave, on the island of Gotland is an example of a stone ship setting on the island, dating to the Late Bronze Age. (Photo courtesy of the author).

approximately 1700 BCE to 1000 CE (Skoglund, 2008). The ship-formed stones settings are found in various regions during different periods, with about 2000 examples identified at sites across Northern Europe, but primarily concentrated in Scandinavia (Bradley et al., 2010; Kobyliński & Rabiega, 2018; Skoglund, 2008). For example, 'Tjevars grav' or Tjelvar's grave, on the island of Gotland is dated to around 1100-500 BCE, but markedly, the island has some 300 examples spanning multiple technological periods, with an initial Bronze Age period lasting from 1100-500 BCE, and later Early Iron Age and smaller stone ship settings occurring frequently in Late Iron Age and Viking Age burial grounds both on Gotland and in other areas mentioned above (Bradley et al., 2010; Kobyliński & Rabiega, 2018; Skoglund, 2008) (see Figure 3.2).

Ship settings are defined by the presence of upright rounded boulders, often ovular or oblong in shape, placed to represent the outline of a ship with the largest stones, used in each setting, defining the prow and stern of the vessel as well as the middle of the ship (Bradley et al. 2010). The stones selected to represent the prow and stern were sometimes pointed to accentuate the ends of the vessel. These settings are of variable lengths, with many approximately 10 meters long but with some as small as two meters and the largest at 45 meters long (Skoglund, 2008). They can be found singularly, as with Tjelvar's grave mentioned above, or in small groups, and have been found in association with other monuments such as cairns or circular monuments (Bradley et al. 2010). While some of these stone ship settings represent cenotaphs, others have been found to contain burials, which can range from solitary burial to group interments, although the impetus behind this is unclear given the wide geographic and temporal range of the practice (Bradley et al., 2010; Skoglund, 2008).

It has been posited that similarities between the vessels depicted in southern Scandinavian rock art and the stone ship settings, suggests a certain degree of continuity, at least in terms of the significance of ships and maritime activity, if not the particulars of local or regional spiritual belief and practice (Skoglund, 2008; Bradley et al., 2010). For example, in south-west Scandinavia ship symbols were common on stone and metal work during the early Bronze Age, but the imagery was not translated into an architectural expression in associated with death ritual until 1300-700 BC (Skoglund, 2008). However, unlike ship settings on Gotland, stone ships in south-west Scandinavia were constructed in the shape of oval stone cists or as boulders laid out in an ovular, ship-like pattern however all of these 'ships' were entombed in earthen mounds, while those on Gotland were left open to the air (Skoglund, 2008). The grand scale and infrequency of this practice in the region, relative to the settings found on Gotland, and the presence of only singular, or at the most double burials, within these mounds, suggests that the burial practice in this area was reserved for important individuals (Skoglund, 2008). This contrasts with the high quantity of ship settings on Gotland discussed above.

Smaller exposed stone ship settings, often in uniformed groupings, can be found as an element on many Scandinavian burial grounds both on Gotland, Denmark, and the Scandinavian Peninsula in the Late Iron Age underlining their ritual function and cultural significance to the people of these regions (Skoglund, 2008). Alternatively, we also see their use once more as a prestige symbol on the east coast of Sweden. Here we find exposed ship settings as well with some as large as 40 meters in length and made of distinctly sizable stones or boulders set in the typical ovular shape seen elsewhere (Skoglund, 2008). In addition to the continued use of stone ship settings in burial practice we also find another form of distinctive memorial marker that employs ship iconography on the island of Gotland.

Figure 3.3 Sanda kyrka IV is a large Migration/Vendel period picture stone that has been dated to c. AD 400–600CE (type A) (Photo courtesy of the author).

Gotlandic Picture Stones

The picture stones from the island of Gotland in the Baltic Sea were errected between 400 and 1100 CE, spanning both the Migration/Vendel Period and the Viking Age; they provide viewers with a uniquely visual source for Norse mythology as well as Germanic heroic legends (Oehrl, 2017; Westerdahl, 2019). In the early 1940s, Sune Lindqvist, used electric lamps from multiple angles to cast shadows across the surface of the stones to traced the scenes with paint, so that the iconography could be clearly visible (Oehrl, 2017). Lindqvist also divided picture stones into Types based on their relative age, stone shape, and iconographic content and complexity: Types A and B are associated with the Migration/Vendel period, while Types C and D are dated to the Viking Age. The function of these stones as memorial markers has been suggested given that much of the iconography pertains to burial rights and depictions of the journey to the afterlife (Oehrl, 2017; Westerdahl, 2019).

Image of swirling disks and boats are commonly found on many of the picutre stones dated to the Migration/Vendel period. Sanda kyrka IV is a large example of a Migration/Vendel period Type A picture stone dated to c.400–600 CE (see Figure 3.5). The boats depicted in many of the Migration/Vendel period stones have been considered ships of the dead (Oehrl, 2017). If we look at Sanda kyrka IV we can clearly see see two large serpentine creatures encircling the disks in the central segment of the stone slab. Parallels with the World Serpent (*Miðgarðsormr* in Old Norse) from Norse mythology can be seen here. Given the parallels to *Miðgarðsormr* and to the mythological journey of the sun in Bronze Age rock art, that these disk have been regarded as celestial bodies (Sognnes, 2008; Oehrl, 2017).

Picture stones continued in use throughout the early and late Iron Age with many of the later picture stones (Types C and D), being dated to the 9th and 10th centuries; the Viking Age stones are often organized into horiontal pannels that depict a variety of different narrative or mythological themes (Oehrl, 2017). As with the gradual change in the depictions of Bronze Age sailing vessels mentioned above, if we look at the iconography of the boat shown on the Sanda kyrka IV stone (Figure 3.3) and Stora Hammars I (Figure 3.4) we can clearly see a major technological development: the presence of a square sail is clearly visible above the boat's occupants. The oldest *depictions* of Scandinavian sailing vessels have been attributed to their presence on Gotlandic picture stones (Westerdahl, 2019). In his discussion on the development of the sail in Scandinavia Westerdahl (2019) presented three possible reason for the apprent reluctance to the adoption of the sail despite its presence in other areas of Europe. Two of the reasons he provided were related to the use of rowing vessels in combat applications, which involved stealth, coordination, and mobility during raids or the employment of hit and run tactics.

Figure 3.4: Gotlandic picture stone Stora Hammars I, Lärbo Parish, Gotland, Sweden (Photo courtesy of the author).

If we look again at Stora Hammars I in Figure 3.4, there is another boat, this one without a sail, depicted in the middle panel in which individuals with shields and swords can be clearly seen facing another opposing group of individuals, presumably on land, who are similarly equipped. Westerdahl (2019) argued that the adoption of the sail would have spoiled the element of surprise and the reliance on variable winds would have limited the ability of multiple vessels to seamlessly coordinate with one another. His other argument, one echoed by Skoglund, (2008) is that the act of rowing denotes a social system of variable status in which one man captains a vessel while the others row. The cultural motives behind the erection of larger more ostentatious stone ship settings in the Iron Age, often with smaller ship setting close at hand, may have been to represent the social hierarchy, relative status, and relationship between the deceased individuals.

Westerdahl (2019) maintains that the social system that was in place was, in all likelihood, not dissimilar to the Germanic concept of the commitatus, with one man to one row lock representing a place within the ritune of a more powerful individual. Consequently, having a position at a rowlock on rowing vessel could be seen as a position of social and military siginificance. The archaeological and isotropic evidence from the Salme boat burials in Estonia, dated to around 750 CE, suggest that the individuals inturred within the two vessels were high status individuals, such as diplomats and their ritunes, from central Sweden who died violently in the eastern Baltic (Price et al., 2016). The death of these individuals and the signifgance of the discovery of their graves are considered further in the discussion on boat and ship burials below.

The adoption of the sail within Scandinavian society could, in part, be linked to new social ideologies and the consolidation of political power around the start of the Viking Age (Barrett et al., 2000; Westerdahl, 2019). The development of the sail thus correlates with the enactment of new social strategies which focused on the concept of being seen as way of communicating conspicuous displays of wealth, organization, and power (Westerdahl, 2019).

Burials in Boats

When we speak of ship burials, the image that typically comes to mind of some of the most famous examples such as the early 7th century Anglo-Saxon Sutton Hoo ship burial in England (Bonde & Stylegar, 2016) or the fabulously well preserved Oseberg ship burial from

Norway (Bonde & Stylegar, 2016). In these instances, the presence of a ship burial is generally considered indicative of the high status of the individual, or individuals, interred within it (Price et al., 2016). However, the Iron Age burial practice of interring individuals in actual watercraft, which began in the Vendel/Migration Period and continued into the Viking Age, was not an exclusively high-status practice (Bonde & Stylegar, 2016; Kobyliński & Rabiega, 2018; Skoglund, 2008).

Going forward I will distinguish between high-status burials, which explicitly involve large ocean-or sea going vessels, and the general Iron Age practice of burying people, in a more modest fashion, inside small boats, because while both practices cover the same geographic regions, burials in small boats are markedly more common (Bonde & Stylegar, 2016; Kobyliński & Rabiega, 2018; Nordeide, 2019). As such it is important to consider the potential for diverse traditions behind these burials when taking place over such a large geographic expanse. Within the literature, the purpose of the vessel in these burial contexts has been considered to fulfill one of four roles: that of a coffin or burial chamber, as a vehicle for otherworldly transport, as a form of grave good, or as fuel for cremation burials (Nordeide, 2019).

Burials involving boats can be difficult if not impossible to identify archaeologically. For example, if we consider cremation burials, the funeral pyre would in due course use the boats as fuel, in ideal conditions, this process would leave an oxidized layer of soil due to the high temperatures of the pyre, but outside of such contexts, (i.e., soil acidity, or natural decay), ship remains are more often than not, archaeologically invisible. Clinker-built vessels which were common in the region, could be fastened together using iron rivets, but wooden pegs or sinew lashings were also used; in such instances they can be incredibly hard to identify (Kobyliński & Rabiega, 2018). Regardless of the burial practice employed, it is often only the impression of the hull and the iron rivets that denote the location of these vessels. That, alongside tidal action and coastal erosion, is what makes the discovery of the vessels discussed below so significant archaeologically.

The archaeologist Michael Müller-Wille published the book *Bestattung im Boot* (German for 'Interment in a Boat' -author's translation) in 1970. In it, he documented every boat- or ship burial that, to his knowledge, had been discovered up to that point, totaling 422 vessels from some 300 sites (Müller-Wille, 1970). Since that time, the total number of documented sites has grown to nearly 400; the more recent discoveries, up until 2013, are displayed in Figure 3.5. As of 2013 the total number of documented ship and boat burials has increased to roughly 650 (Kobyliński & Rabiega, 2018). Going forward, I will refer to high status burials using the term

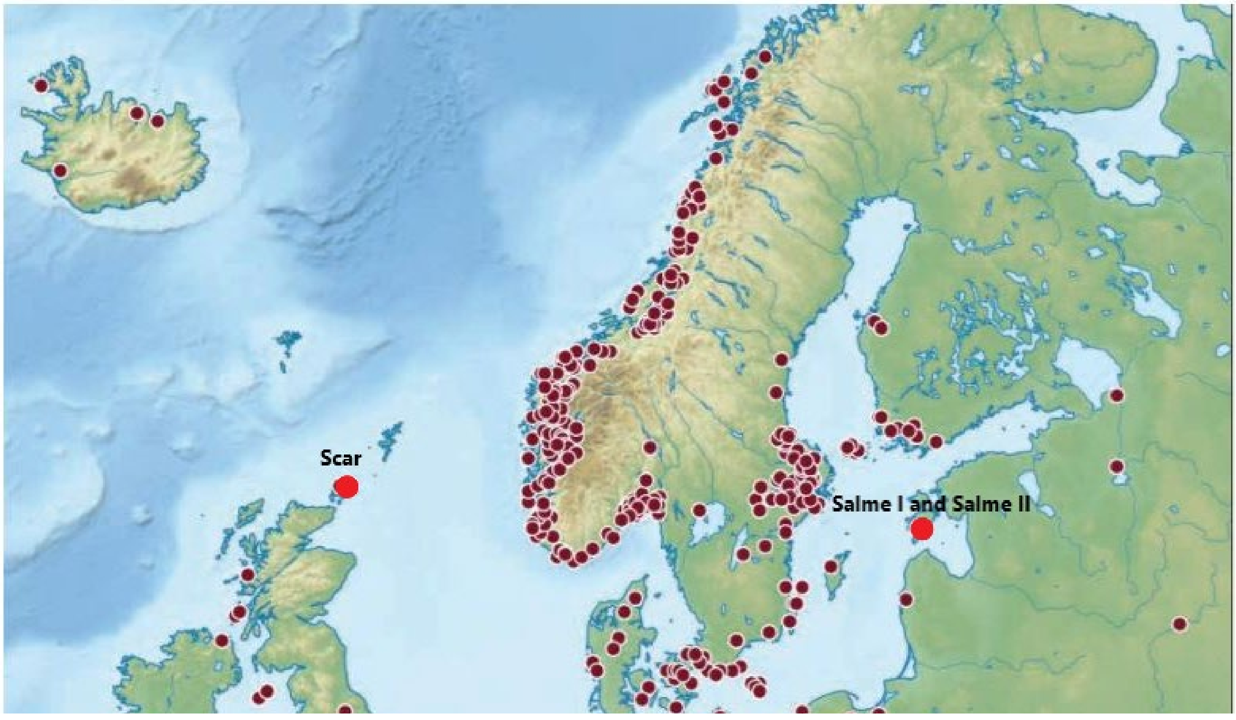


Figure 3.5: Boat- and ship burials from sites in Prehistoric and Early Medieval Northern Europe discovered between 1970-2013 as compiled by Kamil Rabiega. Nearly 100 sites, all found since 1970, are represented here some of which represent more than one burial. Müller-Wille (1970) estimated that roughly 300 sites containing boat- or ship burials had been found in the region up until 1970. Kobyliński & Rabiega,(2018) have demonstrated these numbers have increased greatly in recent years (image adapted from Kobyliński & Rabiega, 2018). The sites of Salme I, Salme II, and Scar boat burials have larger bright red dots.

'ship' burial while the general burial practice involving smaller watercraft will be denoted with the term 'boat' burial.

As mentioned above, boat burials were a common form of Iron Age burial practice in Northern Europe and as such I will limit my discussion to two sites, one to the East (Salme I and Salme II) and one to the West (Scar). These two sites were selected because of the distance separating the two regions but this was not the only reason. The Salme I and Salme II boat burials on the island of Saaremaa in Estonia were dated to around 750CE, a suggested early date for the start of the Viking Age (Price et al., 2016). Whereas, Scar represents an early 9th century CE date and is one of the few non-Christian Scandinavian burials in the Northern Iles of Scotland (Owen, 2004).

Figure 3.6: Salme II during various stages of excavation. Left: outline of ship rivets and humus stains in addition to skeleton layers I-III. Middle: skeleton layer IV in a position transverse to the ship; Right: The outline of Salme II without the skeletons present. (Photographs by Juri Peets and Reet Maldre. Adapted from Price et al. 2016).

The Salme I and Salme II boat burials on the island of Saaremaa, Estonia have a total forty-one individuals interred between the two vessels and isotopic and archaeological evidence suggests that the interred individuals originally came the Malaren region of central Sweden (Price et al., 2016). The clinker-built Salme I encompasses the large end of 'boat burials,' having been equipped with six pairs of oars, such six-oared vessels were known as *tolværing* (Bonde & Stylegar, 2016). While Salme II can be considered a ship burial as it seems to have been equipped for both rowing and sailing and was large enough to hold a crew of 30 or more (Price et al., 2016).

Salme I was approximately 11.5m in length and contained seven individuals who appear to have been buried in seated positions (Price et al. 2016). Unfortunately, due to the modern construction activities that identified boat, Salme I was severely damaged and much of the archaeological material, which included 75 bone gaming pieces as well as an axe, two swords, and spear- and arrow heads, was not recovered in context. Salme II was excavated by a team of archaeologists in 2010 approximately 30-50m from Salme I (Price et al., 2010). The remains of 34 individuals, stacked in rows, were recovered from Salme II which was approximately 17-17.5m long. The stages of excavation for Salme II can be seen in Figure 6. The weaponry recovered from the vessel included 40 single- and double-edged swords, many of which had hilts that were gilded or bejeweled bronze (Price et al., 2016). A variety of other high status grave goods were recovered as well. It has been suggested, due to the non-local origin for both the individuals and their high-status grave goods, that these individuals were from a diplomatic delegation that was protected by a group of warriors. The presence of so many individuals within a boat burial is distinctly odd given that most ship- or boat burials contain one or two bodies, although examples of three person burials have been identified at excavations in the grave fields at Kaupang in Norway and the boat burial from Scar, on Sanday in Orkney, UK (Owen, 2004).

The boat burial at Scar, which was dated to the early 9th century, contained three individuals all at various stages of life: a boy around age 10, a man in his mid- to late thirties, and a woman who was possibly as old as 70 or more (Owen, 2004). The burial chamber in the Scar boat burial consisted of a single makeshift wall dividing the vessel, Owen (2004) suggests that the presence of this simple chamber, and of other well-known examples such as the Oseberg ship that had distinct burial chambers built onto them, demonstrates the symbolic importance of the ship as a component of the burial. In other words, it is more than using an expedient container for the deceased.

Owen (2004) notes that all three individuals barely fit within the small boat. He goes on to note that the man seems to have been interred last, almost haphazardly, despite his high-quality grave goods which included a sword, an exquisitely crafted bone comb, and twenty-two whale bone gaming pieces. The woman was interred with equally elaborate grave goods but was laid out full length within the ship as was the young boy. The assemblages salvaged from the grave after erosional forces took their tole suggest that the elderly woman and man were likely of similar status, but the status of the young boy remains an enigma as does the cause of death for all those interred within. These findings remind us that even when graves conform to a particular mortuary style or general practice, life is messy and interpretation can only get us so far without additional information. As a result, often times burials offer up more questions than answers regarding the particulars of these sites, regardless of whether they are burials in boats, as discussed here, or burials in larger ships like those covered in the following section.

Burials in Ships

The ships burials of Storhaug and Grønhaug were excavated on the island of Karmøy in Rogaland, on Norway's western coast in 1887 and 1902 respectively (Bonde & Stylegar, 2016).

Several aspects made these two burials stand out from earlier examples of boat burials was the use of large ocean-going vessels in the graves, as well as the erection of timber burial chambers, as distinct spaces inside of the ships and the burial of these ships beneath large earthen mounds. This practice calls to mind the earlier practice in south-west Scandinavia of interring stone ship settings within earthen mounds.

The excavations revealed that the Storhaug ship was an oak-built rowing vessel with a keel length of roughly 22m (Bonde & Stylegar, 2016). The grave was determined to be that of a singular man who was buried with a wide variety of high-quality grave goods including an entire blacksmithing tool kit, a fire-starting set of flint and steel two gaming piece sets, one of glass and the other amber, as well as two swords, two spears and a quiver of arrows. Bonde and Stylegar (2016) posit that the Storhaug ship grave may be one of the only ship graves of its scale not to be plundered in antiquity. The excavation of Grønhaug in 1902 on the same island brought to light a similarly elaborate ship burial. The Grønhaug ship grave, as with the Storaug grave, was a single person burial that included the addition of a burial compartment. There was also evidence of grave furnishings including fabrics, and furniture like that found in other well-known ship graves (Bonde & Christensen, 1993). Initial dating using artifacts from these two vessels provided ambiguously wide date ranges of 700 CE - 900 CE; after dendrochronological dating was performed it was determined that the Storhaug ship was built in ca.770 CE and was used in the burial just nine years later (Bonde & Stylegar, 2016). As for the Grønhaug ship, it was built around 780 CE, and the burial was estimated to have occurred between 790 CE - 795 CE (Bonde & Stylegar, 2016; Westerdahl, 2019).

This falls in line with the dates assigned to the construction of the Oseberg ship and its later use in burial (820 CE and 834 CE respectively) as well as the dates assigned to the Gokstad (887 CE and 900-905 CE), and Tune (910-920 CE) ship graves (Bonde & Christensen 1993; Bonde & Stylegar, 2016). These three vessels were discovered in south-eastern Norway in the Oslo Fjord region and were at sites between 20 and 50 km apart from one another (Bonde & Christensen, 1993). The discussion of these three ships is limited to their age and dimensions as they are some of the most well-known, and extensively researched ship burials in the world and further details on these vessels can be readily found elsewhere (Bonde & Christensen, 1993). All three vessels were clinker built primarily of oak, although the Tune had crossbeams and a rudder made of pine, they all sported masts, sails, and side rudders (Bonde & Christensen, 1993). The Tune ship, which was

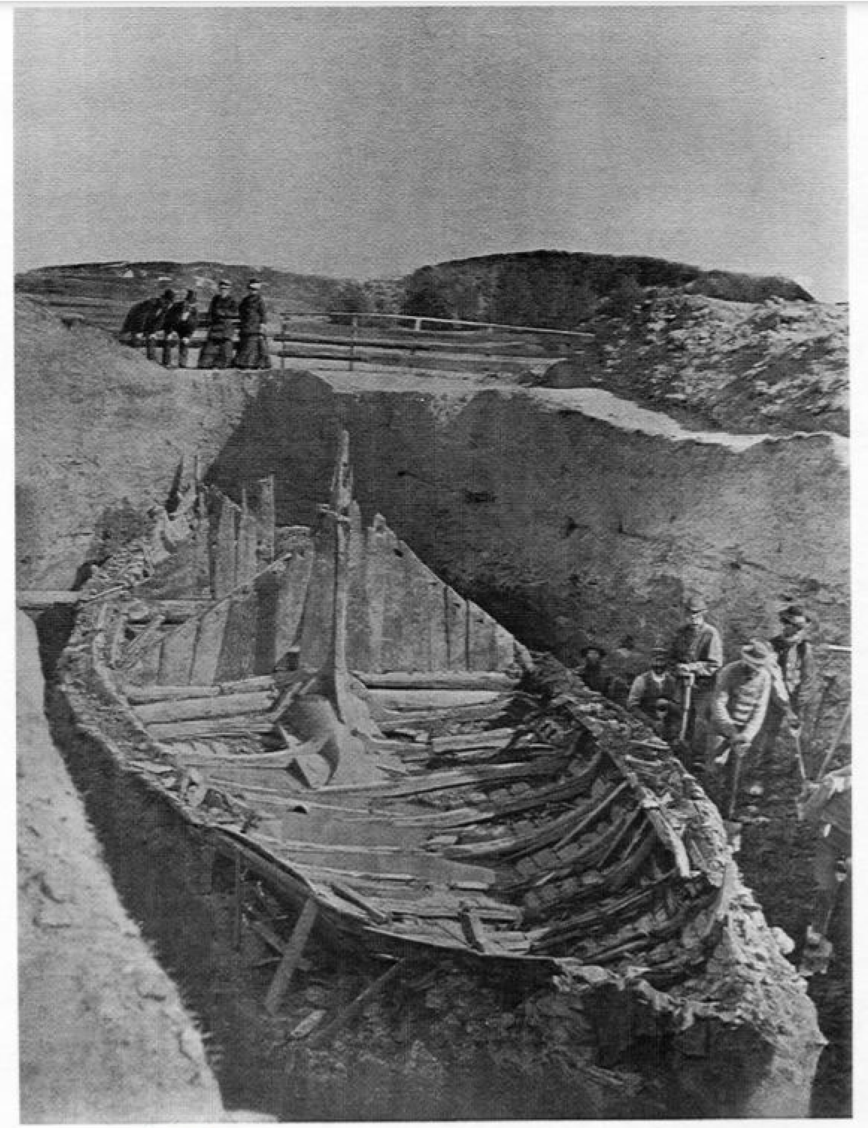


Figure 3.7: The Gokstad ship during its 1880 excavation. The gabled walls of the burial chamber can be seen behind the mast. (Photo: University Museum of National Antiquities, Oslo, Norway.

excavated in 1867, was the first major archaeological discovery of a Viking ship; it was a 20m long ship was equipped with 11 or 12 pairs of oars (Bonde & Christensen, 1993). The Gokstad ship, which can be seen in figure 3.7, has been considered largely contemporary with the Tune ship and its composition was not dissimilar with an overall length of 23.2 m and carrying 16 pairs of oars (Bonde & Christensen, 1993). Lastly the famed Oseberg ship was incredibly well preserved with roughly 90 percent of its 21.85m length still intact (Bonde & Christensen, 1993).

Extravagant ship graves, like those uncovered in the Oslo Fjord area and on the island of Karmøy, were likely intended to serve as socio-political displays of power and wealth; as such, ship burials are relatively rare and can be viewed as an exclusive form of burial for high status individuals in the late Iron Age (Bonde & Christensen, 1993). As noted above, there is a discrepancy between the date of construction for these ships and when they were converted for their use as burial vessels. This tells us that the vessels were not constructed explicitly to be used in burial rights and that roughly 10-15 years elapsed before they were decommissioned. This can be seen as an early retirement as none of the vessels discussed above showed evidence of being outdated or heavily damaged, and thus past their period of usefulness, at their time of interment (Bonde & Christensen, 1993; Bonde & Stylegar, 2016). This lends support to Bonde and Christensen's (1993) argument that these vessels can be viewed as symbols of the status and wealth of the deceased individual and evidence of a shift in political strategy in which claims to legitimacy may have held a visual component.

All the various phenomena briefly addressed above lend credence to the argument that ships, and boats played a significant role in both the daily lives, and cosmological views of the societies of Northern Europe from the Bronze Age through the Viking Age and beyond. Afterall, boats and ships were a primary means of swift transportation and trade across the region. They enabled common people to engage in subsistence activities and higher status individuals to engage in militaristic and diplomatic exploits with distinctly separated polities. As was touched on above, the use of watercraft, particularly rowing vessels, created and nurtured strong inter-personal and social relations between the captain and the members of the crew.

This chapter has discussed the cultural expression of maritime societies in northern Europe spanning from the Bronze Age into the Viking Age. These expressions have taken various form, from the depictions of ships in iconography ranging from the Bronze Age into the Viking Age, to the use of ships, both real and symbolic, in burial practices that span the same time range. These various forms of cultural expression demonstrate the cultural importance of watercraft and the seascapes they plied to the peoples of northern Europe for roughly 3,000 years, as well as the interconnected nature of land and sea (Bonde & Stylegar, 2016; Kobyliński & Rabiega, 2018; Skoglund, 2008; Westerdahl, 2006). In doing so, it is argued that these expressions represent the cultural practices and expressions of a northern European maritime society. A society which, towards the end of the Iron Age was likely implementing new social and political strategies, which focused on the concept of being seen as way of communicating conspicuous displays of wealth, power, and organizational capabilities (Barrett et al., 2000; Barrett, 2010; Westerdahl, 2019).

CHAPTER 4: THE VIKING AGE: THE SCANDINAVIAN DIASPORA AND ITS IMPACTS ON EUROPE AND FARTHER AFIELD

The diaspora of Scandinavian peoples during the Viking Age serves as the cultural and temporal contextual framework for my research. This chapter discusses the Viking Age as a transitional period in European history and its impacts on not only Scandinavia, but also Europe and other regions at the end of the Iron Age and the beginning of the Medieval period. A brief overview of the events of the Viking Age in some of the major regions of Europe are divided geographically east and west with some caveats into some of the major events that took place in these regions during that time in order to set the stage for the stage for the more thorough examination of the study area and its socio-cultural and economic links.

The Scandinavian expansion westward into the Northern Isles of Scotland, the Irish Sea, England, France, the Islands of the North Atlantic and eastward into the shores of the Baltic Sea and the river systems of Eastern Europe during the Viking Age represents the diasporic settlement efforts of a Northern European maritime society. Judith Jesch (2015; 2016) reframes the migration, exploration, and expansion of Scandinavian seafarers during this period not strictly as a process of conflict and colonization, but as a diaspora, with all the associated semantic baggage bound up with the term. To clarify, the term diaspora has come to be used more frequently in recent years, particularly in the social sciences to refer to a broad range of human migrations throughout time and space. The term diaspora differs from terms previously used to describe the Viking Age in that there is a sense of interconnectedness experienced by the migrant for the purpose of maintaining a cultural and often physical link with their homeland even after settling in a new location.

In these instances, the migrant's place of origin takes on a nostalgic character while also serving as a tangible place of origin that can be returned to (Jesch, 2015; 2016). For this reason, Jesch's (2015; 2016) arguments pertaining to the idea of Scandinavian expansion during the Viking Age as a diaspora are intimately connected to not only Terrell's (2010) concept of social seascapes, but also Farr's, (2006) interpretation of seafaring as social action, and Broodbank's (2000) views on insular community identity formation.

These interconnected networks of diasporic communities that Jesch (2015; 2016) speaks of can be found throughout the Viking world linking geographically distinct regions where Scandinavian seafarers engaged in a variable pattern of trading, raiding, and settlement activities that necessitated the engagement of Scandinavians from all levels of society with the sea. This in turn impacted much of what I refer to broadly as the 'Viking world' in transformative ways that varied both temporally as well as regionally as an amalgam of political, ideological, economic, and social forces influenced the decisions made by past people.

Viewing Scandinavians as an outside force impacting Europe (with a capital 'E') has long been the outlook from a historical perspective since contemporary chroniclers, first recorded raids by Northmen in the late 700s CE (Barrett, 2003; 2010; 2012b; Brink, 2012; Downham, 2007a; 2007b; 2012a; Ó Corráin, 2001; Sindbæk, 2013). Downham, (2012a) brings attention to the partial nature of many of these sources as they tend to be focused on a particular region, i.e., Wessex is the focus of the Anglo-Saxon Chronicles, and as such it is reasonable to assume the writers held political motivations and biases. Sindbæk (2013) takes issue with these longstanding conceptions of Scandinavian seafarers as a force that is foreign and external to Europe, arguing that Scandinavians should be viewed as an internal force that had a profound and varied influence on not only European history, but the world if not directly, then by proxy.

The Viking Age, as we have come to call it today, was an important transitional period spanning the end of the Iron Age and beginning of the Medieval period in Scandinavia. As far as man-made temporal distinctions go, the Viking Age with its traditional Anglo-centric dates seems relatively well defined at first glance. It begins with the Viking raid on the Monastery on the Isle of Lindisfarne in Northumberland, England in 793 CE and culminates with the defeat of Haraldr Harðráði (anglicized Harold Hardrada) at the Battle of Stanford Bridge in Yorkshire, England on the 25th of September 1066 CE (Brink, 2012a; Carlsson & Selin, 2012:11-14; Downham, 2012a:346-347). However, the historical events and processes that both led up to and continued after this arbitrary date bracket are what truly define the Viking Age, which was characterized by the growth and development of local and long-distance trade, urbanization, the development of production centers, as well the centralization of political authority within Scandinavia and elsewhere (Barrett et al, 2000; Brink, 2012a; Callmer, 2002; Jørgensen, 2010; 2012; Sindbæk, 2012). It is important to note that these various phenomena developed and were expressed at different times in various regions of the Viking world. Two interrelated processes, the Europeanization and Christianization of mainland Scandinavia and its ruling class (Brink, 2012b; Nyberg, 2000) mark the end of the Viking Age.

In addition to these phenomena, the Viking Age was also characterized by the diffusion of Scandinavian raiders, traders, seafarers, and settlers to locations outside of mainland Scandinavia. The dispersal of these seafarers occurred not only westward into the British Isles and across the North Atlantic (Barrett et al., 2000; Downham, 2012a:346-347; Scofield, & Edwards, 2016; Sigurđsson, 2012), but also, into the lands and river systems of eastern Europe and on to Byzantium (Carlsson & Selin, 2012; Androshchuk, 2012), and south into northern France (Price, 2012a), Germany (Callmer, 2012), and Poland (Gardeła, 2015,). In fact, there are accounts of Scandinavian seafarers going to places even farther afield, including Spain and North Africa along the shores of the Mediterranean, and it is possible they even traveled as far as the Middle East, into what is now modern-day Iran (Carlsson & Selin, 2012; Price, 2012b) although that is still a matter of some debate (see Böhm, (2019) for an alternative destination of Ingvar the Far-Travelled's expedition).

The perception of Vikings in the fields of History and Archaeology prior to the events of the Second World War have tended to view them in the light of rampaging barbarian marauders, which no doubt has links back to their depiction in contemporary sources, the writers of which were on the receiving end of those raids, sea-based assaults, and acts of piracy. Despite the blanket term we use today, contemporary chroniclers did not refer to Scandinavians by a singular unifying term. Often, they would be referred to simply as ‘Pagans,’ ‘North-men,’ or ‘Danes’ in England and France (Brink, 2012a). Irish chroniclers, on the other hand, seemed to have made a distinction between *Finngall* meaning ‘white foreigners’ and *Dubgall* meaning ‘black foreigners,’ although, precisely what this distinction was intended to represent is unclear (Brink, 2012a; Downham, 2007b; Etchingham, 2014). Some argue that the terms indicate Norse and Danes respectively (a recognition of ethnicity), while others advocate that it serves as an indication of their political relationships with local Irish kings, or the timing of their arrival relative to one another (Etchingham, 2014; Downham, 2007b).

The Old Scandinavian words *víkingr* (m) meaning: a man who goes on a journey alongside companions and *víking* (f) meaning: a journey, raid, or military expedition (over sea) are found in the Anglo-Saxon Chronicles as well as in runic inscriptions (Brink, 2012a). Despite a lack of modern consensus on the word’s origin, it has come to be a word easily recognized in pop culture as being associated with sea warriors and raiders. As such, it should come as no surprise that the representations of these men, and possibly women as well, (Hedenstierna-Jonson, et al. 2017; Price et al., 2019) have fixated on their representation as an external threat to Europe (Barrett, 2010; Brink, 2012a; Sindbæk,2013). While perhaps a threat, the Viking diaspora, nevertheless contributed to the rise of urbanism in some regions of Europe such as Ireland (O’Sullivan & Breen, 2007; Wallace, 2016), Scotland, (Barrett, 2012a), Russia, and

Ukraine (Carlsson & Selin, 2012) and as a galvanizing factor to state formation in those same regions as well as in England, France and within Scandinavia itself (Bagge, 2010; Downham, 2010a; Price, 2012a). The debate regarding the degree of influence that Vikings had on state formation, in Russia in particular, is highly politically charged, and has been since long before the collapse of the Soviet Union (Androshchuk, 2012; Stender-Petersen & Bach, 1953). Nevertheless, it is difficult to deny the extensive impact that the events of the Viking Age had on Europe as a whole.

The Viking diaspora resulted in a complicated pattern of cultural contact between Scandinavian and Indigenous peoples outside of mainland Scandinavia. Interactions between these diverse groups encompassed a broad continuum of events ranging from armed conflict, pillaging, and enslavement to cultural integration, assimilation, and even intermarriage. Evidence supporting this spectrum of intercultural contact comes from a wide range of sources including historical texts (Brink, 2012a; Etchingham, 2014; Lönnroth, 2012), archaeological excavations (Arge, 2012; 2014; Ashby, 2019; Bond & Dockrill, 2016; Boyd; 2016; Downham 2012b; 2019; Glørstad, 2014; Griffiths, 2004; Jesch, 2015; 2016; O'Sullivan & Breen, 2007; Sindbæk, 2019; Skre, 2011; Wallace, 2016), linguistic studies, (Albris, 2015; Fellows-Jensen, 2012), and in more recent years, isotopic analyses (Knudson et al., 2011), and genetic evidence (Ebenesersdóttir et al., 2018; Helgason et al. 2001; Margaryan et al., 2020). As historical and archaeological evidence does not provide all the answers that we desire about the past, the following section will discuss spatiotemporal genetic analyses of individuals from the Viking Age to offer a more holistic view. Following this discussion, I present a brief historical overview of some key events that took place around the associated regions during this tumultuous period.

A recent genetic study published in the journal *Nature* has shed new light on the maritime expansion of Scandinavian peoples during the Viking Age. Margaryan et al. (2020) conducted a wide scale genomic study which included n=442 human genomes from past populations across Europe and the North Atlantic spanning from the Bronze Age to the Early Modern period. The authors of the paper found substantial evidence supporting an influx of Norwegian ancestry into the Isle of Man, Ireland, Iceland, and Greenland as well as a significant admixture of Danish ancestry into England, they also found a similar phenomenon in the Baltic Sea region regarding individuals of Swedish ancestry over the course of the Viking Age. These findings fit well with the archaeological evidence for raiding, settlement, trade, and exploration in these regions. This genetic study and others like it add an additional layer to the social and cultural complexity of interactions between Scandinavian seafarers and populations during the Viking Age. The following sections provide a brief overview of the Viking diasporic expansion into disparate regions by looking at both historical and archaeological evidence.

Vikings in the East

In the east, Scandinavian seafarers, many of whom originated in what is now modern-day Sweden, were called *rus'* or *varjag* (ON *væringi, væringr*) in the eastern Baltic, modern-day Russia, Ukraine, and as far south as Byzantium (Brink, 2012a; Carlsson & Selin, 2012 Margaryan et al., 2020). Expeditions leaving mainland Scandinavia for eastern shores would often set off towards the Baltic Island of Åland and from there either follow the southern coast of Finland or make the crossing from the Island of Gotland to the coastal regions of Latvia or Estonia (Edgren, 2012; Jesch, 2015; Valk, 2012). From there, they would voyage farther inland to the river systems of what are modern-day Ukraine and Russia; often stopping in the vicinity of Lake Ladoga, which served as a primary nodal point for trade voyages to the east and south

(Androshchuk, 2012; Carlsson & Selin, 2012; Jesch, 2015). Lake Ladoga and the Volga-Oak region are the areas that were the most densely populated by Scandinavian settlers during the Viking Age in the East (Androshchuk, 2012; Jesch, 2015).

Settlements in these regions were primarily composed of rural populations that had access to lively trade routes along the Volga, Don, Vistula, Dvina, and Dnieper River systems, but evidence from Ladoga, Kyiv, and Gorodische also provide evidence from more urban settlements (Androshchuk, 2012; Carlsson & Selin, 2012; Jesch, 2015). In both cases, archaeological evidence indicates the presence of entire family units focused on trapping and fur trade rather than strictly Byzantine-focused trade outposts (Androschchunk, 2012; Shepard, 2012). Warfare and trade activities involving Byzantium and the Caliphates in the region in the 9th and 10th centuries are well documented in contemporary Byzantine and Islamic sources (Androschchunk, 2012; Carlsson & Slein, 2012; Shepard, 2012).

Scholars have argued that the desire for Islamic silver created a nexus of commerce and exchange not only with Scandinavia but also with the rest of Europe and the Eurasian Steeps (Shepard, 2012; Carlsson & Slein, 2012; Philippsen et al., 2021). A recent re-evaluation of radiocarbon dates from Ribe, a major Viking Age trade center in Denmark, has shown that trade connections with the Middle East were already in place as early as 790 ± 10 CE (Philippsen et al., 2021). Byzantium no doubt also served as a major draw for both trade and politico-military considerations among Scandinavian traders and travelers. Indeed, many Scandinavians came to serve in the personal guard of the Byzantine Emperor: the ‘Varanginan Guard,’ including the young Haraldr Harðráði, discussed above (Carlsson & Slein, 2012; Jesch, 2015). The diasporic communities in the west took on different forms than their eastern counterparts where the physical and political environments varied by region.

Vikings in the West

The Viking Age in the west was characterized by opportunistic raiding, political machinations, and armed conflict, in addition to the establishment of settlements, both in lands previously occupied and those without evidence of extensive human occupation. In the cases of both England and Ireland contemporary chroniclers, historical records, and later historical compilations provide a relatively high level of detail related to the events of the Viking Age. With a nod to partisan nature of the perspectives held by the author of these sources, and any held by subsequent translators, scholars by-and-large agree that they represent largely accurate records of past events (Downham, 2007a; 2007b; Ó Corráin, 2001). Historical sources, regardless of whether they are primary or secondary, cannot recount every instance of raiding or conflict that took place at the time. Nevertheless, the dates and events detailed here, are intended to provide a general sense of the complex and volatile nature of the times within the British Isles and its relationship with the North Atlantic *landnám.*

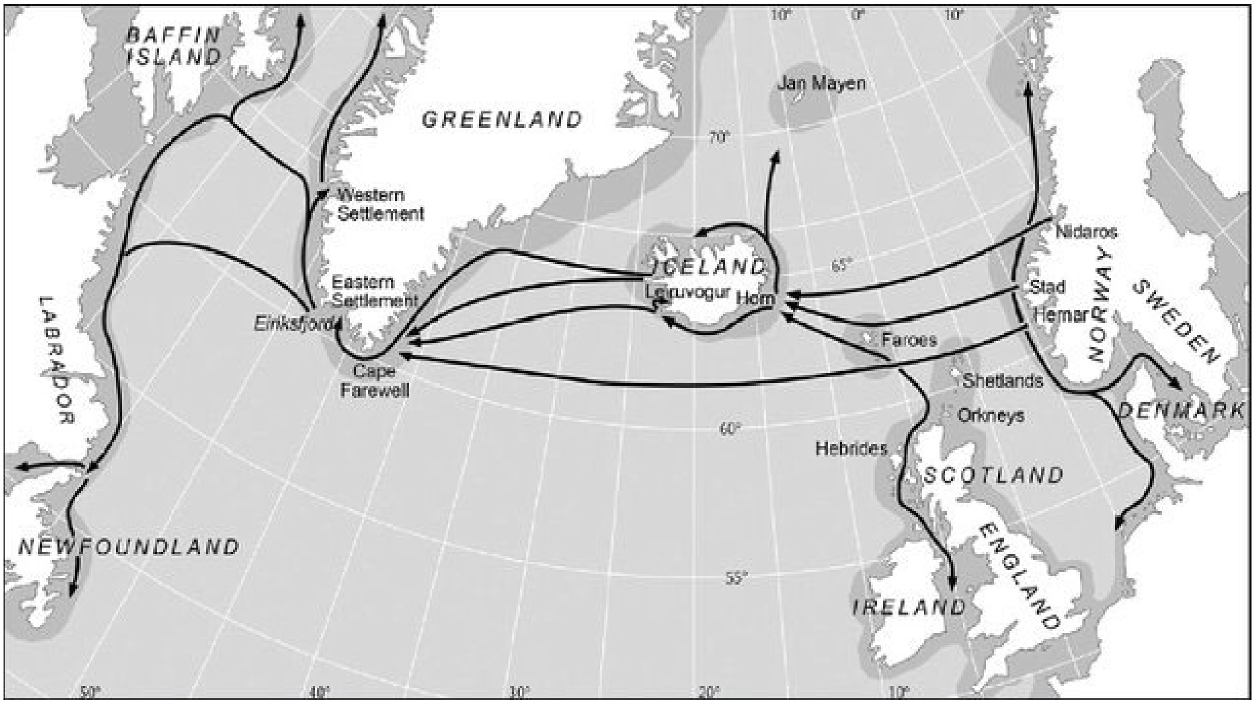


Figure 4.1: Map detailing historically documented Viking Age sailing routes in the west. Adapted from Byock & Zori (2017)

England

Genetic evidence suggests that Viking incursions into southern and eastern portions of England, were largely the result of Viking incursions by individuals of Danish-like ancestry (Margaryan et al., 2020). These genetic finding differ from those in Scotland and Ireland, where Scandinavian settlers primarily originated from what is now modern-day Norway (Margaryan et al., 2020). It is also important to recall that when Viking raids first began in the southern reaches of the British Isles, the political geography of the 'England' was not heterogeneous let alone harmonious, with seven kingdoms that included Strathclyde and Northumbria in the north, Mercia in the Midlands, East Anglia, and Essex along the eastern seaboard, and Kent, Sussex, and Wessex in the south (Downham, 2012a). The first record of Viking raids in what would become England began with an attack by Vikings on the island of Portland in Dorset which was followed shortly by the attack on the Christian monastery on the isle of Lindisfarne, Northumbria in 793 CE, which unlike the attack on Portland has gone down through the ages (Carlson & Slein, 2012; Downham, 2012a). Later, Viking raids seem to have continued in Northumbria in 794 CE and extensive Scandinavian activity is documented in Kent between 792 and 822 CE (Downham, 2012a).

Viking raids and pitched battles continued from the 830s through the 850s, but the scale of these conflicts changed dramatically with the arrival of 'a great heathen army' on the shores of East Anglia in 865/866 CE that ravaged the Anglo-Saxon Kingdom and its neighbors; this force was later joined by a Viking 'summer army' in 871CE (Downham, 2012a). Over the next thirteen years spanning from 865-878 CE Vikings conquered not only the city of Jórvík in 866CE, but soon after the Kingdom of Northumbria was subjugated in 867 CE, which was followed by the Kingdoms of East Anglia (869 CE), Mercia (873), and finally Wessex in 878 CE

(Downham, 2007a; 2012a). However, a victory at the battle of Edington by King Alfred of Wessex (also known as Alfred the Great) against the Viking leader Guthrum, resulted in treaty setting a boundary between land held by Danes and those by Anglo Saxons (Holman, 2001; Downham, 2012a). A boundary, which encompassed all land from the River Tees to the Thames within which the law of the Danes held saw; that is distinct from the West Saxon (Wessex) and Mercian, law codes (Downham, 2012a; Holman, 2001). Outside of this, the exact extent and intensity of Scandinavian settlement within this territory has been a matter of scholarly debate over the years.

In the time of Alfred's successors (886-954 CE) various conflicts occurred with successes and defeats on both sides as Anglo-Saxon make attempts to reconquer the Danelaw; during this time political fragmentation seems to have occurred between conflicting Anglo-Danish and Hiberno-Norse (who came initially from Ireland) factions in Northumbria (Downham, 2007a; 2012a). 954 CE marks the year that the forces of Wessex retook the Viking city of Jórvík signifying the gradual decline of Viking power in England (Downham, 2012a). Svienn Haraldsson (Forkbeard), later to become king of Denmark, led a renewed series of Viking raids in the 990s, which may have contributed to what followed not long after: on St. Brice's Day in 1002 CE King Æthelred ordered that all the Danes in the England to be killed in what became known as the St. Brice's Day Massacre (Downham, 2007a; 2012a).

Sveinn Haraldsson would go on to conquer England in 1013 CE, but his rule was short lived, as he died not long into 1014 CE and his son Knútr ruled from 1016-1035 CE (Downham, 2007a; 2012a). After his death, England fell once more into conflict over succession until Æthelred's son Edward claimed the throne in 1042 CE (Downham, 2007a; 2012a). The defeat of Haraldr Harðráði, king of Norway at the Battle of Stanford Bridge in Yorkshire on September

25th 1066 CE is recognized by many as the official end of the Viking Age (Brink, 2012a; Carlsson & Selin, 2012:11-14; Downham, 2007a; 2012a).

Ireland

The first recorded Viking raid in Ireland took place in 795 CE at Rathlin Island on Ireland's northeast coast, monastery on the island of Inishmurray, Co. Sligo, on Ireland's west coast, was raided the same year (Ó Corráin, 2001; O'Sullivan & Breen, 2007). In 821 CE Vikings again raided a remote Irish monastery, that of Skellig, located 14km off the coast of Co. Kerry. Around this time attacks not only became more frequent, but also ranged farther inland by way of major river systems such as the Boyne, the Erne, the Shannon, and the Liffey (Downham, 2007b; Ó Corráin, 2001).

These inland Viking raids impacted larger more prestigious monasteries such as Slane and Fennor on the River Boyne in 834 CE; the inland push of the 830s also saw the involvement of Viking war bands in small scale armed conflicts both for and against local Irish kings (Ó Corráin, 2001). As a point of clarification, during the 9th century Ireland was composed of more than one hundred and fifty lesser kingdoms, which were subject to six overkings (Downham, 2007b). Those six overkingdoms were Northern Uí Néill and Southern Uí Néill, Ulster, Leinster, Connaught, and Munster (Downham, 2007b; Ó Corráin, 2001; O'Sullivan & Breen, 2007).

Unlike in England, where large scale armed conflict resulted in the territorial acquisitions and the capitulation of nations, the 'highly localized character' of the Irish political landscape that limited the ability of the Vikings to gain a strong territorial foothold in Ireland (Downham, 2007a; 2007b). By the later 830s and early 840s Viking raiders had begun over-wintering in Ireland, at times fortifying coastal islands, or constructing fortified riverine outposts or 'longphuirt' (Downham, 2007b; Ó Corráin, 2001). While longphuirt like Dublin, which was built in 841 CE, were initially intended as temporary fortifications to provide protection to longships, several longphuirt became the nuclei of urban centers; these included Waterford, Wexford, and Limerick (Downham, 2007b; Wallace, 2016). Located on, or near the coast, these early Scandinavia settlements often held tenuous control over their hinterland (Downham, 2007b; Wallace, 2016). These Hiberno-Scandinavian fortifications served as trading posts, slave markets, and staging points for attacks on neighboring Irish kingdoms of varying sizes (Downham, 2007b; Ó Corráin, 2001).

The 850s CE saw the arrival of a king of Laithlind -originating in either mainland Norway or the Scandinavian controlled territories of Scotland- and his kin who attempted to compel the Hiberno-Scandinavians, who had already settled in Ireland, to submit to their dynastic rule (Downham, 2007b; Ó Corráin, 2001). By the mid-850s or early 860s the dynasty had moved its seat of power to Dublin; despite fierce opposition by earlier Viking settlers, the kingdom of Dublin had become the most powerful Viking center in all of Ireland (Downham, 2007b; Ó Corráin, 2001). Their descendants would rule in Dublin until political instability led to the expulsion of Vikings from Dublin in 902 CE, when the kingdoms of Brega and Leinster jointly attacked the port town (Downham, 2007b).

It has been suggested that this expulsion only extended to the ruling class, which included Røgnvaldr and Sigtryggr the grandsons of Ívarr the Boneless, and ignored the Scandinavian or Hiberno-Scandinavian artisans, traders, and farmers who made up much of the town’s population (Downham, 2007b). Despite sporadic coastal raids and sea-battles along the northern coasts in 904 and 910 respectively, Scandinavians would not make another attempt to rule in Ireland until 914 CE when a fleet of longships landed in Waterford Harbour (Downham, 2007b; Ó Corráin, 2001). The Anglo-Saxon Chronicles suggest that Dublin’s royals, Røgnvaldr and Sigtryggr, spent their time in exile campaigning in Northumbria, Strathclyde, and Pictland (Northern England and mainland Scotland) (Downham 2007a; 2007b). However, in 917 CE Røgnvaldr and Sigtryggr added their forces to the reconquest of Waterford and Dublin and succeeded in retaking Dublin that same year (Ó Corráin, 2001; Downham, 2007b). Throughout the late 920s and 930s the joint forces of Waterford and Dublin came into conflict with the Vikings of Limerick when political turmoil in Jórvík in 927 CE posed a serious threat to the Scandinavian dynasty that straddled both Jórvík and Dublin (Downham, 2007a; 2007b).

Both Downham, (2007b) and Ó Corráin, (2001) contend that, the rulers of Dublin, even after the fall of Jórvík in 927 CE, had a great deal of influence not only within Ireland, but also over-seas including the northern isles of Scotland, the Hebrides, and Northumbria. They argue that Dublin's true strength came not from political or military power, alone, but its economic connections as a trade emporium surrounded by a web of highly lucrative sea-lanes (Downham, 2007b; Ó Corráin, 2001). In the later 10th and early 11th centuries the increased political power and prosperity of the Viking port cities, especially Limerick and Dublin became a matter of concern for Irish kings (Downham, 2007b; Ó Corráin, 2001). In 972 CE, Brian Boru became king of Dál Cais (the north-western region of Munster) and by 978 CE he had crushed the port of Limerick and took control of its resources including their sailing fleets, and trade revenues (Ó Corráin, 2001). Brian Boru then allied himself with the Vikings of Waterford against the kingdom of Dublin; these acts played a significant role in the erosion of the political independence of the Viking power centers in Ireland (Downham 2007b).

Mael Sechnaill mac Domnaill, king of Meath, delt a crushing defeat to the Vikings of Dublin and their allies from the Hebrides at the battle of Tara in 980 CE (Ó Corráin, 2001). In 997 CE, Ireland was divided between Mael Sechnaill and Brian Boru; Mael Sechnaill gave Brian control over Dublin and Leinster (Ó Corráin, 2001). Sitric Silkenbeard, the Hiberno-Scandinavian king of Dublin led a revolt against Brian's rule in late in 999 CE, but the city of Dublin was looted and burned in retaliation as the revolt was brutally put down (Downham 2007b). Revolts against Brian's rule took root once more in 1012 CE and by 1014 CE the forces of Dublin and Leinster had built an alliance with the Earl of Orkney, and several fleets from around the Irish Sea. The battle of Clontarf took place on 23rd of April 1014, on the coast north of Dublin, between the Viking alliance and the forces of Brian Boru in which, the Vikings were routed, but Brian was killed in the fighting (Ó Corráin, 2001).

Scotland

Later Medieval sources paint a picture of the settlement of Scotland with a broad brush and the histories they recount are at best biased distortions of reality, and at worst fanciful reconstructions peppered with mythology (Barrett, 2003). Despite this dearth of contemporary written records to properly document of Scandinavian settlement in the region, Scotland, of all the places in the British Isles, was the most extensively settled and experienced the long-lasting Scandinavian influence, in particular the archipelagos of the western and northern isles (The Hebrides, Orkney, and Shetland) (Jesch, 2016). Early Irish sources, such as the Annals of Ulster, provide us with some dates for early raids in the British Isles seem to have focused primarily on remote coastal monasteries which represented sources of immense wealth as well as a source of slaves (Downham, 2007a; 2007b; Ó Corráin, 2001). Support of this view can be taken in part from the Annals of Ulster, which document recurring Viking raids on the great monastery at Iona, an island just off Scotland's Atlantic coast, not only was the site raided in 802 CE, but also in 806 CE, and again in 825 CE (Ó Corráin, 2001).

It has been suggested that the general shape of events that are chronicled in Ireland also took place in Scotland, about a generation earlier (Ó Corráin, 2001). That is, an initial period of exploratory raiding was later intensified on specific, highly lucrative, targets such as the monastery at Iona, which was then followed by occupation, settlement, and eventually the establishment of a regional dynasty. Ó Corráin's (2001) arguments stem from references to Laithlind in the Annals of Ulster as early as 848 CE, which he suggests is a reference to areas of Scotland under Scandinavian control. (Barrett, 2003; 2012) urges caution, insisting that, if Scandinavians did indeed have a territorial presence at that time, little is known, with any real certainty, about the settlement process of the isles (The Hebrides, Orkney, and Shetland) the various areas of mainland Scotland. If there was a marked Scandinavia territorial presence in Scotland by 848 CE, then it is reasonable to assume that initial raiding in the region predated this period and the scope and nature of those settlements did not include territory under the control of the Scots of Dál Riata (Argyle and the Inner Hebrides) or the Picts of Pictland (Barrett, 2003). These two kingdoms merged sometime after 843 CE and became known as the kingdom of Alba around 900 CE (Barrett, 2003).

This would suggest, by process of elimination, that the geographic contenders for a location for Laithlind would be, if it was in Scotland at all, the archipelagos of Shetland and/or Orkney, or in Caithness the northern most region of the Scottish mainland. Since these locations lay along major sea routes between mainland Scandinavia and the British Isles and North Atlantic, they would later become nodal point for vessels interested in trading, raiding, and settlement in the Viking Age and beyond (Barrett, 2010; Jesch, 2015; 2016; Ó Corráin, 2001). Evidence taken from place-name densities strongly suggests that these regions, as well as the Inner and Outer Hebrides would become locations of Scandinavian settlement during the Viking

Age, although neither the density of such settlements nor the size of their populations is so readily discernable (Barrett, 2003).

Genetic evidence can also provide another avenue to approach these issues. Helgason et al., (2001) identified evidence of Scandinavian admixture to populations in the Orkney Islands, the Inner and Outer Hebrides, and the Isle of Skye just off Scotland's northern and western coasts. A massive ancient DNA analysis of study for Viking Age burials was conducted by Margaryan et al., (2020). Orcadian individuals from the Margaryan et al. (2020) study displayed an unexpected level of complexity. Two individual burials on Orkney were identified as archetypical Viking warrior burials, in that they held Scandinavian grave goods including Scandinavian weaponry and apparel. However, it was determined that their genetic makeup was similar to modern Irish and Scottish populations, meaning they were most likely indigenous Pictish individuals (Margaryan et al., 2020). This may not come as a total surprise given that in the Shetland and Orkney islands, evidence of early Scandinavian settlements often coincide with earlier Pictish settlements along the coasts Two other individuals from Orkney were shown to have had 50% Scandinavian ancestry, and another five individuals with both presumedly Pictish and Scandinavian ancestry were found in mainland Scandinavia. The authors suggest that this indicates the integration of Pictish peoples into the Scandinavian cultural milieu during the Viking Age (Margaryan et al., 2020). This was something that has long been an issue with interpretation of the archaeological evince and modern place-name analysis when considering what the rate of acculturation was or entertaining the potential for Scandinavian cultural and political hegemony (Barrett, 2003; 2012). Further discussion of Scandinavian diasporic material culture is discussed below.

The North Atlantic

While the settlement of the islands of the North Atlantic may not have involved large scale cultural contact -with the exception of perhaps a few Irish hermits in the Faeroes -see Ó Corráin, (2001) and Hansen, (2003)- as we saw in England, Scotland, or Ireland, this does not mean that the fallout from these innumerable instances of culture contact had no impact on other regions. In the archaeological record of the North Atlantic individuals of British Isles ancestry are practically invisible due to the dominate physical evidence of Norse cultural expression in the region; this contrasts with the genetic evidence (Als et al., 2006; Ebenesersdóttir et al., 2018; Helgason et al., 2001; Margaryan et al., 2020). The findings of Margaryan et al. (2020) regarding the diaspora of individuals with Norwegian-like ancestry across the North Atlantic are further bolstered, and clarified by other genetic studies from the region, such as Helgason et al. (2001) and Ebenesersdóttir et al. (2018). Both studies suggests that the first Norse settlements in Iceland and Greenland also included individuals with British Isles-like ancestry, suggestive of individuals of either British Isles ancestry or mixed Norse and British Isles descent in the founding populations of Iceland and Greenland.

Findings such as these remind us of the complexe nature of cultural and social connections that developed between incoming Scandinavian populations and indigenous populations of the British Isles. Genetic evidence of British-Isles and Scandinavian admixtures has been identified among the founding populations of the Faroe Islands as well (Als et al, 2006). However, the populations in the Faroes were even more highly sexually disparate than those of either Iceland or Greenland, in that, male individuals were almost exclusively of Scandinavian descent, while female individuals were of predominately of British-Isles ancestry (Als et al, 2006).

The Saga of the Faroe Islanders is not a singular work, but the accumulation of various fragmentary works that were written around 1200 CE (Hansen, 2003). It accounts that the first settlers arrived in the Faroes from Norway sometime after the battle of Hafersfjorð in 872 CE, however it also claims that the grandchildren of those first settlers took part in the first phase of the Icelandic *landnám* (Hansen, 2003). These two statements present a chronological conundrum because the Icelandic *landnám*, also based in Saga literature, is said to have begun around 870 CE and lasted until 930 CE (Schmid et al., 2021; Sveinbjarnardóttir, 2012). As historians and archaeologists have worked to solve this problem, they estimated that the dates for Faroese *landnám* must be pushed back to around 825 CE if two generations were to separate these two settlement phases (Hansen, 2003).

This progression fit with our understanding of the process of raiding and settlement in the British Isles, where the first exploratory raids began in the 793 and 794 with temporary settlements beginning in the mid-800s (Barrett, 2010; Downham, 2007 a; 2007b; Ó Corráin's 2001). Considering that this region lacked major human occupation, if any at all, prior to Scandinavian settlers it is reasonable to assume that less time would have been needed in between the period of initial exploration and initial settlement. Throughout the Viking Age the into the late-Norse period, the Faroes served both as a staging point and a landmark on voyages between Norway and Iceland (Thirslund, 1997)

A recent, multidisciplinary study of the by Schmid et al. (2021) reminds us that the investigation of the Icelandic *landnám* is chronologically constrained due to the presence of a volcanic ash layer, called the *Landnám* Tephra Layer (LTL) dated to 877± 1 CE and its relationship to the archaeological features that are present after that date. Two later tephra layers similarly encapsulate the date range for settlement, the *Eldgjá* tephra and the V-Sv tephra dated to 939 CE and 938±6 CE respectively, which gives an end date for initial settlement in the region (Schmid et al., 2021). While there is evidence, both structural and environmental, to support human habitation on the island just prior to the LTL; the majority of the settlement period activity took place after the volcanic eruption of 877± 1 CE (Schmid et al., 2021; Sveinbjarnardóttir, 2012).

Schmid and her colleagues (2021) conducted an investigation of 550 recorded archaeological sites dated to the Viking Age (800-1100 CE) in Iceland; they found that n=300 of those sites recorded the location of settlements, which they then divided by geographic region. Schmid et al., (2021) found that only two settlements, both in southwest Iceland, were dated to the pre- *Landnám,* period, and both sites were later developed into permanent settlements during the *Landnám,* period. A total of 81 settlement sites were dated to *Landnám* period and were found both at coastal and inland areas in all four geographic areas of the island: north, northwest, southwest, and east (Schmid et al., 2021). The post- *Landnám* settlements (ca.938/9-1104 CE) totaled 124 and showed similar geographic spreads as the - *Landnám* settlements but had a higher concentration to the north of the island; an additional 93 settlements were assigned to a general category titled ‘Viking Age’.

Thirslund, (1997) muses over the initial often accidental discovery of the islands of the North Atlantic, noting that a great deal of luck must have come into play for those vessels who were not only blown off course, but were also able to find their way back to the known world. Fitzhugh and Ward (2000) also discuss the accidental nature of these discoveries, remark that Bjarni Herjolfsson, reportedly the first European to see the Atlantic Coast of North America, only managed this because he had been blown off course while sailing from Iceland to Greenland in 985/6 CE. In that same year (985 CE), the author of *Íslendingabók* claims Erik the

Red led a group of Icelanders to establish colonies in Greenland (Arneborg, 2003). These Icelanders would go on to settle in two locations along the coasts and fjords of Greenland, an Eastern and Western Settlement (Arneborg, 2003; Fitzhugh & Ward, 2000).

These settlers were predominately farmers focused on animal husbandry, raising sheep, cattle, and goats; access to suitable land no doubt played a role in both the Eastern and Western Settlements, but hunting also played a significant role in the Greenlandic economy (Arneborg, 2003). Gården Under Sandet (GUS), a Viking Age farmstead in the Western Settlement in Greenland, was occupied from around 1050 CE until the site's abandonment around 1380 CE (Ólafsson & Albrethsen, 2016). Archaeological evidence from GUS suggests that from its establishment it was a successful non-elite farmstead of the western settlement as indicated both by construction method and longevity (Arneborg, 2003; Ólafsson & Albrethsen, 2016). Access to suitable land no doubt played a role in both the Eastern and Western Settlements.

Distinctions between elite and non-elite farmsteads have generally been based on the presence of a church associated with the farm, the presence of a high percentage of cattle, versus goats and sheep, and whether the farm structures were spread out, or nucleated (Arneborg, 2003). Archaeological evidence from the Eastern Settlement indicates that a total of about five hundred farms of variable social status have been identified, based on the variable potential for livestock rearing among the different holdings (Arneborg, 2003). The quality of the land, however, does not seem to have deterred settlers in the initial stages of the Greenlandic *Landnám.* It is generally accepted that the Western Settlement was largely abandoned by the 1360s CE, although evidence from GUS, which was abandoned around 1380 CE, might suggest a less uniform departure (Arneborg, 2003; Ólafsson & Albrethsen, 2016). The last documented evidence of occupation in the Eastern Settlement is the record of a marriage at the Hvalseyfjord church in 1408 CE

(Arneborg, 2003). The abandonment of these settlements is not well understood, but environmental, and economic issues have both have their merits and a marriage of these two perspectives seems reasonable, if not a definitive answer (Arneborg, 2003; Fitzhugh and Ward, 2000; Ólafsson & Albrethsen, 2016).

Bjarni Herjolfsson's accidental sighting of the Atlantic Coast of North America in 985/6 CE is said to have led to later expeditions and eventually a short-lived settlement, (Arneborg, 2003; Fitzhugh and Ward, 2000; Wallace, 2003a; 2003b). The site of L'Anse aux Meadows in Newfoundland Canada is our only evidence of the greatest extent of Scandinavian expansion outside of literary sources (Wallace, 2003a; 2003b). Brigitta L. Wallace (2003b) suggests that L'Anse aux Meadows is the location of the 'Fjord of Currents' or *Straumfjörðr* recorded in the *Vinland Sagas* as the primary basecamp from which much of Vinland was explored.

Her arguments for this rest on the functional aspects of the settlement, both in terms of what is present, and what is not (Wallace, 2003b). There are several structures at the site including evidence of a longhouse indicative of habitation and a forge was identified at the southwestern edge of the site, which would have been used for tool production and repair (Wallace, 2003b). What was distinctly lacking from the settlement at L'Anse aux Meadows was the presence of a farm at the site; there were byres, stables, or animal pens recorded during either excavations or survey procedures. Kuitems et al. (2022) used a Miyake solar event to calibrate radiocarbon dates associated with the construction of the settlement at L'Anse aux Meadows in Newfoundland Canada. The study found that the trees used to build the settlement were felled using a metal axe in 1021 CE. Such precise dating is rarely possible outside of primary literary source material and provides a firm date for at least one instance of Scandinavian exploration of North America. The date of 1021 CE is approximately two decades after the dates suggested for

Leif Eriksson’s first exploratory voyage to Vinland as recorded in both *Eirik’s Saga* and the *Greenlander’s Saga,* which place the date at or just shortly after 1000 CE the same date given for the conversion of Iceland to Christianity (Wallace, 2003b; Schmid et al., 2021).

Thus far, we have covered some of the key events of the Viking Age across much of Northern and Eastern Europe. It may come as no surprise that we have a clearer understanding of later historical events, because of the very fact they were written down, than we do from earlier times. We have also seen that historical chronicling and other forms of documentation come with their own challenges. Thus, the need for the arbitrary start date of 793 CE, despite the fact this date does not work well over multiple politically, culturally, and geographically diverse regions. As mentioned earlier in the section on Vikings in Eastern Europe, a recent high-resolution radiocarbon dating study from Ribe, Denmark, has shown that trade connections at the trade center were already well established with both the Middle East and Arctic Norway by 790 ± 10 CE (Philippsen et al., 2021). The researchers used a single-year radiocarbon calibration curve, linked to a Miyake solar particle event -a similar approach to the one used by Kuitems et al. (2022) at L’Anse aux Meadows- to anchor various radiocarbon samples at Ribe to the site’s stratigraphy (Philippsen et al., 2021).

These early dates suggest that arguments for the cause of the Viking Age being rooted in economic, technological (ships), or political factors may be misplaced or ill assigned as a blanket argument for all regions at the same time. An argument could be made that the search for a singular cause to a complex multifactorial problem is ill-advised. Barrett (2010) postulates that many of the political, economic, and social impetuses that have been suggested as causes of the Viking Age were already aspects of daily life in late Iron Age Scandinavia, and it was instead a shift in mindset and mentality that truly sparked the Viking Age.

Despite continued discourse surrounding the origins of the Viking Age, the extensive sociopolitical and trade networks that began to take shape during the latter part of the Scandinavian Iron Age and throughout the Viking Age, made use of sea lanes and riverine trade routes to maintain connections between far-flung diasporic communities with mainland Scandinavia. Those same expansive networks also strengthened connections between diasporic communities along those routes and regional trade centers such as Ribe, Birka, Kaupang, and Dublin (Ambrosani, 2012; Carlson & Slein, 2012; Jesch, 2015; 2016; Philippsen et al., 2021; Skre, 2011). Having already focused on the broader currents of history, a more in-depth look at a series of links within the diasporic network is warranted. Specifically, the links between the Scandinavian mainland and insular communities of northern Scotland, Ireland, and the communities of the North Atlantic.

CHAPTER 5: RELATED SITES AND INDICATORS OF INTER-INSULAR TRADE AND EXCHANGE IN THE WESTERN VIKING WORLD

The following chapter focuses on the archaeological evidence of the Scandinavian diaspora in the west. The consideration of a series of diagnostic artifact types is discussed along with several sites aligned with their distribution. A key point of these compilations is that each of these artifactual signatures, Hiberno-Scandinavian ringed pins, steatite vessels, and organically rich black stone personal ornamentation items, have been found at the Viking period settlement at Jarlshof, thus linking the multiperiod farmstead at the site into the broader diasporic narrative by means of either trade or travel (Hamilton, 1956: 114, 121, 127). The expansion of Scandinavian vernacular architectural in to the British Isles and North Atlantic will also examined in relation to the structures present at Jarlshof. It is argued here, that distribution of these various forms of archaeological evidence can be seen as expressions of the degree interconnectivity between the various sites discussed below throughout the Viking Age (800-1066 CE) and into the Late Norse period (ca. 1050–1450 CE).

While trade and exchange throughout the North Atlantic region is documented sporadically from the Late Norse period (ca. 1050–1450 CE) onward, no first-hand historical accounts document trade and exchange in the region during the Viking Age (ca. 800–1050 CE) (Forster & Bond, 2004). James Barrett (2012b:6) refers to the island settlements and insular societies of the North Atlantic as, "physically removed from centers of consumption yet… interconnected by the sea." The following chapter will aim to illustrate the validity and extent of these connections and cultural contact between diasporic insular localities by considering artifactual evidence indicative of inter-insular trade and connectivity. These include the extent and continuity of Scandinavian architectural features found throughout the western Viking world that coincide with the dispersal of three forms of diagnostic artifact. The artifacts to be considered in further detail below include Hiberno-Scandinavian crafted bronze ringed pins, personal adornment items, such as finger rings, armlets, and bracelets that incorporate black stones namely jet, lignite, and cannel coal, and steatite stone vessels along with subsequently reworked steatite fragments that were reworked into other artifacts.

Hiberno-Scandinavian crafted bronze ringed pins have been found in Ireland, England, the Isle of Man, Shetland, Orkney, the Faroes, Iceland and even as far as west as Newfoundland in Canada (Fanning, 1994; Gibbons et al., 2005; Hamilton, 1956; Hansen 2003; Harrison, 2013; Wallace, 2016). Lignite, jet, and cannel coal artifacts share a similar distribution, having been recovered from burials and settlement sites Ireland, England, the Hebrides, the Faroes, the Shetland Islands, Orkney, and Iceland (Hamilton, 1956; Hansen, 2003; Hunter; 2008; Wallace, 2016). Steatite stone vessels and other soapstone artifacts, crafted in either Norway or Shetland, have been found at sites across the North Atlantic and British Isles from the Northern Isles of Scotland, the Faroe Islands, England, Ireland, Iceland, and Newfoundland, Canada (Foster & Jones, 2017; Hamilton, 1956; Hansen 2003; Larsen, 2016; Sindbæk, 2019; Wallace, 2003a; 2003b).

Scandinavian Vernacular Architecture in the Western Viking World

The principal buildings representative of the Scandinavian settlement period in the British Isles (Britain and Ireland), and across the North Atlantic were timber- or stone-built rectilinear longhouses, that share a general form with those found in mainland Scandinavia (Hansen 2003; Harrison, 2013; Barrett, 2003). The vast majority of Viking-Age settlements in the western Viking world were located along waterways or in coastal areas and were primarily comprised of dispersed clusters of rural dwellings and outbuildings that served a variety of functions (Hamilton, 1956; Hansen, 2003; Harrison, 2013).

Longhouses in the rural diasporic communities of the North Atlantic during the Viking Age tended to expand organically as they experienced alterations and changes in their use or function throughout the course of their occupation (Boyd, 2016; Harrison, 2013; Ólafsson & Albrethsen, 2016). Often, this resulted in the addition of annexes and smaller outbuildings associated with a parent dwelling or set of dwellings (Hansen 2003; Harrison, 2013). Knappett (2012) reminds us that the operational chain of an artifact’s life is the ongoing process of procurement, manufacture, use, maintenance, and repair that concludes with the eventual discard of the item. Structures, much like artifacts, have a use-life if we consider that life as being divided into phases over the course of the sites’ occupation. Building material must be procured and used in the erection of the structure, which will in turn be maintained, repaired, and repurposed or expanded in order to better serve a designated and often variable function (Boyd, 2016; Buckland, 2012; Dugmore et al., 2007; Hamilton, 1956; Kimball, 2003; Ólafsson & Albrethsen, 2016; Wallace, 1992).

The archetypical timber-built longhouses of the late Iron Age and Viking Age Scandinavia with its bowed rectilinear walls were distinct from the building traditions employed by indigenous communities in the British Isles and Irish Sea where dwellings were predominately circular in nature and employed different construction methods (Boyd, 2016; Curle, 1935; Hamilton, 1956; Wallace, 1992). Even in nearly treeless regions, such as the Faroe Islands and Shetland we see stone-built versions of the same architectural design being used (Curle, 1935; Hamilton, 1956; Hansen, 1988; Larsen & Hansen, 2001).

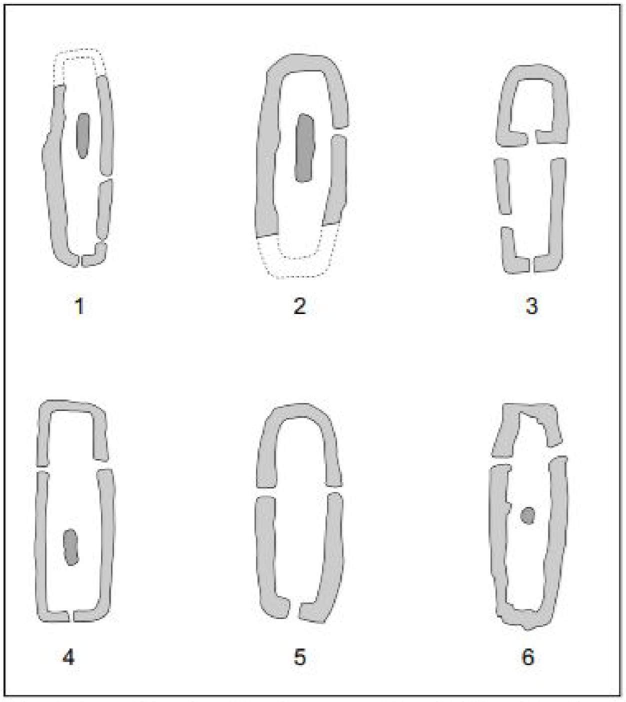


Figure 5.1: Examples of the continuity in form present in Viking Age long houses across the Viking west. 1. Toftanes, Faroes; 2. Niðri á Toft, Faroes; 3. Hamar, Shetland; 4. Jarlshof, Shetland; 5. Brough of Birsay, Orkney; 6. Oma, Norway (Adapted from Larsen and Hansen, 2001).

Larsen and Hansen, (2001) argue that it is this very reuse of dwelling form, despite a distinctive change in access to typical building materials, that makes the longhouse a ‘cultural emphasizer’ that likely held some sort of symbolic importance to the settler’s household culture. “Culture can thus be considered… a…mental matrix for action…” (Olsen, 2010, p.5 emphasis on original). To put it another way, it is not just the cultural items within the house, but the layout of a typical longhouse must have been central to the performance of activities encompassing a fundamental part of the settler’s social and daily lives (Larsen & Hansen, 2001; Sindbæk, 2019). The structures in Figure 5.1 illustrate uniformity of form across geographic regions, this conformity is even seen in areas where prolonged cultural contact resulted in a melding of architectural styles, as was the case in Hiberno-Scandinavian Dublin (Boyd, 2016; Wallace, 1992; 2016) (See figure 2). Hodder (2011) notes that archaeologically things appear transient, always in a process of transformation and change. Dublin, and other Hiberno-Scandinavian settlements exemplify this process as seen in Figure 5.2, where the overall shape of the structures still conforming to the longhouse form, despite native Irish methods of house construction being employed (Boyd, 2016; Wallace, 2016; 1992). The longhouses constructed by Scandinavian settlers were also distinct from the building tradition of the indigenous peoples of North America and was still the case at the time of later European contact centuries later (Wonders, 1979).

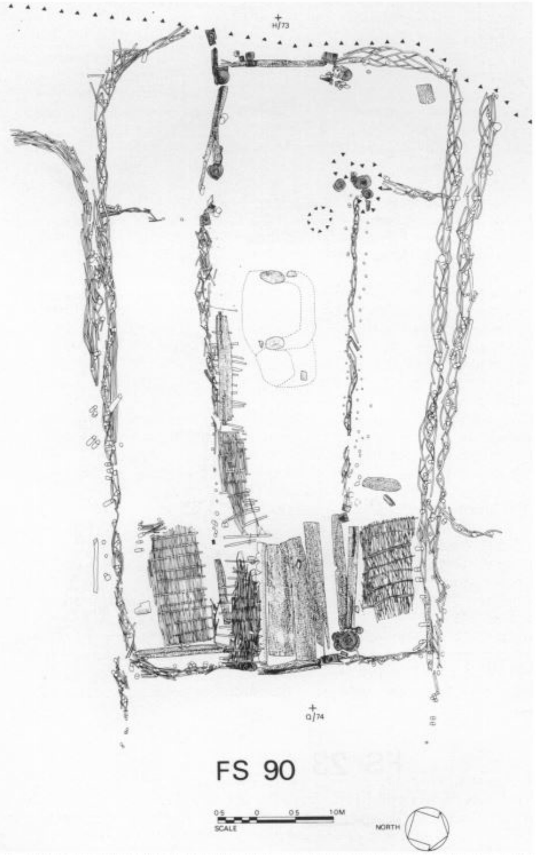


Figure 5.2: Hiberno-Scandinavian building Type 1. The overall form can be compared to those structures in Figure 1 despite the wattle and daub construction (Adapted from Wallace, 1992).

Researchers have posited, that the joint appearance of these rectilinear longhouses, steatite vessels, and other associated cultural objects of in the British Isles and farther west are a general indicator of Scandinavian settlement in those regions, rather than the result of indigenous appropriation or trade connections (Barrett, 2003). Thus, diagnostic artifacts are interpreted to represent the interaction between cultural groups or even the construction of distinctive cultural identities as with Hiberno-Scandinavian art styles (Boyd, 2016; Downham, 2019; Glørstad, 2014; Jesch, 2015; 2016; Larsen & Hansen, 2001).

Hiberno-Scandinavian Ring-Headed Pins

The development of ring-headed pins as dress fasteners originated in Ireland prior to Scandinavian contact, likely as a blending of influences and exchange between the Celtic west and sub-Roman Britain (Fanning, 1988; 1994; Larsen & Hansen, 2001). This is supported by finds from Ireland associated with pre-Viking levels that have secure stratigraphic contexts (Fanning, 1988; 1994). Despite its origins, the ringed pin was adopted and adapted rather quickly by Scandinavian settlers in Ireland which resulted in a blending of Celtic and Scandinavian ornamentation (Larsen & Hansen, 2001).

During the Scandinavian diaspora these Hiberno-Scandinavian ringed pins became a symbol of the developing emigrant communities of the west and the North Atlantic as a distinctive blending of two parent cultures (Larsen & Hansen, 2001). It is necessary to note that the artifacts discussed below are not, nor are they intended to be, an exhaustive list of documented ringed-pin finds from Dublin and the western Viking world more broadly. For a more complete albeit older compilation and discussion of finds from Dublin and abroad see Thomas Fanning's (1994) *Viking age ringed pins from Dublin*.

Although ringed-pins themselves were used as clothing fasteners and were not typically in and of themselves items of great value, they are indicative of cultural interaction and acculturation in Hiberno-Scandinavian towns and diasporic settlements from the Irish Sea region into the North Atlantic. The distribution of ring-headed pins of Hiberno-Scandinavian make have a distribution that is largely coterminous with the western expanse of the Viking world as they have been found primarily at sites in Ireland, Isle of Man, Scotland, England, The Hebrides, Orkney, Shetland, the Faroe Islands, Iceland, and Newfoundland (Hansen 1988; Fanning, 1994; Gibbons et al., 2005) (See Figure 5.3).

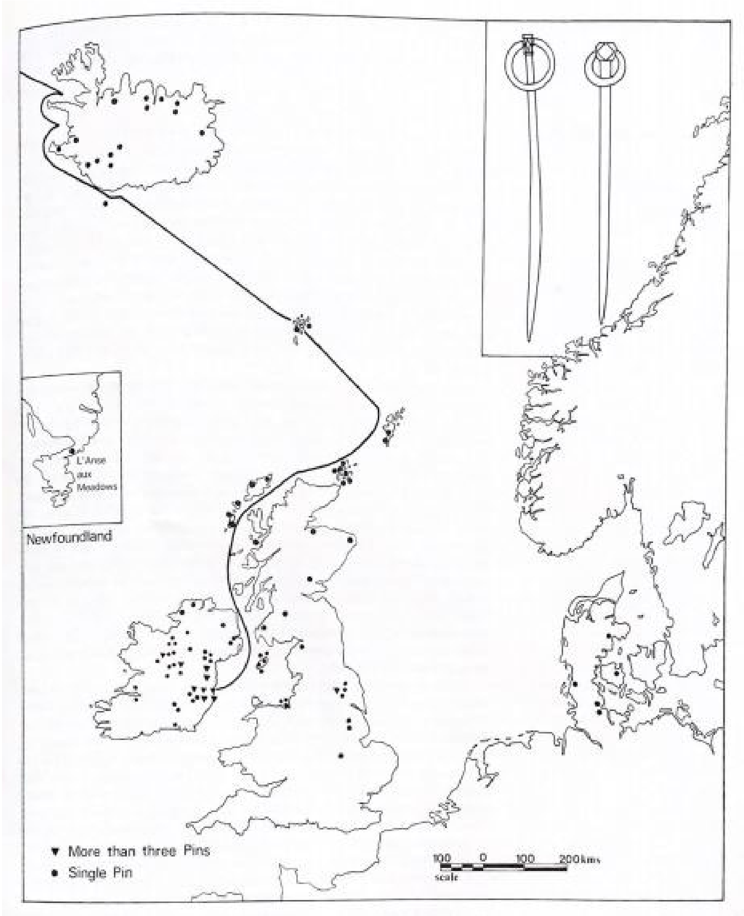


Figure 5.3: Distribution of plain-ringed baluster- and polyhedral-headed pins in conjunction with western sea-routes in the Viking Age (Adapted from Fanning 1994)

Ringed-pins can be divided into classes based on the type of ring attached to the head of the pin and then further subdivided by the style of the pinhead itself (Fanning 1994). There are six recognized classes of ring including spiral-ringed, plain-ringed, kidney-ringed, stirrup-ringed, knob-ringed, and link-ringed, as well as a few, transitional, outliers. For the purposes of this work, I will focus on three classes of ringed-pin that can either be directly linked to the farmstead at Jarlshof or related pin types with links to sites in the surrounding region that are an earlier stylistic development or that have been shown to overlap temporally. These artifacts and associated sites will be discussed in further detail below.

The three styles of ringed-pin to be discussed can be seen in Figure 4. They include plain-ringed, kidney-ringed, stirrup-ringed pins. Plain-ringed pins can be further subdivided into Loop-headed, Baluster-headed, and Polyhedral-headed pins. The type found most frequently throughout the North Atlantic region during the Viking-Age are plain-ringed polyhedral-headed pins (Fanning, 1994; Wallace, 2016). Kidney-Ringed pins are exclusively Polyhedral-headed as they are seen as a later development of the earlier style. Lastly, the stirrup-ringed type which developed around the same time as the Kidney-ringed pin has crutch-headed pin heads (Fanning, 1994).

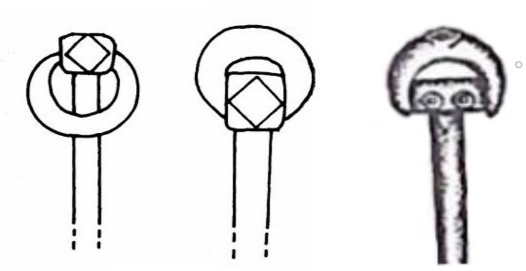


Figure 5.4: Examples of classes of ringed pins left to right: plain-ringed, kidney-ringed, and stirrup-ringed pins. (Adapted from Gibbons et al. 2005 and Hamilton, 1956)

Due to their relatively low cost these pins were replaced fairly frequently and can be found in various forms across the afore mentioned regions in line with the trade interests of Hiberno-Scandinavian markets such as the emporium in Dublin (Gibbons et al., 2005; Fanning, 1994). Plain-ringed polyhedral-headed pin types were produced in Dublin primarily in the 10th century but have been dated from the early 10th to the mid-11th century (Fanning, 1994).

Excavations at Woodstown 6 revealed a bronze ring-headed pin which was found at what seems to have been a *longphort* or ‘ship camp’ settlement near the river Suir in county Waterford, Ireland (O'Brien et al., 2005). The pin (02E0441:2256:2) was found amongst the *in-situ* burial assemblage of a Viking warrior grave (F2224) from excavations in Field 24 (O’Brien et al., 2005). The ringed-pin present in the grave was dated to between the mid-9th and mid-11th century based on stylistic comparisons between the ringed pin and the sword hilt that were recovered from the grave (O’Brien, et al., 2005). Perhaps unsurprisingly, the largest number of Hiberno-Scandinavian ringed pins have been recovered from Irish contexts, with the majority being found during the numerous excavations in Dublin (Fanning, 1994).

Figure 5.5: Bronze ringed-pin 934A from Jarlshof Phase III midden material. (Adapted from Hamilton, 1956).

A bronze ring-headed pin 934A was recovered from the midden overlaying the cobbling at Jarlshof. [Sq.71A] (see Figure 5.5). Another ring-headed pin, G998, this one made of bone, was recovered from midden I [Sq. 81B] which was located on top of the pavement of structure 1A after its abandonment. According to Hamilton (1956) G998 closely resembled the bronze ringed-pin 934A. Both finds were found in secure contexts which Hamilton (1956) allocated to Phase III at the site. A similarly crafted bone pin, DRP263 was recovered from Fishamble Street in Dublin in a level numismatically dated to 945-955. It was crafted as a copy of the common plain-ringed copper pins. (Fanning, 1994 pp.51). Another polished bone ring-pin E141:3584, this one with a polyhedral head was recovered from Fishamble Street (Fanning, 1994).

If turn our attention to the northwest to the Faroe Islands we see that the first ringed pin recovered from the Faroe Islands was a polyhedral-headed ringed pin, which was found among the grave goods from a Viking-Age grave excavated at Tjørnuvík on the isle of Streymoy (Dahl & Rasmussen, 1956 as cited by Hansen, 1993; Fanning, 1994). Later the Norse farmstead site of Toftanes was excavated in the village of Leirvík on the isle of Eysturoy in the Faroe Islands. The early occupation layers display a number of parallels with the early phases of settlement at Jarlshof. These similarities occur not only in terms of the artifacts recovered

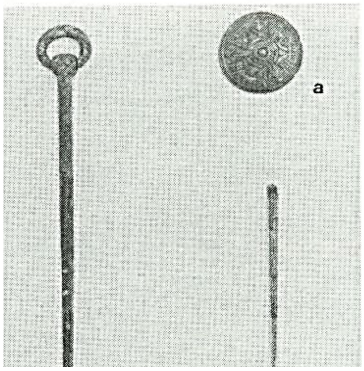


Figure 5.6: Find B: The polyhedral-headed ringed pin also featured in figure 17 and find C: the fragment of the second pin found at Toftanes farmstead Faroes. (Adapted from Hansen, 1988).

from each site, but also the overall layout of the homestead as well. Hansen, (2003) notes that the second phase of occupation at Toftanes, with its four contemporary buildings shares close parallels with the earliest Norse settlement phases at Jarlshof, Shetland. Both settlements are characterized by two rectilinear buildings with two smaller outbuildings or extensions (Hamilton, 1956; Hansen, 1988; 1993; 2003). The radiocarbon dates, which came from the floor layer of House 1 span from 870-1020 CE at one sigma and 780-1040 CE at two others, placing the occupation of the farmstead at Toftanes in the 9th and 10th centuries (Hansen, 2003). In addition to the architectural aspects, two polyhedral-headed ring pins were recovered from the layers outside the farmstead's structures (see Figure 5.6), (Hansen, 1988; 1993; 2003). A sketch of the complete pin from Toftanes can be seen in Figure 5.4 alongside other similar examples. While one of the ringed-pins was found intact and the other was fragmentary, the two pins were of the same type (polyhedral-headed) as the pin recovered from the burial at Tjørnuvík on Streymoy, Faroes in 1956 (Dahl & Rasmussen, 1956 as cited by Hansen, 1993; Fanning, 1994; Hansen, 1988; 1993).

Anne Ritchie excavated a multi-period settlement at Point of Buckquoy, Birsay, in the Orkney Islands, UK. Ritchie uncovered remains of five superimposed farmsteads and associated finds of both Pictish and Scandinavian origin. Phases I-II were determined to be from the Pictish settlement period which was dated to the 7th to early 8th centuries, while phases III-V displayed classic Scandinavian longhouses (Ritchie, 1976). Grave goods retrieved from a burial that was interred in the ruins of the Phase V house provide a tentative end date for the Viking occupation of the settlement to the third quarter of 10th century. These items included a bronze ringed-pin of the early 10th century style along with a whetstone, an iron knife a javelin head, and of particular note, part of a silver penny depicting Edmund I, who ruled England from 939-946 CE (Hansen, 1988;1993; Ritchie, 1976). The polyhedral-headed bronze ringed pin from the Buckquoy, Orkney, discussed above, displayed the same double-sided ornamentation of the pinhead as the intact pin as not only the complete pin found at Toftanes, Faroe, but also a pin recovered from the Fishamble Street excavations in Dublin (see Figure 5.7) (Dahl & Rasmussen, 1956 as cited by Hansen, 1993; Hansen, 1988; Larsen & Hansen, 2001; Ritchie, 1976).

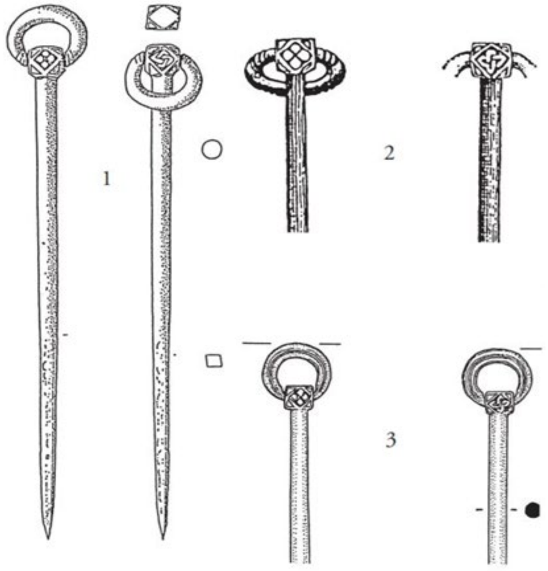


Figure 5.7: Three bronze ringed pins that share the same double-sided design on the pin head, 10th century type, found at Viking settlements: 1. Toftanes farmstead, Faroe Islands; 2. Fishamble Street, Dublin, Ireland; 3. Buckquoy settlement, Orkney (Adapted from Larsen and Hansen 2001: which was based on Hansen, 1993; Fanning, 1988;1994; A. Ritchie, 1977)

The farthest west that a Hiberno-Scandinavian ringed-pin has been recovered is the site of L'Anse aux Meadows in Newfoundland Canada. The site consisted of three discernable building complexes, each with its own rectilinear hall and small sunken hut, with one of the complexes also boasting a small rectilinear longhouse, a bloomery (a furnace commonly used for iron smelting) was also identified at the southwestern edge of the site (Wallace, 2003a). Unlike many of the other sites discussed in this section, the most notable feature of the L'Anse aux Meadows site is the apparent lack of enclosures designed for domestic animals. No byres, no stables, or animal pens were recorded during excavations or surveys at the site. A small number of personal items were documented from the excavations including a bronze ringed-pin of Hiberno-Scandinavian manufacture dated to late 10th-early 11th century (see Figure 5.7), a spindle whorl made of soapstone, which will be discussed later, a glass bead, a fragment of a gilded bronze ring, a needle hone, a broken bone needle, and (Fanning, 1994; Wallace, 2003a).

They were gradually supplemented with Kidney-ringed pins which become more prevalent in the mid-10th century and continue in use into the early 11th century. The Omey island pin discussed by Gibbons et al. (2005) is an example of a Kidney-ringed pin recovered from native Irish contexts. Kidney-ringed pins are most most often round in levels dated to mid- to late10th at excavations in Dublin, Ireland (Fanning, 1988; 1994). One such example from Dublin is DRP161 [E172:6649] from the Fishamble Street excavation. DRP 161 was discovered in plot 5, building level 10 which has been dated to 1000 CE (Gibbons et al., 2005; Fanning, 1994) Outside Ireland, finds of Kidney-ringed pins are concentrated primarily in Western Isles of Scotland, also known as the Hebrides, where six pins have been found (Fanning, 1994). Single finds of this type have been documented at Westray in the Orkney Islands, Bishops Gate in London, and at Hladir in Iceland (Fanning, 1994; Gibbons et al., 2005). Despite the lack of kidney-ringed pin finds at Jarlshof, they share a similar geographic distribution as polyhedral-headed and crutch-headed ringed pins and bridege the gap temporally between the production of the pin types that have been found there.

Crutch-headed ring pins, also known as stirrup-ringed pins, were manufactured starting in the early 11th century and continued being produced into the 12th century (Fanning, 1994). Stirrup-ringed pins have been found at several sites in Dublin, Ireland. Some examples that were recovered from these excavations include DRP214 [E190:783] which was found in Plot 14, building level 12 at Fishamble Street and DRP 226 [E71:3076] which was recovered from excavations at High Street. A number of other stirrup-ringed pins were also recovered from other excavations in Dublin including Christchurch Place and Winetavern Street. Both finds discussed here, from High Street and Fishamble Street, were dated to the early to mid-11th century and depict the same double ring and dot motif as those found at Jarlshof (Fanning, 1994; Hamilton, 1956) (see Figure 5.8).

Jarlshof has a number of Stirrup-ringed pins recorded in several different contexts, including finds from house occupation layers (Curle, 1935) and a number of finds from midden material (Hamilton 1956). These include F918 which was recorded in the Upper Slope midden [Sq. 80G] which has a similar double ring and dot motif on the head of the pin as DRP226 from Fishamble Street.

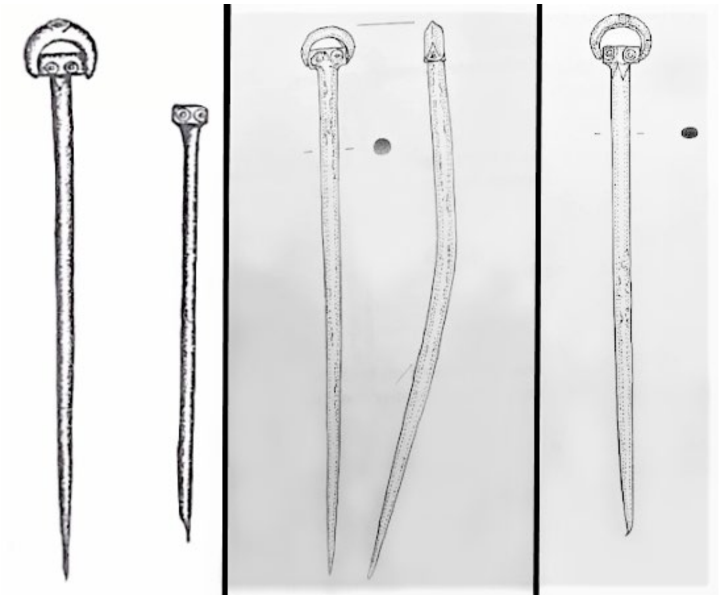


Figure 5.8: Stirrup-ringed pins from Jarlsholf and Dublin from Left to Right. Left panel: F918 with ring, Jarlshof (left) and 1289 without ring, Jarlshof (right); Center: DRP 214 [E190:783], front and side view, Fishamble Street, Dublin; Right panel: DRP 226 [E71:3076] from High Street. (Adapted from Hamilton 1956 and Fanning 1994).

The stirrup-ringed pin 1289 was recovered from the base of Lower Slope Midden [Sq. 76C]. The designs on the pin head of 1289 are stylistically nearly identical to F918 both of which are associated with midden deposits associated with Phase I at Jarlshof (Hamilton, 1956). Another stirrup-ringed pin, 1406 was recovered from the peat ash beneith alley midden 2 west of House 1 [Sq. 99B] which was dated to the late 10th to early 11th century (Hamilton, 1956 p.151). The absolute and numonical dating of Irish crutch-headed stirrup-ringed pins consistantly to between the early and mid-11th century raises implications for some aspects of the midden dating sequences established by Hamilton (1956) at Jarlshof. These implications are examined further in the dicussion section.

Jet, Lignite and Cannel Coal Personal Adornment Items

Another type of artifact known from burials and habitation sites in the western settlements during the Viking Age were personal adornment items of jet, lignite, cannel coal and other similarly organically rich black stones. The use of jet and similar stones such as lignite and cannel coal in the production of items used for personal adornment, such as, finger rings, armlets, bracelets, and bangles were not a traditional Scandinavian practice, as no local sources of these materials exist in mainland Scandinavia (Hunter, 2008). As such, it can be assumed that the custom was adopted by diasporic Scandinavian settlers as they encountered indigenous populations in the British Isles (Hunter, 2008).

According to Hunter, (2008) all currently known Scottish examples of jet or jet-like bangles from burial contexts have been associated with female burials. Similar finds from farther afield in Iceland at the site of Alaugrey and known examples from burials as far east as Birka, Sweden were also all from female burials (Hunter, 2008). Based on these associations and an examination of the internal diameter of bangles, to determine if they could be fit over the hand, found that they were primarily at the smaller end of the spectrum as would be anticipated for female ornaments (Hunter, 2008). If we think back on the discrepant proportions of British Isles and Scandinavian ancestry in the western Viking world it is also possible that this form of adornment originated with indigenous women and was adopted by incoming Scandinavian settlers (Als et al., 2006; Ebenesersdóttir et al., 2018; Margaryan et al., 2020). Like the bangles, finger rings crafted from jet, lignite, or cannel coal are also well-represented from settlement sites in Scotland, however, none are known from burial contexts making it difficult to determine if gender played a role in their use (Hunter, 2008).

In his work on identifying southern-based cultural and trade connections with Viking settlements in the Faroes, Hansen, (1993; 2003) noticed that the distribution of Hiberno-Scandinavian style bronze ring pins overlapped considerably with the recovery of personal adornment items crafted of jet, lignite, and cannel coal. Hansen (2003) and Wallace (2016) suggest that an inter-insular trade network was operating within the western expanses of the Viking world, in which the Hiberno-Scandinavian port at Dublin played a principal role. Hansen (2003) based these assertions, in part, on the high concentration of jet and jet-like stone adornment items that were produced, traded, and sold at the Viking trade emporium in Dublin, Ireland, being found throughout the North Atlantic and elsewhere in the British Isles including Orkney and Shetland.

It has been suggested by Wallace (2016) that the initial settlers to Scandinavian Dublin originated in south-western Norway; this assertion is corroborated by finds of jet jewelry being concentrated in the same region of Norway (Hansen, 2003). It is possible that the presence of these artifacts in both locations is indicative of interconnectivity between the settler's homeland in mainland Scandinavia and their new homes in the Irish Sea and still farther west. The range of finds from Dublin share similarities with those found in 10th century burial and settlements contexts in Caithness, on mainland Scotland, the Faroe Islands, Orkney, Shetland, and Iceland, in that, jet or jet-like bangles predominate, but a sizeable number of finger rings, and unworked or roughed out nodules of raw organically rich stone were also present (Hunter, 2008; Larsen & Hansen, 2001; Wallace, 2016). Finds associated with the import, export, and production of jet, lignite and cannel coal jewelry recovered from excavation at Fishamble Street and Christchurch

Place in layers associated with Viking Age Dublin, indicate that local and non-local sources of these stones were utilized (Hunter, 2008; Larsen & Hansen, 2001; Wallace; 2016) (see Figure 5.9).

The presence of local and non-local raw materials both at insular settlements and major trading centers suggests that the trade in jet and jet-like stones was not limited to finished products. Hunter, (2008) notes that the production process did not involve specialized tools stating that all objects were shaped by hand using basic tools such as knives, gouges, or points prior to being abraded and polished to their finished state. It was also suggested that care was taken to ensure damaged bangles could be reworked in order to extend their use-life, suggesting a certain level of importance to the wearer (Hunter, 2008). This was the case with a bangle [FN 2] recovered from excavations at Castletown, Caithness, Scotland which can be seen in Figure 5.10 (Hunter, 2008).

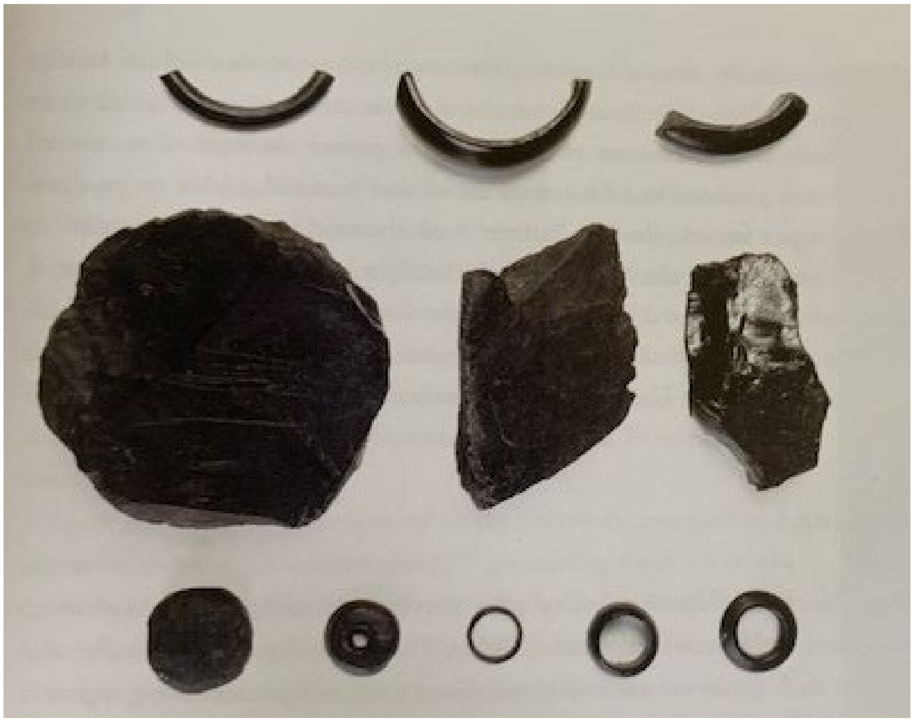


Figure 5.9: Selection of Jet or cannel coal including unworked nodules and roughly shaped examples as well as finished rings and bracelet or bangle fragments from Fishamble Street and Winetavern Street excavations, Dublin Ireland. (Adapted from Wallace, 2016).

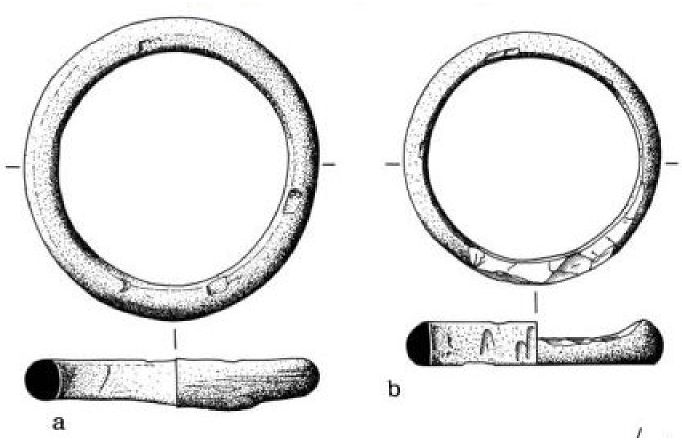


Figure 5.10: Viking bangle from A. Lamba Ness, Unst, Shetland [IL 349]; B. Viking bangle from Castletown, Caithness, Scotland [FN 2] showing a segment that was reworked to prolong its use. (Adapted from Hunter, 2008; Drawn by Alan Braby ©National Museums Scotland).

It is worth noting that many archaeologists including Hansen (1993; 2003), Wallace (2016), and Ritchie (1976), and Hamilton (1956) have tended to discuss jet or jet-like stones by referring to them generally as jet, or lignite, or it could be either lignite or cannel coal, without determining which stone type the item is actually made from. Hunter (2008) takes issue with this lack of clarity that is commonplace when referring to jet artifacts. He argues that, rather than being referred to interchangeably or based on personal preference, these materials should be clearly identified as either jet or their specific stone type, such as lignite or cannel coal. Despite his desire for, and implementation of, more rigorous typologies, his findings in many ways support Hansen's (2003) conclusions. Lignite deposits are found in locations the Inner Hebrides and extensively in northern portions of Ireland thus supporting Hansen's suggestion that Dublin served as a crafting and distribution center (Hunter, 2008). Sheehan (2016) in his discussion of Scoto-Scandinavian ring money and coin dated and coinless silver hordes points to economic and political relations between the northern Irish kings and the Vikings of Dublin.

This connection could be one potential mode of accessing lignite, or other resource deposits in the area around Dublin. Finds recovered from various contexts in Dublin indicate extensive production evidence of not only lignite and cannel coal, but also true jet from Whitby near Jórvík (modern-day York), which is far rarer, suggesting that both local and non-local sources were procured and used by Dublin's craftsmen (Hunter, 2008; Wallace, 2016). He also found evidence of jet in Faroe Island contexts, as discussed by Hansen, (1993; 2003), and even indications that Whitby sourced jet was recovered as far south as Denmark.

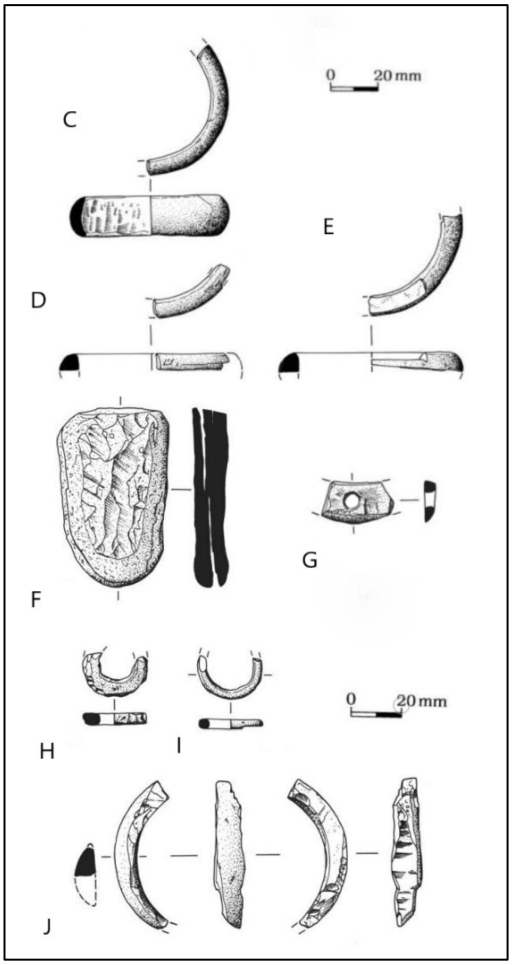


Figure 5.11: Finds of lignite or cannel coal jewelry from Jarlshof (D,E,E,F & H) and Brough of Birsay (C,I, & J) including beads, rings, working debris, roughouts, and bangle fragments. C: [HB512] Birsay; D: [HSA783a] Jarlshof; E: [HSA 784] Jarlshof; F: [HSA788] Jarlshof; H: [HSA 787] Jarlshof; I: [HB 515] Birsay; J: [5068] Birsay. (Adapted from Hunter, 2008; Drawn by Alan Braby ©National Museums Scotland).

In addition to determining whether a given stone was true jet, Hunter's (2008) investigation of jet and jet-like stone also shed light onto some finds from the Viking age settlements in the Northern Isles. Figure 11 shows a number of finds recovered from both Jarlshof, Shetland and the Brough of Birsay, Orkney. Hamilton (1956) documented the recovery of three cannel coal or lignite bracelet fragments which were recovered from the earliest midden levels, as well as two lignite finger rings from Jarlshof. Hunter's (2008) X-ray and elemental analysis of these finds revealed that the majority of the finds from Jarlshof were made of lignite, which came from a series of related sources rather than any singular source (Hunter, 2008). Of all the samples taken from Jarlshof, only [HSA 783b] was determined to be crafted of cannel coal (Hunter, 2008).

On the other hand, samples of jet-like material tested by Hunter (2008) from the settlement site at the Brough of Birsay, Orkney clearly differ from the material documented at Jarlshof, Shetland. X-rays used on the Birsay finds determined that one unfinished bangle was made of oil shale, while another reworked bangle fragment was made of lignite. The remainder of the Birsay material was determined by Hunter (2008) to be cannel coal. Material finds such as these jet, lignite, or cannel coal armlets, rings, and other personal items recovered from North Atlantic contexts indicate long-distance connections linking these island communities with areas to the East and South.

The distribution of these two types of personal equipment associated with the blending of Celtic and Scandinavian material culture coincide with the expansion of Scandinavian diasporic communities into the North Atlantic and Irish Sea. It has been suggested by Larsen and Hansen (2001) that these western settlers may have regarded themselves as being part of a western Viking culture that was distinct both from their homeland in Scandinavia and the indigenous insular cultures they encountered. However, despite the distinctive nature of the physical ornamentation associated with western diasporic settlers this does not necessarily indicate what past people experienced or recognized as their cultural ‘identity’. This is because the individualized nature of identity results in it often being fluid and situationally variable. Although it is possible that individuals in the past may have held a strong sense of cultural or social identity, for example as Rus, Norse, Danes, Anglo-Saxons, Picts, Gaels, or some admixture of these or other identities, it is not feasible to make these determinations with any real accuracy based on archaeological, genetic, or even historical evidence. This does not exclude the possibility that the cultural and genetic admixture present in diasporic populations in the region resulted in a distinct identity for these past people just as Larsen and Hansen (2001) suggested, it simply heeds caution. After all, alongside the blending of Celtic and the Scandinavian cultural aspects in the dress and personal adornment of people of the North Atlantic during the Scandinavian diaspora, we find that they also maintained aspects of their Scandinavia heritage, such as, the form of their vernacular architecture. While the general form was maintained, regional variability in building materials or methods used in construction was clearly visible. In the following section we will see how yet another form of material goods, in this case cookware and other domestic artifacts crafted from steatite, or soapstone, represent both the retention of certain aspects of Scandinavian identity while also indicating the incorporation of cultural influences from the British Isles.

Steatite Vessel Forms and Reworked Steatite Fragments

Steatite, more commonly known as 'soapstone' is a malleable, naturally occurring rock type known both from mainland Scandinavia, the Shetland Islands, and Greenland (Forster & Jones 2017; Hansen, 2003; Larsen, 2016; Sindbæk, 2019). Steatite vessels are considered one of the archaeological signatures of Scandinavian settlement during the Viking-Age, so much so that North Atlantic settlements during the early settlement period were largely aceramic (Foster & Jones, 2017; Hamilton, 1956; Hansen, 2003; Larsen, 2016; Sindbæk, 2019). Steatite vessels sourced from Norway and Shetland have been found at sites across the western diasporic region including the Northern Isles of Scotland, the Faroes, England, Ireland and Iceland (Foster & Jones, 2017; Hamilton, 1956; Hansen 2003; Larsen, 2016; Sindbæk, 2019; UHIAI, 2019). Steatite vessels have also been found at sites in Greenland; Scandinavian settlers in the Eastern and Western settlements had access to local sources of steatite (Forster & Jones, 2017).

However, there is currently no evidence to support Greenlandic vessels being exported to other areas (Forster & Jones, 2017) (see Figure 12).

Sindbæk, (2019) argues that changes in steatite use over time in diasporic regions should be taken as evidence of cultural contact and change as well as the interaction between material goods and socio-cultural connections. As the physical remnants of past cultures, debris and debitage represent the main subject of archaeological investigation; archaeology as a discipline is uniquely situated for the investigation of material culture (Hodder, 2011; Olsen 2010, 2012). The basis of traditional archaeological interpretation relies upon the dual nature of artifact construction, in that, they are socially, as well as culturally, constructed and that they are also physically constructed out of materials (Hodder 2011; Knappett 2012; Olsen 2010).

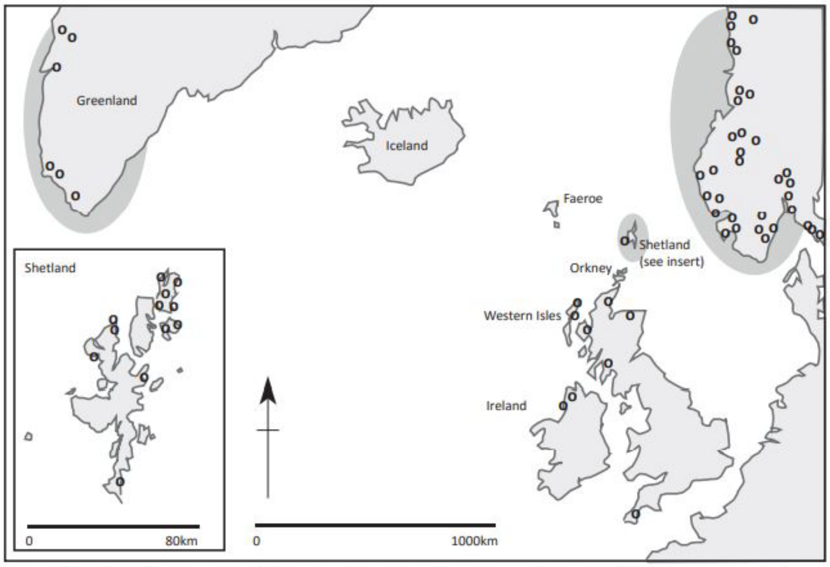


Figure 5.12: Location of known steatite outcroppings in Norway, the British Isles, and Greenland. The dark grey halos represent locations in use during the Viking Age. (Adapted from Foster and Jones, 2017).

In this way, the decisions behind the physical construction of material things cannot be fully separated or removed from the socially constructed significance of that production process. Take for example, the use and production of steatite vessels in Scandinavia and their subsequent use and eventual production in the rural diasporic communities of the North Atlantic during the Viking Age. In this example, steatite can both reaffirm a cultural connection to the homeland, while also reiterating aspects of a cultural change. The trade and use of steatite vessels or other steatite artifacts over long distances to numerous sites in Iceland and even Newfoundland, Canada indicates a cultural as well as possible economic connections with sites in mainland Scandinavia or Shetland (Forster & Jones; 2017; Wallace 2003a). Shetland possesses the largest steatite quarry yet discovered in the British Isles, Cunningsburgh, as well as 23 localized steatite sources, many of which are archeologically relevant outcroppings, such as those found on the isle of Unst, that show evidence of quarrying activities (Forster & Jones, 2017; Hall, 2007; Larsen, 2016). Many of these sites have modern names that include Clibber or Clebber which originates from the Old Norse *Kle-berg* or 'loom weight stone' (Forster and Jones, 2017 Hall, 2007). Figure 5.12 shows the locations of all known steatite outcroppings in the North Atlantic, British Iles, and mainland Norway.

Sindbæk, (2019) notes a distinctive drop in the number of steatite vessels in mainland Britain and Ireland in direct contrast to the prolonged use of steatite in the North Atlantic Islands and Northern Isles of Scotland. He suggests that this distinctive drop off in steatite finds may represent a long-term distribution zone for steatite between either Shetland or mainland Scandinavia and the North Atlantic isles that places the Hebrides, Ireland or mainland Britain on the periphery (Sindbæk, 2019). See Figure 5.13 for a distribution map of Viking Age steatite vessel finds across Northern Europe. We can see this southerly drop off by looking at the

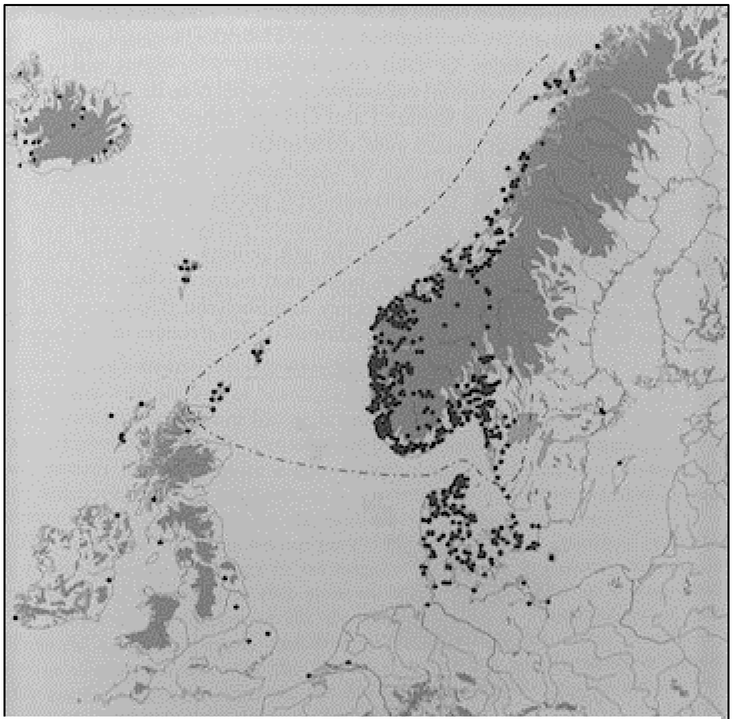


Figure 5.3: Viking Age steatite vessel find distributions from across Northern Europe. (Adapted from Sindbæk, 2019).

quantity of finds recovered from early settlement layers at Jarlshof, Shetland and Toftanes, Faroes versus steatite finds recovered from Dublin, Ireland or in the Hebrides. At Jarlshof, over 270 sherds of steatite vessels were recovered from the earliest deposits levels alone (Hamilton 1956). A similarly copious number of steatite finds, more than 700 objects in all, were recorded during excavations at Toftanes, Faroes (Hansen, 1988; 1993). Even less extensive excavations in the Northern Isles, such as the 2019 excavations of the Viking Age Hall beneath the Skaill Farmstead on Rousay, Orkney included steatite from Shetland amongst their initial finds (UHIAI, 2019). This Norse drinking hall at Skaill, on Rousay was built on a settlement mound, although one not as extensive as the mound at Jarlshof, the hall is estimated to date to the 10th to the 12th centuries CE (Hamilton, 1956; UHIAI, 2019). Alternatively, a minimum of half a dozen steatite vessel shards have been recovered from excavations in Dublin, Ireland, a site considered to be a major port associated with long distance trade, as has been demonstrated above, and the largest Scandinavian trading hub in Ireland (Sindbæk, 2019). Admittedly, many of the excavation reports from Dublin remain unpublished, but the relative dearth of steatite finds given the relative physical scale of these sites is telling. Interestingly, among the steatite finds recovered from Dublin were steatite molds for ingots and even one for a Thor’s Hammer matrix suggesting the use of steatite for crafting purposed in major Scandinavian trade centers such as Dublin, Ireland and Jórvík, England (Sindbæk, 2019).

Other areas in the British Isles such as the Hebrides provide a distinctly different perspective on cultural contact and appropriation. Sindbaek (2019) notes that despite the lack of continuous steatite use over time in the Hebrides, the use of Scandinavian longhouse dwelling likely contributed to the adaptation of local pottery styles to accommodate Scandinavian hearth forms and cooking methods. In other words, at the time of Scandinavian settlement in the

Figure 5.14: Type 7 steatite vessel. (Adapted from Foster and Jones 2017; Hamilton 1956).

Hebrides, local pottery forms took on morphological characteristics that seems to have been in imitation of steatite vessels. Hodder (2011) and Olsen (2012) postulate that the decisions surrounding the construction of artifacts are directly impacted by not only access to a given material, but also the physical characteristics of the materials employed. This view is shared by Sindbaek (2019) who notes that, while local pottery was likely viewed by Hebridean Scandinavian settlers as an adequate replacement for steatite vessels in many instances, steatite was still used from time to time because of its physical properties. For example, steatite could be more easily crafted into larger more spacious vessels such as the Type 7, after Foster and Jones (2017), a larger circular steatite vessel form with straight, flared walls. (See Figure 14).

Another of the attractive features of steatite is its durability. A damaged steatite vessel that becomes cracked or broken can be repaired with iron staples, extending its overall use-life (Foster & Jones, 2017; Hall, 2007). An example of this repair process can be seen in Figure 15, a Type 1 vessel, [BEG-C1959:748] that was recovered from Beginish Island, co. Kerry, Ireland. See discussion of Foster and Jones (2017) vessel morphology criteria below. The durability and heat-resistance of steatite also allowed it to be directly suspended over a fire by iron loops, which could be directly attached to the vessels (Forster & Jones, 2017; Hall, 2007). Once a vessel became too damaged to be readily repaired it could also be reworked into a variety of other items. This process of repurposing steatite shards will be discussed further below.

Figure 5.15: Steatite Bowl Type 1 from Beginish Island, Ireland. (Adapted from Foster and Jones, 2017).

Foster and Jones (2017), consider steatite provenience as it relates to migration and settlement patterns in the North Atlantic. They divide Viking-Age steatite vessel forms that have been found consistently across the North Atlantic into seven distinct categories based on vessel morphology. These seven types are separated into two separate temporal phases. Type 1 and Type 2 steatite vessels fall into the first phase 800-950 CE while vessel types 3-7 are placed in the second phase lasting from 950-1200 CE (Foster & Jones, 2017). For the purposes of this research, I focus primarily on Types 1-4 for the sake of distinguishing between those vessels that were most likely manufactured in Norway and those crafted in Shetland.

Type 1 steatite vessels are typically identified by the quality of their manufacture in terms of the thickness and symmetry of their overall shape and curvature. The consistency and uniformity seen in vessel form is likely indicative of an organized production process. Of the seven types outlined by Foster and Jones (2017) it is the most commonly produced Norwegian vessel form. Type 1 Vessels have been found at sites across the North Atlantic, in layers dated to the initial settlement or *Landnám* period between 800–950 CE (Hansen 1993; Foster and Jones, 2017). These Type 1 vessels are often considered original imports, that is they were likely brought to the settlement sites as personal items by the initial settlers rather than arriving later as items of trade (Foster & Jones, 2017; Hansen, 1993). During these early phases, large numbers of well-preserved Type 1 vessels were recorded at Old Scatness and Jarlshof in south mainland Shetland and at Toftanes in the Faroe Islands (Hamilton 1956; Hansen, 1993). Type 1 vessels were also found in levels associated with the *Landnám* period in Reykjavík, Iceland during excavations at Suðurgata 3–5 (Foster & Jones, 2017).

A similar process of artifact deposition is apparent in assemblages from Jórvík, England and Dublin, Ireland, in that, Type 1 steatite cooking vessels and other artifacts such as casting molds seem to have been brought by early Scandinavian settlers to these towns. As with early finds from settlement sites in Orkney, the Faroes, and Shetland, the Type 1 vessels recovered from those contexts are believed to be of Norwegian origin. However, unlike the artifacts recovered from rural settlements, finds from Viking Age towns were likely not representative of the belongings of the entire settlement's population, but rather the belongings of individuals such as craftsmen or traders (Foster & Jones, 2017; Sindbaek, 2019). The idea of trade diasporas: mercantile communities settling in enclaves in foreign ports, was first posited by Abner Cohen, (1971). He suggested that individuals in these migrant communities would assimilate certain aspects of the local culture while maintaining others from their homeland, and by doing so, serve as intermediaries in long distance trade. Downham (2019) draws parallels between Scandinavian settlers in Ireland and the subsequent development of the Hiberno-Scandinavian cultural milieu and historical trade diasporas as discussed by Cohen (1971). Whether at trade enclaves or rural settlements, the appearance of Type 1 steatite seems to clearly coincide with the period of initial settlement in these regions.

The development of Type 2 vessels can be most clearly seen at the Viking age settlement at Norwick, Shetland (Foster & Jones, 2017). Unlike earlier and later styles Type 2 vessels cannot be clearly identified as coming from Norwegian or Shetland with certainty. The vessel morphology is still curved; it is distinguished from Type 1 vessels for its thicker walls, flatter base, and a generally coarser finish (Foster & Jones, 2017). Foster and Jones (2017) suggest that this vessel type could be an attempt by less-skilled artisans to reproduce the Type 1 vessels of their homeland with local steatite sources.

Figure 5.16: large fragment of Type 3 vessel from Jarlshof [JARL-HSA718] (Adapted from Foster and Jones, 2017).

Sindbaek, (2019) notes that the production of steatite vessels and other objects was likely a seasonal or part-time occupation requiring knowledge of, and proficiency with, readily available skills and tools. Alternatively, Foster and Jones (2017) also consider the possibility that, rather than a general lack of experience or skill, different sources of steatite may have variable working qualities due to their geologic composition. It is worth investigating whether Shetland's steatite might be more readily shaped into square and rectangular vessel forms as a result of its geologic make up, or if inspiration was taken from local examples. For example, Viking period Type 3 vessels which originate from Shetland, share a similar square form to four small, square-sided, locally made vessels recovered from Bronze Age contexts at Jarlshof (Foster & Jones, 2017; Hamilton 1956:20) (see Figure 16). Type 3 vessels are square-walled vessels that often have vertical tooling on the external face; the vessels also sport flat bases and a flared profile (Foster & Jones, 2017).

If we look at the Viking age settlements in the Shetland Archipelago, locally sourced steatite vessels have been recovered from sites such as Norwick, Belmont, Underhoull, Old Scatness, and Jarlshof (Bond & Dockrill, 2016; Foster & Jones, 2017; Larsen, 2016, Small, 1967). From these sites, it can be seen how the physical lay of the land, as well as prominent geological features, in this instance the presence of steatite outcroppings, have had an impact on the decisions made by past people (Bond & Dockrill, 2016; Fisher 2009; Hodder 2011; Larsen, 2016; Olsen 2010). The relatively close proximity of Orkney to these sources enabled settlements in Orkney to still have access to a large number of steatite vessels of both Type 3 and Type 4 (Foster and Jones, 2016). The presence of Shetland vessels at sites in Orkney such as Brough of Birsay and Quoygrew on Westray as well as Pool, where they are frequently seen in contexts from the mid-10th century onwards, suggests Shetland's steatite industry had developed to an extent that it could serve as an acceptable replacement for imported Scandinavian steatite abroad (Bond & Dockrill, 2016; Curle, 1982; Foster & Jones, 2017).

Type 4 vessels are ovular in plan with similarly flat bases and flared profiles as the Type 3 vessels mentioned above, but with more inconsistencies in terms of decoration and vessel thickness (Foster & Jones, 2017). Type 4 vessels have been found in limited quantities in the Faroe Islands as well as in the Hebrides, suggesting that Shetland steatite vessels were being traded, albeit not to a great degree, to other islands in the North Atlantic and Scotland aside from Orkney (Foster & Jones, 2017). It has been suggested that Shetland may have served the wider diasporic community as a source of steatite vessels (Larsen, 2016; Hansen, 2003; Foster & Jones, 2017; Sindbæk, 2019). This interpretation is supported by recent findings from the site of Belmont on Unst, the northern most island in the Shetland chain, that suggest the Viking period farmstead had been a finishing site for steatite vessels (Larsen, 2016).

As mentioned above, over 270 sherds of steatite vessels were recovered from the earliest deposits at Jarlshof (Hamilton, 1956). Some of these sherds were reworked into loom weights and other smaller artifacts (Hamilton, 1956:113,117, 129-130). Three of these fragments were of

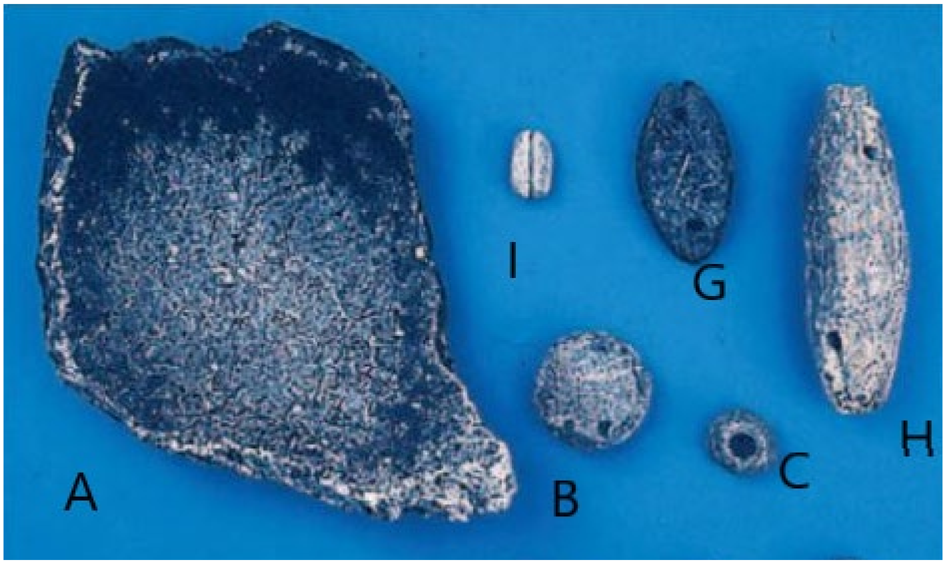


Figure 5.17: Assortment of steatite objects. A. large vessel sherd; B-D. line- and net sinkers used for fishing; E-I. examples of both finished and unfinished spindle whorls. Adapted from Larsen and Hansen, 2001; Photo: Føroya Fornminnissavn, S. Stummann Hansen)

steatite bowls that, based on their physical composition and decoration, were likely imported from Norway (Larsen, 2016; Hamilton, 1956:129-130 Hansen, 2003). Knappett (2012) reminds us that the operational chain of an artifact's life is the ongoing process of procurement, manufacture, use, maintenance, and repair that is concluded, under anticipated circumstances, with the item being eventually discarded. However, at Jarlshof and other sites in the North Atlantic, see below, steatite vessels were not only repaired to be reused as vessels, but were also reworked for entirely new purposes as 'new' objects such as net or net sinkers, tuyères, spindle whorls and loom weights (Hamilton, 1956:129-130; Hansen, 1988;1993;2003) (See Figure 17). Once a vessel reached a point that it was no longer reasonable to attempt to repair it, as detailed above, the suitable fragments would be reworked to serve a new function.

This initial use of steatite vessels by Norse settlers and the later reworking of steatite sherds has also been identified at the site of Toftanes in the Faroe Islands (Hansen 1988; 1993; 2003). Many of the artifact finds recovered from Toftanes were fragments of Type 1 vessels (Foster & Jones, 2017; Hansen 1988; 1993). Of the over 700 steatite finds recovered from Toftanes, more than fifty were spindle whorls, both finished and unfinished, indicating the importance of textile work in the Faroes (Hansen 1988;1993). Examples of spindle whorls at various stages in this production process can be seen in Figure 17.

The various forms of artifactual evidence discussed above point towards the involvement of not only Shetland, but Jarlshof specifically, into the broader web of cultural and economic interactions that occurred in the western branch of the Viking diaspora (Bond & Dockrill, 2016; Hamilton 1956). These sailing routes spanned not only the sea ways of the North Atlantic, but also overlapped with the trade networks of the British Isles and mainland Scandinavia permitting seemingly isolated island communities to remain enmeshed in social, economic, and political ties within multiple contemporary socio-cultural spheres (Crouch, 2010; Farr, 2006; Glørstad, 2014; Griffiths, 2004; Terrell, 2010). When we think of terms like isolated or central it can be difficult to see islands as anything but marginal, not only environmentally, but also socially. However, as mentioned above, centrality in maritime networks has been shown to be linked to the number of connected trade routes between insular location as well as the relative nearness between respective islands or coastal settlements (Terrell, 2010; Farr, 2006; Crouch 2010). These connections with multiple cultural spheres allowed diasporic communities of the western Viking world to maintain social ties and cultural parallels with contemporary rural society in mainland Scandinavia, not only in terms of settlement patterns, but also vernacular building customs, and the exploitation of the natural resources while incorporating ideas and form and decoration based on traditions in Celtic society (Barrett, 2003; 2012; Boyd, 2016; Buckland, 2012; Downham, 2019; Glørstad, 2014; Griffiths, 2004; Harrison, 2013; Larsen & Hansen, 2001; Wallace, 1992; 2016).

The genetic evidence for the admixture of individuals Gaelic and Norse ancestry into the region during the Viking Age, discussed earlier, corresponds well with the artifactual evidence (Ebenesersdóttir et al., 2018; Helgason et al., 2001; Margaryan et al., 2020). Likewise, the results of these findings, when viewed in tandem, further support the assertions presented here regarding insular interconnectivity and socio-cultural ties among diasporic Scandinavian communities. The following section will refine our focus farther still from the broader western diasporic network to a singular archipelago, the Shetland Islands, UK. Background information regarding the physical environment of the Shetlands in general with a particular focus on the southernmost tip of Mainland, Shetland where the primary focus of this research takes place.

Shetland's Geology and Physical Environment

James R. Coull, (1996) suggests that there are two main perspectives with which one can view the Shetland Islands. The first being that of the landsmen which provides one with a perception of islands as being "bare, bleak and windswept, with a summer without night and a winter without light" (Coull, 1996:66). Of which they would not be entirely wrong, given that the longest day of the year, the summer solstice, provides Shetland with 18 hours and 48 minutes of full sun with the sky never going completely dark, a time locals refer to as the 'simmer dim'. Comparatively, there are only 5 hours and 39 minutes of daylight on the winter solstice (Small 1983:20-24). The second perspective Coull (1996) describes is that of the mariner who looks at the Shetlands -with the Norwegian Sea and Atlantic Ocean bordering its northern and western shores, and the North Sea abutting its eastern and southern shores- as a primary maritime nodal point in the region that is in no way marginal in terms of maritime movement or access to maritime resources.

The Shetland Islands are the most northerly archipelago in the British Isles located about 539 km (335 miles) from the western coast of Norway and 170km (110 miles) north of mainland Scotland (Hall et al., 2021; Hamilton 1956; Morrison, 1973a; 1973b). The Shetland Islands are composed of approximately 100 islands with a cumulative land area of 352,319 acres, spanning 120km from north to south along a largely north south orientation (Fenton, 1978; Hall et al., 2021). The majority of the Shetlands fall between 60 and 61 degrees north with the modern capital of Lerwick at 60° 46' N. 0° 51' W (Hall et al., 2021; Morrison, 1996; 1973a; 1973b). Morrison (1996) notes that this latitude is shared with Bergen and Oslo in Norway, as well as much of Siberia placing the island chain well north of Juneau Alaska and most of the Bering Sea.

Despite its northerly location, year-round temperatures in Shetland are significantly higher than other localities that share the same latitude due to the interplay between warm oceanic currents and polar circulatory systems that causes westerly and southwesterly winds. Weather data collected between 1999 and 2019 for Lerwick, Shetland indicates that August is typically the warmest month of the year, with temperatures around 12.9 °C (55.2 °F) and the coldest month being February with temperatures around 5.3 °C (41.5 °F) on average (Climate-Data.org, 2021). This makes the average variation in temperature throughout the year only 7.6°C (13.7°F). Despite temperatures that are consistently above freezing, it typically snows in February (Small, 1983:20-24). While this is not a direct indication of climactic conditions during the Viking Age, it does provide a general sense of weather conditions over an extended period.

The southern end of Mainland is open to gales from the south, particularly in winter, and the well-known tidal race or 'roost' off Sumburgh Head at the southernmost tip of Mainland (Morrison, 1973a; USHO, 1915). It is likely that these fierce tidal currents made access to the nearby site of Jarlshof exceedingly difficult, as the Old Norse name for tidal race near Sumburgh Head was *Dynrastarvág* meaning 'roaring roost way' or simply *Dynrøst* meaning 'roaring roost', from which the local parish of Dunrosseness was named (Morrison, 1973a). Today the primary landing site for the extreme southern end of Shetland is Grutness Voe, a sheltered bay a short distance to the north-east of Sumburgh Roost (Morrison, 1973a).

Shetland's northernly location places it 50km (30 miles) from the north-western edge of the European continental shelf and the archipelago is underlain by a bedrock mixture of pre-Cambrian Dalradian Sandstone and equally ancient Old Red Sandstone; the Old Red Sandstone can be found in geologic strips primarily in west Mainland and in southeast Mainland from Bressay to Sumburgh (Coull, 1996; Hall et al., 2021). As discussed at length above, steatite or 'soapstone' outcroppings can be found at sites on the isles of Mainland, Fetlar, and Unst (Forster & Jones 2017; Larsen, 2016). The following section directs its focus to the site of Jarlshof, Shetland Islands UK, in particular. By detailing past excavations and what they have revealed regarding the development and alteration of the site through time, we can glean a better understand how settlement placement, orientation, and thereby interconnectivity played a role in those processes. A diachronic study of the Norse settlement at Jarlshof provides information on its initial settlement by Scandinavians as well as its continued occupation through time.

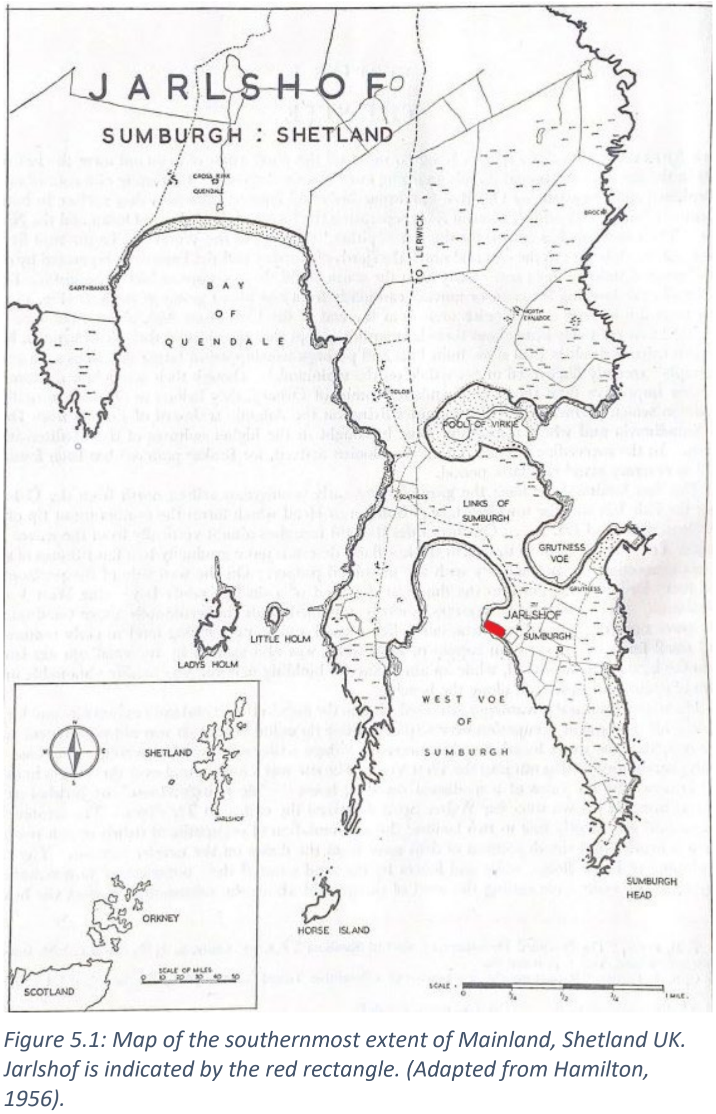


Figure 5.1: Map of the southernmost extent of Mainland, Shetland UK. Jarlshof is indicated by the red rectangle. (Adapted from Hamilton, 1956).

CHAPTER 6: JARLSHOF: THE DIACHRONISTIC INVESTIGATION OF A VIKING AGE FARMSTEAD

This chapter details the previous excavations conducted at the site of Jarlshof as well as an in-depth examination of the architectural changes at the site over the course of the Norse occupation considered in this work (850-1200 CE). I contend that in order for a diasporic farmstead to be successful, its occupants had to be able to adapt to a new environment, as well as maintain connections both locally and with the broader diasporic community of which they were a part. By looking at the settlement's architectural developments through time we can gain a better understanding of what improvements or alterations were deemed necessary by the site's occupants. In addition, by addressing the sites development in a phase-by-phase approach we can consider how these larger structural changes might indicate whether visibility of their surroundings, or the prominence of the site on the landscape, might have played a role in decisions made by the site's occupants.

The archaeological site of Jarlshof is a multi-period settlement site with evidence of habitation spanning from the Neolithic through the Bronze Age, Iron Age, as well as the Viking Age, Medieval period, and more recent occupations in the early 1600s (Barrett, 2003; Bond & Dockrill, 2016; Childe, 1937-38; Curle, 1935; Hamilton, 1956; Hansen, 2003; Larsen, 2016). Jarlshof is located near the southernmost tip of Mainland, Shetland, one of the most agriculturally suited regions in the island chain, on the east side of West Voe, Voe is the local term for Bay, on a low-lying, grassy promontory (Hamilton, 1956; McKirdy, 2010; Morrison, 1973a; 1973b; Turner & Simpson, 2016) (See Figure 7.1).

The first excavations at the site were conducted by the property's landowner John Bruce between 1898 and 1906 after heavy storms eroded away a section of the archaeological mound, revealing the remains of stone structures along the site's coastal boundary in 1897 (Bruce, 1906-1907; Hamilton 1956:40-41). During that time Bruce investigated and excavated these structures while keeping in mind the structural stability of the later structures, long abandoned but still standing, on top of the mound. His excavations revealed an Iron Age Broch and associated courtyard as well as later Iron Age wheelhouse structures, however his excavations did not excavate the area in its entirety due to the risk to the late 15th to early 16th century Liard's house "Jarlshof" which stood above them (Bruce, 1906-1907).

The Liard's House and the surrounding land was passed into state guardianship in 1925; at which point additional structural remains were identified leading to Alexander Curle's excavations from 1931 to 1936 (Hamilton, 1956; Curle, 1935). His excavations revealed both Bronze Age structures as well as transitional early Iron Age houses and souterrains (Hamilton, 1956). Intending to find additional contemporary structures, Curle opened new trenches on the northern face of the mound that resulted in the identification of the first documented Viking Age structures identified at the site (Curle, 1935). Over the next two seasons (1934 and 1935), two house groups were excavated including the parent dwelling (House 1) and an outbuilding (1G) which was associated with the parent dwelling in a later period (Curle, 1935; Hamilton, 1956).

The Office of Works acquired the remainder of the property that now conforms to the modern boundaries in 1936 after recognizing the potential for additional archaeological remains farther down the landward slope of the mound (Hamilton, 1956). Gordon V. Childe carried out excavations through the H. M. Office of Works on the Bronze Age levels and identified the presence of a Neolithic site component in 1937 (Childe, 1937-1938).

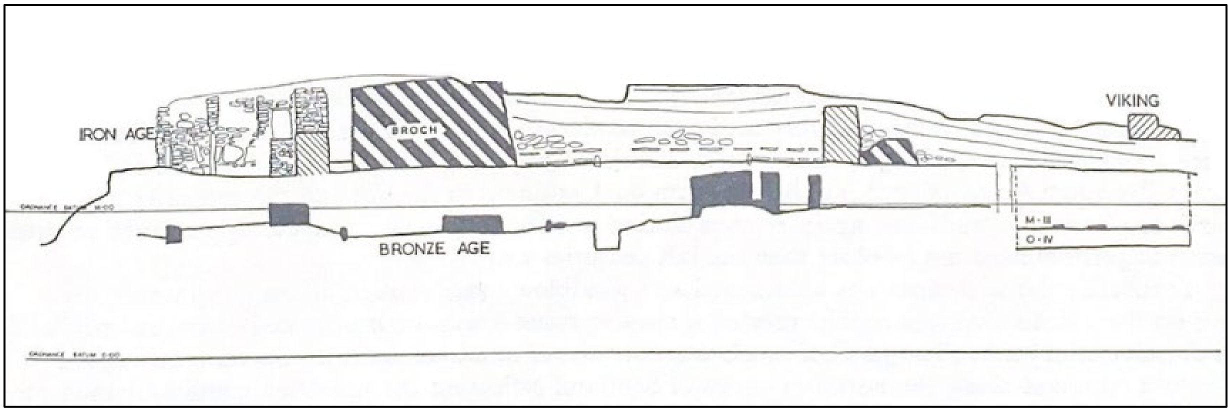


Figure 6.2: Section of the mound of Jarlshof, north to south, displaying the relative levels of occupation at the site during the Bronze Age, Iron Age, and Viking Age (Adapted after Hamilton, 1956).

J. S. Richardson carried out excavations of the Viking settlement from 1936 until 1939, however, the results of his research were never published. As such, the only published record of his excavation, which involved gridding and stripping the entire lower slope of the mound (an area of over two acres) and the removal of the Bruce family mausoleum from the site is documented in Hamilton's (1956) account. The grading and stripping of the slope allowed Richardson to identify seven more structures and over 2000 associated finds (Hamilton, 1956). Richardson noted the presence of additional structures beneath those that were initially documented but was unable to investigate further due to the outbreak of the Second World War.

Excavations at the site did not resume until 1949, headed by John R. C. Hamilton and took place over three seasons from 1949 to 1951. Hamilton's excavations and what they can contribute to our understanding of site habitation and chronology are discussed in detail below. It is important to note that these early excavators did not have the range of archaeological tools at their disposal as we do today. For example, the modern staple of radiocarbon dating only became available for most archaeological practitioners after Hamilton had completed his work. Despite this, Hamilton's (1956) comprehensive account of the earlier excavations as well as his own, and his precise documentation of the site's stratigraphic sequence has had no major reevaluations (Dockrill & Bond, 2009). As of 2004 AMS radiocarbon dates were taken from charred barley from the site's Neolithic and early Bronze Age levels in order to further investigate and attempt to date the site's Neolithic occupation (Dockrill & Bond, 2009). The results of the 2004 work confirmed the accuracy of the stratigraphic profile as detailed by earlier researchers such as Childe and Hamilton and established that the Neolithic component was several centuries older than previously thought (Dockrill & Bond, 2009).

The relatively continuous occupation of the site over millennia resulted in the accumulation of a large amount of refuse and other organic material at the site in addition to the natural accumulation of windblown calcareous sands resulted in the formation of a settlement mound. Hamilton (1956) noted that this accumulation increased drastically in post-broch times on the landward slope of the mound due to both human contributions of midden material as well as the accumulation wind-blown sands in the areas adjacent to the broch and later Iron Age buildings. The 'Upper Slope Peat Ash Midden' as it is referred to by Hamilton (1956) overlaid those deposits and covered the entire upper slope of the north side of the mound ranging from 1-18inches in thickness. This upper slope midden was associated with initial Norse settlement of the site and served as a surface for foundations at the site for several structures (Hamilton, 1956). For the purposes of this research only the Norse settlement phases I-V, that were identified by Hamilton (1956) during his excavations as spanning a roughly four-hundred-year period from 800-1200 CE, are discussed. I pay particular attention to their sequence of construction in relation to midden deposits, and their placement on, and contribution to, the settlement mound over time. As they are integral to the goals of this research which is to investigate the degree to which intervisibility between sailing ships and the settlement at Jarlshof, and therefore the site's organization and placement in relation to the surrounding landscapes and seascapes, contributed to the site's interconnectivity with the surrounding region.

Placement of the Norse Settlement as it Relates to Other Occupational Periods at the Site

Hamilton (1956) felt that the boundary wall enclosing the contemporary Iron Age settlement at Jarlshof may have held some influence over the decision of the Norse farmstead on the landward shoulder (the north side) of the broch mound. This may have some truth to it, however, if we look at the work of Harrison, (2013) we find that, in both the Northern and Western Isles of Scotland, it was a common practice to build longhouse settlements on mounds of either archaeological or natural character. Settlement mounds in the Northern Isles are generally found in ecological zones where wind-blown sands and sand drift geology were present and the accumulation of that sand in addition to anthropogenic additions such as household waste, organic material, and structural debris are superimposed atop one another at the same location over an extended period, at times, even over the course of millennia (Harrison, 2013). Such sites present researchers with stratigraphic records that contain sequences of cultural deposits interspersed with culturally sterile layers of sand strata (Bigelow et al., 2005; Simpson et al., 1998; Hamilton 1956).

On Orkney, sites involving deep stratigraphy formed by a complex process of decommission, infilling with midden material, and rebuilding or alteration often incorporating elements of the previous features, including the Brough of Birsay, Pool on Sanday, and Quoygrew on Westray (Barrett 2012b). Comparable sites are also found in Shetland including Jarlshof and Old Scatness in south Mainland (Bond & Dockrill, 2016; Hamilton 1956). Harrison (2013) refers to the process of mound accumulation as ‘tell-like’ in nature and that there may also be a culturally constructed meaning behind the actions that would have served a socio-political purpose.

The placement of these settlement mounds in “visually dominate bays and sea approaches” may have been one aspect that attracted Scandinavian settlers to these sites (Harrison, 2013). Many central places associated with secular power, trade, or spiritual practice in Scandinavia beginning in the Migration/Vendel period and into the Viking Age were located at sites of visual prominence or high impact (Albris, 2015; Callmer, 2002; Hedeager, 2002). In earlier sections we discussed Scandinavian burial practices, particularly high-status burials, involved the construction of burial mounds. Take for example the area around Borre in Norway, which contains some of the earliest examples of burial mound in the region which are dated to 600 CE alongside ship burials dated to roughly 900 CE (Myhre, 2000). We can also look south to Lake Tissø in Denmark, where the sheer scale of the multiperiod magnate complex allowed it to tower over the surrounding landscape (Albris, 2015; Jørgensen, 2010; 2012). From these examples, and others, it is reasonable to consider that settlers who were familiar with their homeland in Scandinavia where visually prominent mounds or structures were associated with the physical expression of power, control and status, might have implemented a similar strategy for legitimization when establishing a settlement in an already inhabited landscape.

Such conceptions may have played a role in past people's decisions to continue to utilize a settlement location that already has a history of long-term occupation. The continued occupation of the settlement mound could, under these assumptions, be used by Scandinavia settlers to proclaim their right to the land and link those rights to a readily visible, physical expression of continuity (Harrison, 2013). However, the mound's potential as a socio-political symbol may only be one of several potential functions. In their discussion of northern Norwegian farm mounds Mook and Beretelsen, (2007) postulate that actively decaying organic materials may result in an increase in temperature for these locations (see also Urbańczyk, 1992:105–121). Investigations at Old Scatness Broch, just a mile to the north of Jarlshof, revealed that throughout the course of its multiperiod occupation, midden material had been mixed with the soil in the agricultural fields at the site in order increase the crop yield of the sandy soils (Simpson et al., 1998). Dockrill and Bond (2009) reported similar findings from their investigation of Neolithic and early Bronze Age occupation layers at Jarlshof.

While Hamilton (1956) has stated that it is only natural to keep the inside of the home clean while assigning another location to deposit the waste of day-to-day activities such as cooking, cleaning, fishing, or mucking out the byre. He also notes that, over time, the continued addition of these layers of midden mixed with the natural sandy soil and windblown sand deposits resulted in some earlier features being subsumed into mound or beneath the cobbles of the yard after repaving (Hamilton, 1956). This brings to mind the work of Bourdieu (1977) who advocated for the importance of *habitus*: the significance of habitual actions that are carried out daily because those actions are imbued with socio-cultural norms. Gathering water for the day or performing other activities as discussed by Hamilton (1956) are an expression of what was viewed as necessary and important to past peoples on a daily basis.

The daily process of removing refuse from the home and outbuilding, intentionally or otherwise, resulted in the backfilling of preexisting cultural features and the accumulation of midden material over the top of pure sand strata. Harrison (2013) noted that this often-complex process of infilling and distribution of midden material is indicative of a deliberate technique employed to help stabilize the pure sand layers that comprised certain levels of the settlement mounds in preparation for the erection or expansion of structures. Hamilton notes the benefits of the deposition of organic material to the mound, both prior to and throughout the period of Norse settlement, to the establishment of stable soil and vegetation over the mound and eastern portions on the site (Hamilton, 1956:113). The complex, multi-period succession of deposition and construction is well documented by Hamilton (1956) who excavated sections across the mound slope from east to west through the floors of the settlement structures (see Figures 6.4-6.7, 6.9, and 6.10). These sections clearly document the deposition of midden material, either as a base layer over wind-blown sand or as infill in previous structures prior to the erection of new structures at the site. The association of these middens with the structures at Jarlshof was of primary interest to Hamilton (1956). The following sections provide information on the first five Norse settlement phases at Jarlshof as identified by Hamilton (1956).

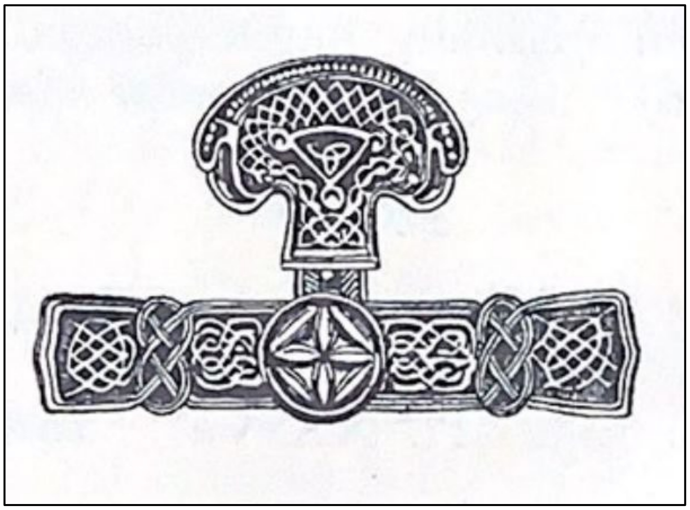


Figure 6.3: Gilt bronze harness mount recovered from the midden material beneath the foundations of House 2 [sq. 18] (Adapted from Hamilton, 1956).

Settlement Phase I

Hamilton (1956) suggested that Phase I of the Norse settlement likely began sometime between 800 CE and the mid-9th century CE. This assessment was based in part on the presence of a celtic gilt bronze harness mount recovered from the red peat ash layer underlaying the foundations of House 2 [SQ. 18] which had parrallels with similar celtic artifacts recovered from burials dated to the early 9th century in mainland Scandinavia (Hamilton 1956) (See Figure 6.3).

Olwyn Owen (2004) in her discussion of Viking boat burials in Scotland's Northern Isles reminds us of the inevitable murky nature of chronological distinctions when it comes to Viking grave goods whether in or outside of mainland Scandinavia. Stating that typologically dating assemblages can be problematic at the best of times, particularly in regard to sites in the Viking colonies because artifacts have the potential to not only be far from their source of manufacture, but also may be of some antiquity when they are interred. We can take this general principal and expand it beyond the scope of burials to other contexts in the western Viking world where such items may represent family heirlooms, trade goods, or ecclesiastical or secular goods brought home by returning raiders.

In recent years, it has been suggested that the earliest Viking settlements in the Northern Isles likely occurred at longstanding multiperiod sites such as Old Scatness and Jarlshof, on Mainland Shetland, Norwick on Unst, Shetland, on Shetland and at sites like Buckquoy and

Quoygrew on Mainland Shetland in the Orkney Islands (Bond & Dockrill, 2016; Harrison, 2013). In southern Shetland in particular, these site also were the location of successful Iron Age and or Pictish estates where metallurgy and fertile agricultural lands were well established by the time of Norse settlement in the 9th and 10th centuries (Bond & Dockrill, 2016; Turner and Simpson, 2016). Although there is still heated debate over the nature of these initial contacts, with some arguing for trade relations and gradual settlement while others advocate for armed conflict (Barrett, 2012a; 2003). Jarlshof and Old Scatness both show evidence of pre-Norse structures with certain Scandinavian characteristics, such as the presence of long hearths and material culture items (Bond & Dockrill, 2016; Hamilton, 1956).

The current understanding of the chronology at the site is based on more recent excavations at other sites of the period in Shetland including Old Scatness, Underholl, and Belmont (Bond & Dockrill, 2016; Larsen, 2016). Works at these sites suggest that although initial contact may have been taking place in the first half of the 9th century, the establishment of the architypical Scandinavian farmhouse and associated structures on the northern slope of the

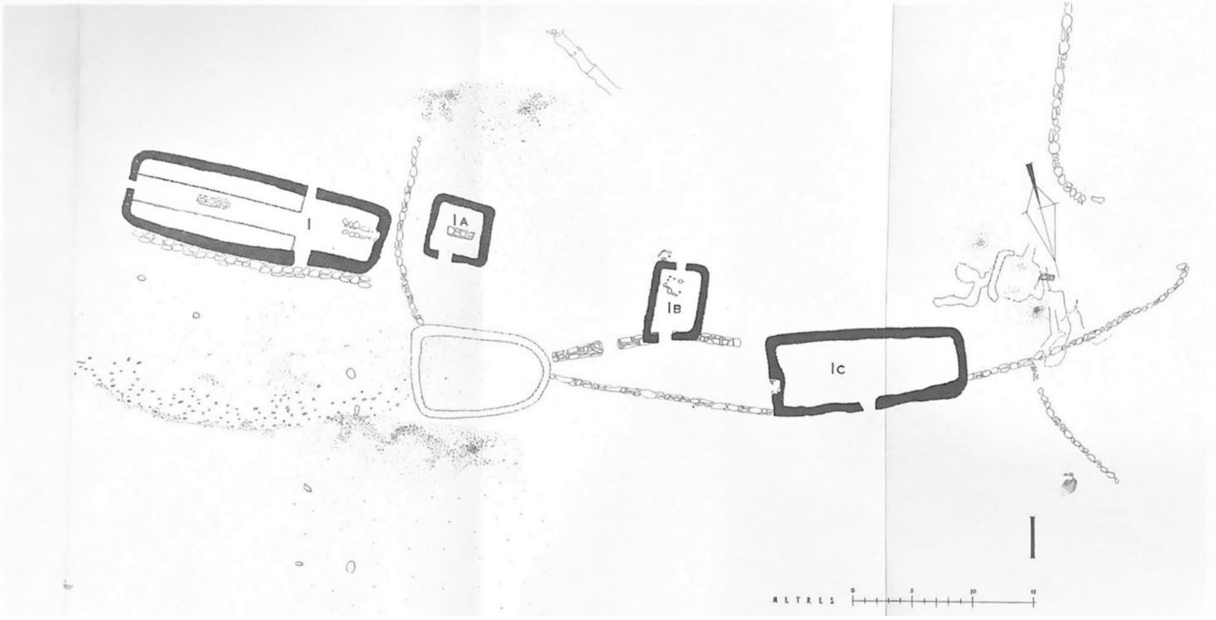


Figure 6.4: Jarlshof Norse settlement Phase I (ca. 850-900CE) (Adapted from Hamilton, 1956).

settlement mound, likely occurred in the latter half of the 9th century, closer to 900 CE than 800 CE. There is an interesting parallel to be drawn from these new date estimations, in that Viking armies first recorded overwintering on foreign soil also took place around this time. The first documented occurrence taking place in Dublin, Ireland in 841 CE, followed by England during the winter of 850-851 CE, and later in Frankia from 852-853 CE (Barrett, 2010). Radiocarbon- and OSL dating has yet to be exclusively conducted on the Viking Age levels at Jarlshof, so while these dates are currently being refined based on regional evidence from sites like Old Scatness, no definitive answers are, as of yet, forthcoming.

Phase I of the Norse settlement at Jarlshof consisted of the parent farmstead (House 1) and a number of outbuildings as shown in Figure 6.4. The parent farmstead (House 1) consisted of a rectilinear 70ft x 20ft structure with bowed longitudinal stonewalls that were aligned west-northwest to east-southeast. The interior construction of these walls was drystone coursework, with the south wall of the structure partly riveted against the shoulder of the mound, while the exterior of the northern wall, which was freestanding, employed alternating courses of turf and stone (Hamilton, 1956:107). As discussed above, this method of construction has parallels across the North Atlantic both in the Faroe Islands and Iceland where access to building materials differed from their Scandinavian homeland (Bond & Dockrill, 2016; Larsen, 2016; Hamilton, 1956; Jesch, 2015; 2016; Scofield & Edwards, 2016; Hansen, 2003).

There is evidence for the presence of raised benches along both walls and a long stone lined hearth between them at the eastern end of the structure. The western end of the house consisted of the kitchen to the west of the north and south entrances that can be seen in Figure 6.4. House 1 shows evidence of three entrances with doorways on the east end and in the south and north walls to the west of the center of the structure; the north-facing doorway was determined by Hamilton (1956) to be the principal entrance. A position that is bolstered by the presence of a bar hole in the right-hand side of the doorway of the north wall and the presence of a paved pathway leading to the parent dwelling from down slope to the north. The *stett* or yard paving first laid outside the dwelling in this phase was repaved three times over the course of the site's occupation in order to keep pace with the growth of soil, sand, and organic material around the dwelling (Hamilton, 1956).

Structure 1A was originally interpreted as a Hof or pagan shrine, because of what Hamilton (1956) defined as a *langeldr* or stone lined hearth, inside. More recent interpretations have argued that the structure was likely used as a latrine or bath house (Kimball, 2003; Hansen, 2003). Due to a lack of organic material remains the actual function of the structure has remained undefined. However, the structure does share close parallels with a latrine from Phase II at Toftanes on Leirvík, Faroe Islands and although a latrine may not be as titillating archaeologically as a Hof or sauna, it is the most grounded option. The general layout of the first phase of settlement at Jarlshof shares close similarities with the second phase from Toftanes which was characterized by two main oblong buildings with two smaller outbuildings or extensions, one of which was the structure identified as a latrine (Hansen, 2003). Returning to Jarlshof, the other outbuilding, structure 1B, was identified as a smithy based on metalliferous slag recovered from occupation layer of the structure (Hamilton, 1956). The largest of the outbuildings from this phase, Structure 1C, is believed to be a byre for livestock. The foundations of Structure 1C's north wall incorporated the pre-Viking compound wall which likely served to enclose the other outbuildings in space apart from the parent dwelling forming a yard.

Another outbuilding was identified to the west of the byre (1C) that is somewhat distinct from the other structures in its manner of construction. While structure 1D followed the rectangular in plan of the other Phase I structures, the methods employed in its construction appear to be that of the earlier Iron Age dwellings (Hamilton, 1956:11). This can be seen in the series of upright stone slabs that stood against the interior walls as a means of supporting the horizontal stonework. To further muddle our understanding of this structure, a *langelder* or Scandinavian-style long hearth was identified inside the structure. Hamilton describes the finds identified from the structure as being a curious mixture of Norse loom weights and spindle whorls alongside various local slate implements and stone pounders (Hamilton, 1956:111). These elements suggest a blending of building traditions and material culture although whether this is due to cultural diffusion or mixed habitation is unclear. A similar melding of architectural styles can be seen at the Viking trade emporium in Dublin, Ireland where the overall shape of the structures still conforming to the longhouse form, but the methods employed in their construction were

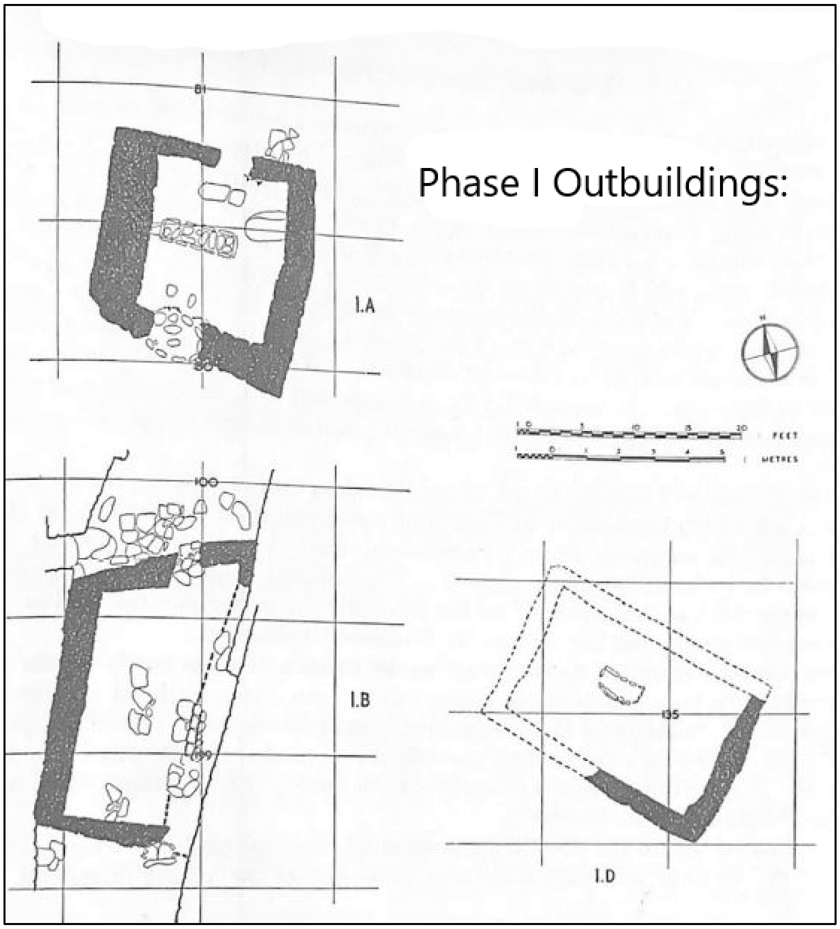


Figure 6.5: Phase I outbuilding 1A (top left); 1B (bottom left); and 1D (bottom right). (Adapted from Hamilton 1956).

based on native Irish methods of waddle and daub house construction (Boyd, 2016). Hamilton's interpretation was that 1D was the home of a *Þraell* or slave, likely of Gaelic or Pictish descent, but the dilapidated state of the structure makes developing a convincing interpretation vexing.

The upper slope peat ash midden covers a large area of the mound slope and is stratigraphically associated with the initial period of Norse occupation. Midden scatter from the upper slop peat ash midden was concentrated around structure 1C and structure 1D which both overlay earlier late Iron Age huts (Hut 1 and Hut 2) which may have been occupied up until the early 800s CE (Hamilton, 1956). In light of recent research at Old Scatness (Bond & Dockrill, 2016), and the methods employed in the build-up of the settlement mound, the late Iron Age huts could have been the location of the earliest Norse occupation prior to the erection of the other Phase I structures at Jarlshof. Unfortunately, the majority of Structure 1D was demolished and very little additional information was able to be recorded. Perhaps due to its dilapidated state and abnormal construction methods, it was not explicitly labeled in master Hamilton's (1956) plans of the settlement in relation to the other structures of this phase. However, it was included in a separate drawing of the outbuildings as can be seen in Figure 6.5.

Aside from the parent farmhouse (Structure 1), all of the other Phase I structures (1A-1D) were built within the boundaries of that yard wall. Another section of wall further to the west formed an enclosure creating a yard that encompassed much of the settlement terminating at either end of the main structure (Hamilton, 1956) (see Figure 6.6). There is also clear evidence that cobbling or *stett* pavement was placed outside of the house running between the structure and the yard wall. In later periods this same process was repeated resulting in well-defined yards for other dwellings (Curle, 1935; Hamilton, 1956).

Settlement Phase II

According to Hamilton's (1956) excavation report, House 2 was built over the top of the primary occupation spread (Upper Peat Ash Midden), at an average of around 9inches in thickness under the structure, which was deposited by the occupants of House 1 prior to its construction. These same midden deposits were overlain by the House 1 house midden material which included burnt stone and peat ash which accumulated outside the east end of House 1 indicating that House 1 and House 2, although not erected contemporaneously, were both erected in the early stages of the settlement. For this reason, the erection of House 2 was seen as a primary indicator of the beginning of Phase II at Jarlshof, which he dated from around 850 CE to 900 CE (Hamilton, 1956:130). House 2 also measured 70ft x 20ft, however it was erected down slope and perpendicular to the main house and positioned farther to the south. It has been suggested that the northern most room of House 2, was likely used as a byre for housing cows and sheep, something that does not appear to have occurred during the first phase of occupation in House 1 (Hamilton, 1956:136). As was the vase with House 1, House 2 had three entrances, however their placement in House 2 different from the parent dwelling in that a primary door was located on the western wall and two additional doors were located at the north and south gable ends.

As discussed above, a pre-Viking Age wall surrounded the majority of the settlement, however with the construction of the second dwelling, an additional yard wall was constructed which ran parallel to the second house on the eastern side of the site. The distance between the newly constructed yard wall and the walls of House 2 was on average around 10 ft for the entirety of its length. The resulting space formed a small separate yard (Hamilton, 1956: 130-132). In addition to the erection of House 2, two additional outbuildings were built during this phase. They included structure 1E, which has been interpreted as a stable located along the slope to the northwest and parallel to House 1. The interior of this space was cobbled and a wall extending from the middle of the south wall served to partition the interior space. The north wall of structure E1 incorporated the pre-Viking enclosure wall. The other structure erected in this period was 1F a latrine, likely to replace structure 1A (the enigmatic latrine) which was decommissioned in this period, its foundations seem to have been quickly filled in with midden material (Hamilton 1956:132). Structure 1F was located on top of a roughly rectangular 30sq ft area that was cobbled in Phase 1 on the south side of House 1 to the west of House 1's south-facing doorway. Alterations that occurred to the settlement layout in Phase II can be seen in

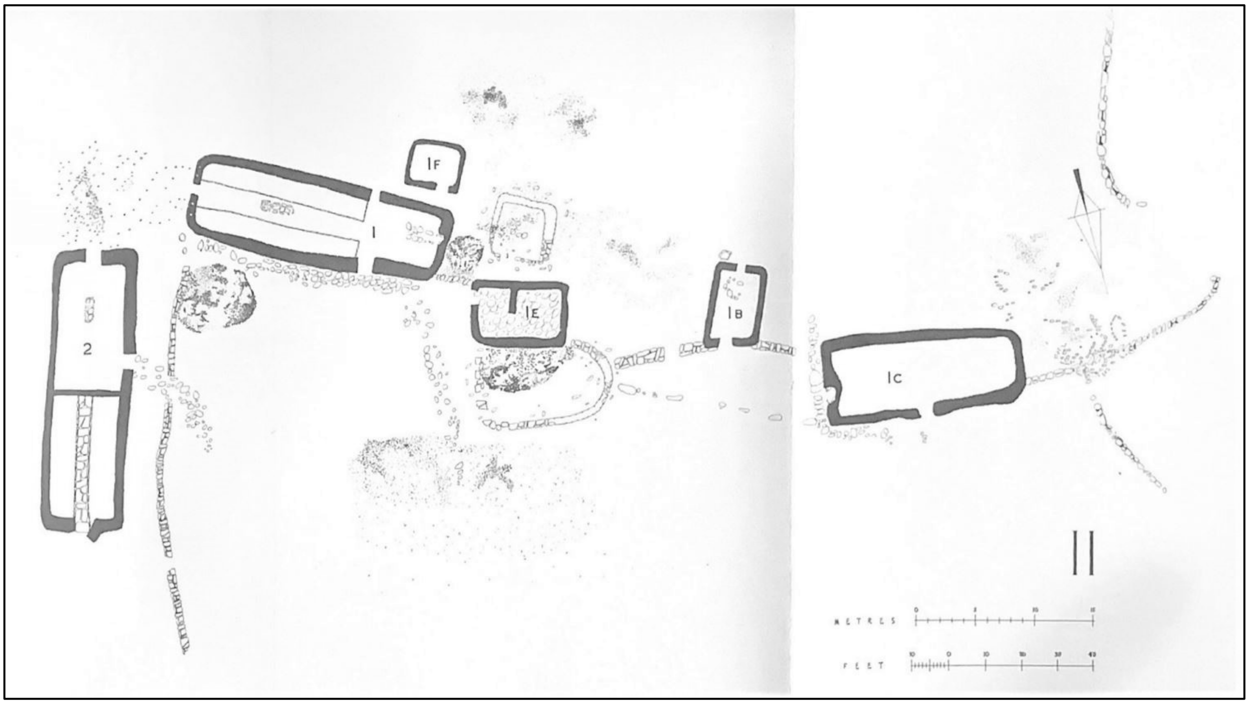


Figure 6.6: Jarlshof Norse settlement Phase II (ca. 900CE-950CE) (Adapted from Hamilton, 1956).

Figure 6.6.

During the second phase of occupation the house occupants began depositing refuse on the lower slope of the mound. This marked the beginning of a 'Communal Peat Ash Midden' which eventually covered some 5,000 sq. ft.by the 10th and 11th century and underlays the foundation of later structures. Finds recovered from the down slope midden and upslope occupation deposits associated with this second phase include several incised slate slabs featuring depictions of boats in full sail and a boat's prow as well as the bronze ringed pins of Hiberno-Scandinavian origin mentioned above (Hamilton 1956:137; Hansen, 2003).

Settlement Phase III

Phase III follows directly after Phase II and continues into the first half of the 11th century CE this interpretation is based on stratigraphic grounds: the southern portion of House 3 and its associated yard wall overlays the primary Viking occupation spread as well as portions of the middens established by the occupants of House 2 (Hamilton, 1956). The reassessment of the earlier dates of Jarlshof settlement would suggest a 50-year advancement for the start first three periods so that the second period ends in ca. 950 and the third Phase begins at that point, rather than in 900 as Hamilton's (1956) interoperation. Despite these chronological adjustments, the settlement sequence remains unchanged (Bond & Dockrill, 2016; Larsen, 2016). With the erection of another yard wall, a small, paved alley was formed between the yards of House 2 and House 3. The later date for this phase of occupation was established using a gilt bronze strap of the Ringerike style, a Scandinavian art style that was commonly seen in metal work and other mediums such as rune stones iconography from around 1000-1075 CE (Graham-Campbell, 2013: 117-132; Hamilton, 1956:154). As mentioned above, a third house (House 3) was constructed roughly 24 feet directly to the west of House 2 and following the same orientation as that structure. House 3 was 73ft long and 16ft wide with sturdy walls sporting an earthen core. As was the case with House 2, House 3 also had three entrances when it was first constructed: a primary door on the western wall and two additional doors at the north and south gable ends (Hamilton 1956). The yard wall present on the eastern side of House 3 was extended along the southern face of the house, forming another paved alleyway between House 3 and the north wall of the parent dwelling. The yard wall continued westward and then northward to run parallel with the main path, which leads up to House 1, and eventually curves at the base of the slope and terminates roughly 20ft north of the north gable entrance to House 3 forming a reversed J shape at its northwestern (Hamilton, 1956:138).

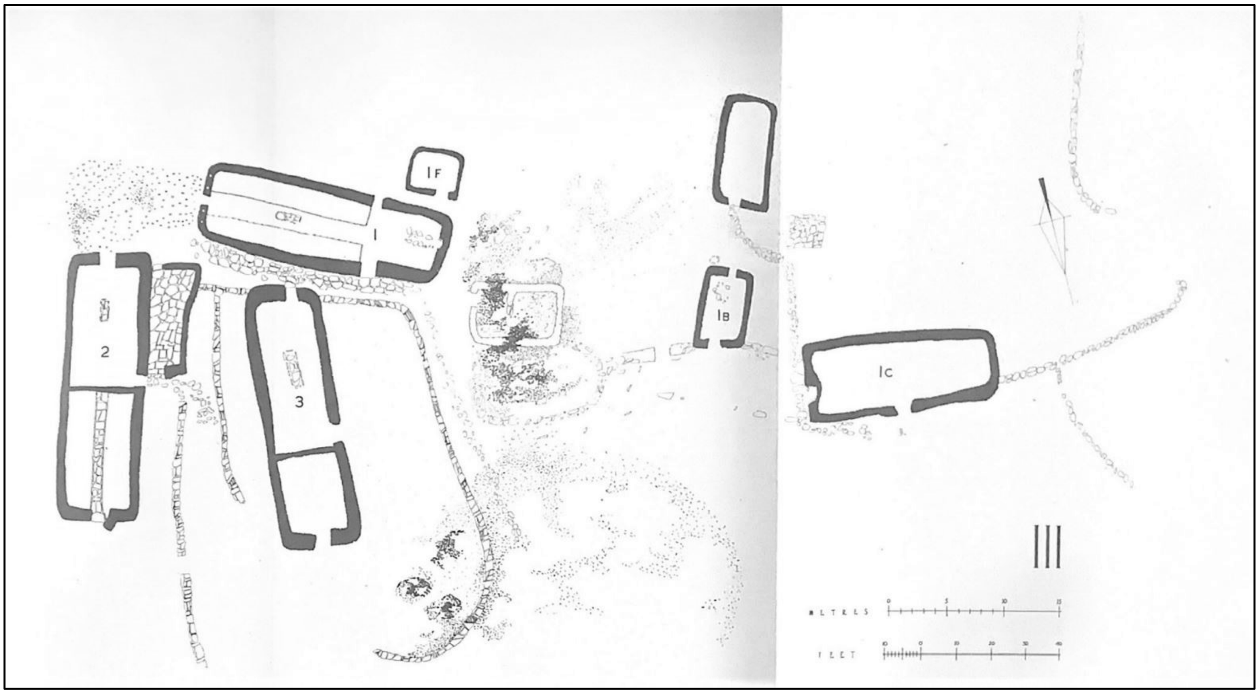


Figure 6.7: Jarlshof Norse Settlement Phase III (ca. 950-1050CE) (Adapted after Hamilton 1956).

In addition to the erecting of a third house, House 2 underwent renovations during this time phase resulting in the addition of a flagstone paved annex to its west side of the main structure (Hamilton, 1956:140). During this time, structure 1E -the stable- went out of use. It is unclear whether the decommissioning was due to poor construction or unstable foundations. The remains of structure 1E would later serve to stabilize the extension of the parent dwelling later House 6 (Phase V). The large rectangular outbuilding (unlabeled in Hamilton's (1956) plan for the period) was built to the south of the smithy (1B). It has been interpreted as a barn due to the presence of haystack bases in the structure that resemble modern Shetland haystacks Hamilton, 1956:140).

Houses 2 and 3 are described by Hamilton (1956) as dependent farmsteads. Evidence from the excavation of these primary farmsteads located on settlement mounds in Orkney indicates that the parent dwellings likely served as central places, both locally and in terms of regional trade connections (Harrison, 2013). Over time, House 1 at Jarlshof experiences a remarkable degree of stability in terms of its location and orientation when compared with the later farmsteads and associated outbuildings. The presence of a paved pathway leading to the parent dwelling from down slope to the north, which was not only maintained, but improved over multiple periods, further supports House 1 being the focal point of the settlement (Hamilton 1956:132). Similarities between Jarlshof and other multiperiod sites in Orkney like Brough of Birsay, which Harrison (2013) describes as being central places, coupled with similarities in the archaeological evidence from both sites discussed above, clearly marks the Norse farmstead at Jarlshof as a similarly significant nodal point within a regional network of trade and maritime movement throughout the course site's occupation.

During the 10th century House 1 seems to have begun using the area next to the west side of the main path which led obliquely down slope for the deposition of a large amount of midden material. New dwellings were erected on top of these substantial midden deposits in the late 11th

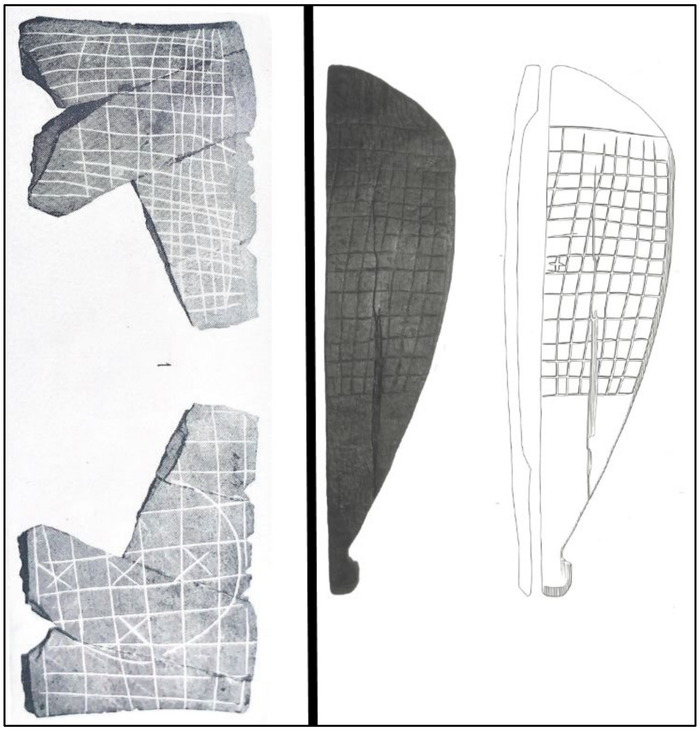


Figure 6.8: Dual-sided gaming boards for Hneftafl, and Nine Men's Morris. (Left) Jarlshof, Shetland (Right) Toftanes, Faroes.

and 12th centuries (Phases 4 and 5 discussed below). Finds recovered from the middens associated with this period revealed several bronze ringed pins, discussed in detail above. An additional incised depiction of a ship was also recovered, but this time it was carved in sandstone rather than slate. Another item of interest was a thin plaque with neatly drawn squares on one side and a circle with crosses and a crisscrossing pattern on the other. The artifact has been interpreted as a gaming board. A similar dual sided gaming board, carved out of wood, was recovered from Toftanes in the Faroes (Hansen, 2003). These dual sided boards have been found elsewhere in the Viking world and were designed to so that *Hneftafl,* a Scandinavian version of chess, could be played on one side while the other side was set up for a game called Nine Men's Morris, a game played commonly throughout Europe from the Roman period into the Middle Ages (Hansen, 2003).

Settlement Phase IV

The fourth phase of Norse occupation at Jarlshof had relatively minor architectural changes when compared with the other four phases discussed here. Phase IV lasted from the second half of the 11th century and possibly till the start of the 12th century CE (Hamilton, 1956). Although this phase continues past the official end of the Viking Age (1066 CE), this

Phase as well as Phase V were included in this analysis to demonstrate the continuity of the settlement into the Late Norse period and to highlight the messy nature of time period designations. Additionally, the large number of changes to the settlement in the fifth phase (see Figure 6.9) allow for additional clarification on how significant changes to the settlement's layout might impact visibility, something that the minor changes that occur in Phase IV do not permit to the same extent as Phase V. The fourth phase saw the demolition of the latrine (1F) located just southwest of the southern doorway of House 1 (Hamilton, 1956). It also saw the construction of a large outbuilding, (Structure 4) directly to the west of House 3, within the yard wall detailed above. Structure 4 was approximately 45ft in length and 16ft wide with an interior floor that was paved roughly with stone. According to Hamilton's (1956) interpretation, the structure's placement over the top of communal peat ash deposits demonstrated that its construction could not have taken place prior to 1050 CE. A set of stairs were located outside the

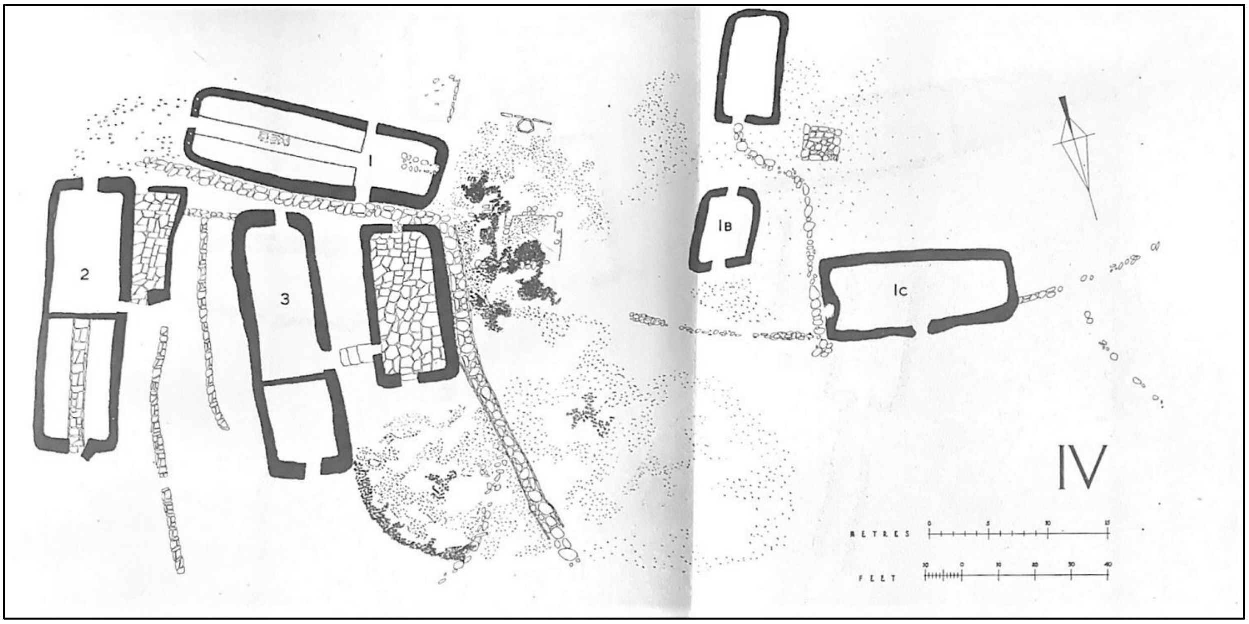


Figure 6.9: Jarlshof Norse settlement Phase IV (ca. 1050-1100CE) (Adapted after Hamilton, 1956).

doorway at the northern end of the eastern wall which seems to have led directly to the main doorway of House 3 (Hamilton, 1956:154).

Settlement Phase V

Phase V is the final occupation phase at the site that is considered in this project, although late Norse occupation continued for a further two phases, totaling seven in all, and was followed by a medieval farmstead. Phase V continued from the end of Phase IV until the late 12th century or the early 13th century CE (Hamilton, 1956: 168). This phase is marked by major structural changes to the settlement layout which included alterations to all of the pre-existing houses (House 1-3), and the construction of three new houses (House 6, 7, and 8). Houses 6 and 7 were 45ft long by 16ft wide and 45ft long by 15ft respectively; both houses had benches along the walls and central hearths with their only entrances facing to the northeast. The barn erected in the third phase of occupation was still in use and lay just south of House 7. Hamilton (1956) noted that Houses 6 and 7 were built on top of the communal peat ash midden and the infilled

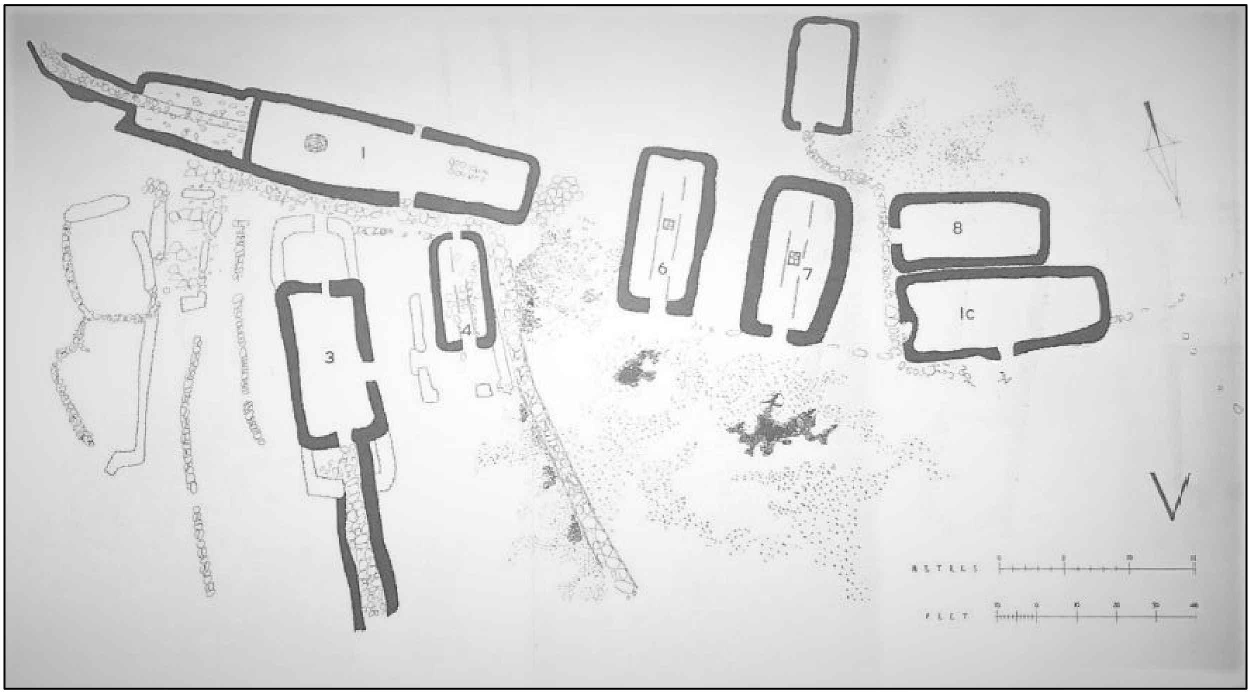


Figure 6.10: Jarlshof Norse settlement Phase V (ca. 1100-1200CE) (Adapted after Hamilton 1956)

foundations of earlier outbuildings, specifically the old smithy (1B), that were in use during the earlier phases of occupation at the site, with the exception of C1 which was still in use. These new houses are smaller than their predecessors and are closer together, as such they lack the walled yard space seen with Houses 2 and 3. House 8 was documented as sitting parallel to structure 1C, but due to the advanced degree of demolition little information was able to be recovered from it. In fact, it was so dilapidated that Hamiliton (1956:164) was uncertain whether the structure should be classified as a third house or a large outbuilding.

Major alterations occurred to all three of the initial houses on the site. The parent dwelling underwent major renovations including extensions at both the east and west gable ends. The eastern end of House 1 was extended approximately 23ft with the add-on being converted into a byre for livestock which was accessed from the east by a walled cattle passage (Hamilton, (1956:158). As a result of these changes, the *langeldr* was decommissioned and the area was paved over. Two closely set post holes suggest a partition wall may have separated this new byre from the living space. The conversion of the east end reduced the previous allotted living space, and perhaps as a form of compensation for this, the west gable end of House 1 was also extended 3 ft. We also see that the path up to the parent house is repaved and extended over the top of the older communal peat ash midden farther down slope.

In contrast to the expansion of the parent dwelling, House 3 seems to have fallen out of use as a dwelling in order to be converted wholly into a byre with a similarly elongated walled access as seen in the addition to the parent dwelling. Similarly, House 2 seems to have been completely decommissioned as dwelling and was converted into a number of livestock compounds possibly for sheep (Hamilton, 1956: 156-157). Outbuilding 4 was initially converted into a byre, in this phase, but presumably around the time that smithy (1B) was torn down, to prepare for the erection of later structures, outbuilding 4 seems to have taken over the old smithy's function. This assertion was based on the recovery iron slag from the occupational surface associated with Phase V inside Outbuilding 4 (Hamilton, 1956: 158-160).

What can be gathered from these alterations is that the primacy of the parent dwelling as the central feature of the settlement has only increased with time. Similarly, the need to house additional livestock is suggestive of changing, if not improved, economic circumstances. This is further supported by the fact that the erection of the new houses is stratigraphically associated with the development of Houses 6-8 at the site (Hamilton, 1956:157). Which suggests the ability of the parent dwelling to enlist or supply enough laborers to complete so many major projects.

When we consider the development of the Norse settlement at Jarlshof on a phase-by-phase basis we can witness the gradual growth of the settlement as well as the establishment of House 1 as a central place within the settlement. A settlement that held connections with the western diasporic community both locally and farther afield for the purpose of gathering resources, engaging in communication, and commerce. As we look at the progression of each phase in succession the complexity of the construction history of the settlement becomes clear. If we consider these developments at the level of the use-life of each structure we can see an even more complicated narrative of alterations, modifications, and adjustments -whether to their use or function- that better suited the needs of the settlement's occupants at a given time in the past.

This variable and often convoluted use-life of structures erected by Scandinavian settlers during the westward diasporic expansion during the Viking Age can be seen, not only at Jarlshof, but at sites from Dublin to Greenland (Boyd, 2016; Buckland, 2012; Dugmore & McGovern, 2007; Kimball, 2003; Ólafsson & Albrethsen, 2016; Hamilton, 1956; Wallace, 2012). Much like Jarlshof, the archaeological site of Gården Under Sandet (GUS), a Viking Age farmstead in the western settlement in Greenland, provides an incredibly well-preserved example of the development, alteration, and adaptation of a Norse farmstead throughout its several hundred-year occupation and utilization beginning in 1050 CE and cumulating with the site's abandonment around 1380 CE (Ólafsson & Albrethsen, 2016). The level of preservation at GUS allowed excavator to document with a high degree of accuracy the series of alterations to the structures at GUS which appears to have occurred on an almost annual basis (Ólafsson & Albrethsen, 2016). In spite of this, the site as a whole was categorized into eight main building phases, each lasting between 20-50 years. Both Jarlshof and Gården Under Sandet in Greenland provide evidence of the extreme degree of flexibility present at Norse farmsteads that demonstrates long occupations. I would argue that, in order for a diasporic North Atlantic farmstead to be successful, they had to have been able to adapt not only to the new environment in which they found themselves, but also maintain connections both locally and with the broader diasporic community of which they were a part. It is the maintenance of these maritime networks, as they relate to settlement development, that is of primary interest to this research.

CHAPTER 7: METHODS

Thus far, the physical and socio-cultural connectivity of insular communities throughout the western Viking World has been discussed. This connectivity could be described as past people's engagement and entanglement with their environment, whether terrestrial, maritime, or an amalgam of these variable regions. This amalgam of land and sea can be viewed as a unified cultural 'landscape' composed of both terrestrial and aquatic environments. I contend that the inextricable nature of these land- and seascapes begs the investigation of their associated cultural 'landscapes'. The following section discusses the methods used to tailor landscape archaeological techniques to not only insular and coastal sites, but also to the seascapes themselves.

Anna L. Tsing argued that "Landscapes are not backdrops for historical action: they are themselves active," (2015:152). If we acknowledge that landscapes, today as in the past, were active, cognitive aspects of perception that we experience every day need to be considered. The use of models that consider the impacts of visibility or motion have often been used as a means of distancing geo-spatial models from the tradition detached objectivism of the top-down or 'bird's eye' perspective inherent in traditional GIS-based analyses (Llobera, 2001; Lock et al. 2014, Richards-Rissetto, 2017; Sullivan, 2017). The implementation of visibility or mobility analyses has a humanizing effect on GIS-based investigations; therefore, by investigating not only visibility, but also movement, a perception-based model that more accurately depicts the experiential use of the landscape as well as the seascape can be developed.

The case study for the methodology discussed below will be the Norse settlement at Jarlshof at the southern tip of the Mainland Shetland, UK during its occupation from 850 CE-1200 CE. The purpose of the model is to determine whether intervisibility could be possible between a mobile sailing ship and the coastal settlement at Jarlshof and whether that visibility might contribute to the site's interconnectivity overtime. Admittedly, the complexities of the cognitive interplay between motion and the perception of motion are difficult to pin down empirically. Therefore, in order to contribute to the development of knowledge in this area it is necessary to develop a rigorous and explicit methodology by which the investigation of these interrelated concepts can occur. To achieve this, it was necessary to conduct two distinct forms of visibility analyses as well as a mobility analysis. The steps involved in the development of the methodology employed for the land based Cumulative Viewshed Analysis (CVA) are discussed first, followed by the Maritime Least Cost Path (MLCP) mobility analysis and the associated Fuzzy Cumulative Visibility Analysis, (FCVA) are discussed last.

360° Cumulative Viewsheds: The View from the Settlement

The final visual analysis to be discussed is a Cumulative Viewshed Analysis (CVA), which will provide the perspective of an observer from the perspective of the settlement. Cumulative Viewshed Analyses are methodologically robust and are not statistically or computationally complex (Wheatley, 1995). One of the benefits of using CVA is that it allowed for the selection of observation points linked to the structural development of the site, which in turn allowed for the consideration of architectural changes though time so that changes in overall visibility could be compared across periods of occupation.

Georeferencing and Shapefile Formation

To ensure that the Cumulative Viewshed Analysis accurately reflected the orientation and scale of the settlement in the past, two site maps –Phase II and another for Phase V- were selected from Hamilton (1956) were georeferenced. These two site maps were selected because they not only depicted the structures within their own occupational phase, but also provided outlines of where the decommissioned structures from the previous period were located in relation to the structures in the phase under scrutiny. This allowed for two rather than five site maps to be georeferenced, which both aided the overall speed and accuracy of the process. This was done by comparing the ArcMap Base map (World Imagery) and the 1m resolution DSM and 1m resolution DTM data files for the southern portion of Mainland Shetland acquired through the remotesensingdata.gov.scot with the georeferenced site maps(SG & JNCC, 2021).

Once these files were brought into ARCGIS their datum and corresponding coordinate systems were transformed from GCS_OSGB_1936 to GSC_WGS_1984 using the transformation

OSGB_1936 to WGS_1984_7. This was done because the DTM and DSM raster files were the only layer not employing WGS_1984. For ease of identification, each DTM or DSM raster file retained their original file names which indicate their location within the British National Grid, in which HU stands for a 100km square that surrounds the majority of the Shetland Islands and the associated number denotes easting and northing of the specific 10km grid. For example, Hu_30_DTMPhase2 was the raster file that encompassed the boundaries of the site itself and the surrounding area. The DTM files were bare-earth raster data while DSM raster files still had all historic and modern structures. The variable perspectives of these different views allowed for increased accuracy when placing the ground control points. The points were placed at easily discernable location on both the site maps and the various data layers such as building edges, corners, and doorways.

Shapefiles were then created for each phase of settlement occupation so that the individual polygons represented the floorplan of each structure and were assigned values attribute fields that detailed the structure and the period it was in use. The Feature classes for Phase V and Phase III were based off the initial floorplan feature class developed for Phase IV due to the reduced number of alterations required to adapt the new features classes and Phase II and Phase I were based off the floorplan for Phase III.

Structure 1D from Phase I at Jarlshof was not included in the analysis for three reasons. First, the degree of dilapidation of the structure at the time of excavation made it difficult to determine the location of the door for the structure, although the possible extent was approximated, and it seems to have been of a size with the smaller outbuilding of the period. Second, none of the site maps explicitly document the structure in direct relation to others from any of the periods. Last, the structure's approximate location on the far northwestern end of structure 1C suggests that its presence or absence is unlikely to have had a significant impact on the scope of the other viewsheds for the same period.

Structure Height Estimation

According to Eriksen (2019) there have been four Iron Age doors recovered from sites across Scandinavia that have provided complete height measurements including sites on the Island of Gotland, at Hedeby in Denmark. Of those doors, two had a height of 180cm, one a height of 165cm dating between the sixth and ninth centuries, while the oldest had a height of 115cm (Eriksen, 2019). Despite the small number of preserved doors, Eriksen (2019) argues that during the Viking Age average door height was equivalent to the average height of a woman of that time, or slightly taller. This assertion is based on the height estimates developed by Sellevold et al. (1984, as cited by Eriksen, 2019) mentioned above (164cm for females and 174cm for males) The total wall height for the structures could therefore be reasonably estimated at 2m.

While little is known archaeologically of what the roofs of the period were constructed of, Eriksen (2019) argues that the most likely method that would have been employed is thatching. Thatching is a roof covering composed of dead plant materials, such as birch bark, straw, or turf (Eriksen, 2019; Hall, 1988). Hamilton, (1956) draws ethnographic comparisons with contemporary rural croft cottages of Shetland and Viking Age vernacular architecture postulating that the Shetland croft was the direct architectural descendant of the Viking Age longhouse in the region. According to Hall, (1988) thatch roofing requires a bare minimum of a 45° pitch, and preferably closer to 50°. This is because the steep pitch of the roof allows the water or snow to run off and if a house were built with a pitch lower than 45°, then the thatch would decay at a rapid pace (Hall, 1988).

A 45° pitch means that the height rises vertically at the same rate the distance is crossed horizontally. So, if we consider House 1 from Jarlshof which has an architectural footprint that is 20ft across and 70ft long, the height of the roof alone would be a minimum of 10ft high, approximately 3m (Hamilton, 1956). Making the overall structure of House 1 approximately 5m tall; this same approximation can be extrapolated for Houses 2 and 3 which had similar dimensions. It is for this reason that the assigned height to the polygon floor plans for each settlement phase was set at 5m for all structures. This was achieved using the Add Z Information tool was used to assign a minimum z value of 0 and a maximum z value of 5 to all polygon feature classes in all phases. In order to add these new features to the DTM raster data, the polygon feature classes were then converted into raster data themselves using the maximum z values to assign the structures their maximum height.

It is acknowledged that this results in a series of unevenly shaped, 5m tall polygons, without considering the actual shape of the roof (a roughly 3m tall 45+° triangle) in the analysis. This assignment also ignored the potential for variability in roof heights for the smaller structures, or even wider outbuildings. By selecting the minimum possible pitch for these three structures it means that this in turn maximizes the potential visibility around these three structures and provides pitches of closer to the ideal 50°s for the smaller structures.

Merging, Masking, and Preparing Raster Files

Once all five of the settlement phases were converted from polygons to raster files, the Mosaic to New Raster Tool was used to merge the Ordinance Survey DTM raster files Hu30, HU31, HU40, and HU41 into a singular 1m resolution DTM file. That file which covered the extreme southern portion of Mainland, Shetland was named 'HU_DTM'. The spatial resolution of 1m was maintained for this new raster layer. At this point the Polygon to Raster phase layers

(PtoRs) were reclassified using Map Algebra equation to conditionally redefine the null values to 0, in which the processing extent was set to be the same as layer HU_DTM. This process was repeated for all five phases. This effectively changed all empty values to 0 and prepared the settlement footprint raster files, from each phase, to be combined with the HU_DTM raster file. This Raster Calculator function effectively created an UrbanDEM raster file that reflected each Phase of occupation at the site.

Once this was complete, it was determined that the spatial extent of this raster exceeded the necessary size for the study area to the north by several kilometers. Therefore, it was decided to select a subset of this larger raster to run the analysis in order to save on processing time and increase the accuracy and functionality of the analysis results. The study area was resized using the Extract by Mask tool to create a new spatial extent from the UrbanDEM using the processing extent of the shape file. This removed the extreme northern portion of the UrbanDEM. This new, smaller UrbanDEM raster file could then be used to run the Cumulative Viewshed Analysis. This same process was repeated from the UrbanDEM layer associated with each of the later phases (II-V). The last step before running the analysis was the creation of the points of observation for each phase of occupation. In the case of Cumulative Viewsheds, the observer points selected are not random, but instead are intended to be either a set value or hold some level of cultural significance.

Observer Point Selection

One aspect to consider is the potential for past actors to be at a given location within the settlement at any point in time. Given the multi-phased nature of this research, this is especially true, because the viewsheds that occur in one phase of occupation may become impacted by changes in the orientation or extent of existing structures, the erection of new, or decommission of older architectural features over the course of the five occupation phases examined here. It is for this reason the selection of observer points was based on architectural features. Fisher (2009) discusses physical and social boundaries and their expression in architecture, with a particular focus on the doorway. The lived experiences of past peoples often result in the patterns of movement both within and around habitation centers (Boyd, 2016; Eriksen, 2015; 2019; Fisher, 2009).

We pass through doorways innumerable times over the course of an average day, but it is rare that we take the time to actually consider them as architectural features. Boyd, (2016) and Eriksen, (2015; 2019) discuss the significance of entryways as gateways between private and social life; this perspective enables a more nuanced understanding of human action, interaction, and experience. Marianne Hem Eriksen (2015; 2019) views doorways as symbolic of the processes of transition and transgression because they serve as 'access control points' to structures because they both create and limit access to a given space. Fisher, (2009) and Eriksen, (2019) suggest that it is this physical process of transitioning, which takes place in doorways, -passing from one space into another- that makes doorways an ideal place from which to observe the space differentiated by the presence of the doorway itself.

Taking this into account, it is reasonable to assume that actors in the past crossed through the thresholds of the various structures within the settlement at Jarlshof with some degree of regularity, and certainly at a higher frequency than at a randomly selected point in the settlement. It is for this reason that the space directly outside of the doorways at Jarlshof were selected as the observation points for the 360° Cumulative Viewsheds that were run for each of the five phases considered in this research. Each observation point was assigned an OFFSETA value of 1.7m, this value was selected to represents a height value between the averages from the period for male and female individuals. These calculations are based on the work of Sellevold et al. (1984, as cited by Eriksen, 2019), who documented the average height of male and female Scandinavians during the Viking Age as being 174cm and 164cm tall respectively (on average).

To create the observer points for each phase a new point feature class was created. Each of the point feature classes that were created represent all the observation points in each phase. This feature class was assigned attribute fields to indicate which doorway each point represented as well as the standard OFFSETA (observer height) of 1.7m. Another attribute was added, RADIUS 2, and was set at 4828.03m (3 miles) which is just under maximum extent of human vision when the curvature of the earth is considered for an individual who is 1.7m tall (Young, 2003).

Figure 7.1: Jarlshof Settlement Phase I polygon structures (green) with observer points (7) placed outside all of the doorways to the structures (purple).

Figure 7.2: Phase II polygon structures (purple) with observer points (11) placed outside all of the doorways to the structures (green).

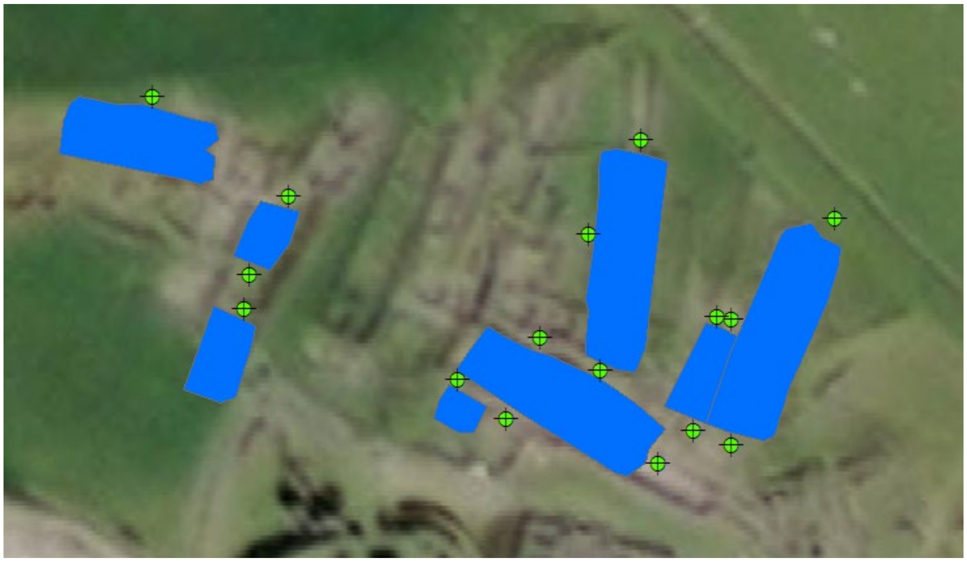


Figure:7.3 Phase III polygon structures (blue) with observer points (16) placed outside all of the doorways to the structures (green).

Figure 7.4: Phase IV polygon structures (yellow) with observer points (18) placed outside all of the doorways to the structures (red).

Figure 7.5: Phase V polygon structures (red) with observer points (14) placed at all doorways to the structures (blue).

Cumulative Viewshed

The Viewshed tool runs a 360-degree horizontal viewshed analysis that continues without end and has a vertical observation range of 180 degrees set at 1 unit above the ground surface. The attribute fields mentioned above alter the parameters of the standard visibility analysis. OFFSETA allows for the height of the observer to be changed, while the RADIUS2 field sets a maximum spatial extent of the analysis. These values were maintained for all five renditions of the analysis allowing for observations to be made regarding how changes in the settlement layout overtime may have had an influence on the overall visibility from the settlement into the surrounding landscape and seascape. It was decided that the modern sea surface data that was captured during initial LiDAR data collection would be included in the settlement CVA analysis, rather than being altered as with the FCVA analysis -see below-, because it provides a sense of how wave height and motion actively impacts visibility. (Refer to Figures 8.1-8.5).

Once each analysis was run successfully, the resulting data fields were reclassified using the 3D Analyst reclassify tool. This converted the output values from the viewshed into a Boolean Raster, assigning it binary values [0,1] in lieu of their previous values which were based on the number of points that could see each pixel. This conversion allows us to visualize what could be seen from the settlement observation points and what could not be observed for each of the phases. Following this step, a new field was added to the Boolean Raster. That field was titled ‘Percent_vis’ and using field calculator it was assigned the SUM value of the Count field statistics. With this final step complete, it was then possible to examine each of the cumulative viewsheds for each of the five settlement phases and compare their visibility percentages.

Considerations for a Mobility Analysis

Conducting a mobility analysis is necessary to identify the potential paths that past sailing vessels may have used to reach the settlement at Jarlshof. Various researchers have employed a number of different methods to model maritime travel in the past including Path Distance (Leidwanger, 2013) Least Cost Path (LCP) and Anisotropic Spread Analysis (ASA) models (Inderuzewski & Barton, 2006; 2008) In these models the primary means of propulsion on open bodies of water, such as oceans and seas, was wind direction and strength which all researchers agreed was a crucial aspect of sail-based travel (Inderuzewski & Barton, 2006; 2008 Leidwanger, 2013). However, as discussed above, Gustas and Supernant (2016) found that rather than focusing on converting slope-based land methodologies, inputting cultural values as costs to motion could also be beneficial in modeling potential sea-based coastal travel routes. The dynamic nature of an ocean, due to the impacts that climatology, seasonality, and weather patterns would have had a profound impact on the decisions and actions of the crews of oceangoing vessels anywhere in the North Atlantic region. In this, waters around Jarlshof are no exception, and therefore demand a less simplistic assessment of their potential costs.

Selecting The Ship

As previously discussed, inter-insular connections between diasporic communities throughout the Viking Age have been demonstrated through the distribution of a number of diagnostic artifact and architectural forms which have been identified at various locations throughout the western Viking world. The connections between these far-flung settlements were maintained by the numerous sailing vessels which plied the waters of the Norwegian coast, the Irish Sea, and the North Atlantic at the time. The channel leading to the town of Roskilde in Denmark was determined to contain a series of Viking Age ships of various designs and purposes that were skuttled, or purposefully sank, as a defensive measure sometime around 1070 CE (Crumlin-Pedersen, 2016). Collectively, these clinker-built ships are known as the Skuldelev Ships and represent examples of not only the archetypical Viking Age long ship, but also fishing vessels, cargo ships, and smaller coastal vessels (Cooke et al., 2002; Crumlin-Pedersen, 2016). Crumlin-Pedersen (2016) provided a list of general features associated with the clinker-built ship building tradition between 950 CE and 1150 CE. These include a keel-based double-ended hull, a curved stem for both the fore and aft, the frame is encased by a series of overlapping planks comprising the hull which would be fastened by use of rivets or treenails. The outer hull was supported internally by a series of evenly spaced transverse timber, or thwarts, running from port to starboard; in some instances, these supports could be reinforced with longitudinal stringers.

According to Crumlin-Pedersen (2016), while each of the Skuldelev ships proved to have been of different types, they were a variation on a theme, in that they shared the fundamental basics of clinker construction methods, as discussed above, but differ in the functional aspects of their construction. Skuldelev 1 was selected as the ideal vessel for the purposes of this study; the reasons for this are detailed below. Skuldelev 1 is recognized as the most complete example of a Viking Age ocean-going cargo vessels, or *Knarr* yet recovered (Crumlin-Pedersen, 2016). According to Ossowski and Englert (2009) and Crumlin-Pedersen, (1999), Skuldelev 1 is an example of a sailing vessel designed explicitly for sailing, as evidenced by the inability to lower their masts while at sea, and the limited propulsive abilities of the vessel's four oars. The location where Skuldelev 1 was constructed is significantly closer to the Shetland Archipelago than its final resting place near Roskilde, Denmark. Skuldelev 1 was built in the area surrounding Sognefjord, on Norway's western coast around 1030 CE; dendro-analysis indicated the vessel, which was originally crafted of heavy pine, was repaired several times throughout its use-life with oak from the area around Oslo fjord (Crumlin-Pedersen, 2016; Ossowski & Englert, 2009). It was a common practice amongst Scandinavian seafarers to conduct repairs and modifications to ships to extend their use-life (Bruun, 1997).

The rounded bows and sterns of *Knarr* not only increased the vessels' potential for storage but also their seaworthiness, making them capable of handling extended voyages across the open ocean as well as stints in coastal waters (Crumlin-Pedersen, 2016; Ossowski & Englert, 2009). The distinctly rounded shape of the bow and stern of *Knarr* was so recognizable that one Saga writer described two women as being '*Knarrarbrigna*' meaning Knarr-bosomed or Knarr-breasted (Crumlin-Pedersen, 2016). Researchers at the Viking Ship Museum in Roskilde, Denmark estimate that Skuldelev 1 was approximately 15.84m long with a beam of 4.8m, a draft of 1m with a displacement of 20 tons, and a 90m^2 sail (Viking Ship Museum, 2021). It is estimated to have been able to carry between 20 and 25 metric tons of cargo; its modern replica *Ottar* carried a load of 17 metric tons, worth of stone ballasts, on its voyage from Hedeby (Haithabu) to Gdańsk (Danzig) (Ossowski & Englert, 2009; Viking Ship Museum, 2021).

Crumlin-Pedersen (2016) argues that due to the origin of the repairs conducted on Skuldelev 1 as well as its final resting place, it was likely an *austrfararknörr*, a *Knarr* built for use in the Baltic Sea Trade, making it somewhat smaller than those that would have typically seen use on the North Sea and in the North Atlantic. Larger sailing ships such as the Gokstad ship, at 23m long, were in use a century earlier ca.895-900 CE (Ossowski & Englert, 2009). However, it is worth considering that Skuldelev 3, which was also identified as a Baltic-based cargo ship, seems to have been outfitted and constructed in a manner more suited to shorter voyages and calmer waters of the Danish coast and the Baltic Sea while Skuldelev 1 was clearly more robustly built for use on ocean-bound voyages (Crumlin-Pedersen, 2016; Ossowski &

Englert, 2009). This position is supported by The Viking Ship Museum (2021) who note the vessels potential for use in the North Sea and the North Atlantic. Modern reproductions of Skuldelev 1 have been shown to be capable of such extensive and dangerous voyages. One reproduction, the *Saga Siglar* sailed from Norway in 1985 and crossed the North Atlantic via Iceland and Greenland onto L'Anse Aux Meadows in Newfoundland Canada (Crumlin-Pedersen, 2016). In fact, *Saga Siglar* would go on to successfully circumnavigating the globe on that voyage (Crumlin-Pedersen, 2016).

Travel Conditions

Skuldelev 1 is estimated to have held a 6–8-man crew and modern sailing voyages with *Ottar* suggest that in stable weather conditions, a watch of four crew members could readily maintain the vessels course and adjust the sail as needed (Ossowski & Englert, 2009). The average speed anticipated for Skuldelev 1 is estimated to have been between 5 and 7 knots (nautical miles per hour) -between 9 and 13 kph-, and a top speed of 13 knots, or around 24kph (Viking Ship Museum, 2021). This speed would likely have been possible when running before the wind and unburdened by cargo, with ideal sailing conditions in mind. Therefore, it is important to consider what conditions would have impacted sea voyages in the late 9th century in the waters around Scandinavia. First and foremost, Englert (2016) draws attention to the ideal sailing season in Northern Europe, which would have lasted from April until September. Englert (2016) based these assertions on High Medieval textual sources, such as *Konungsskoggsjá*, or King's Mirror. He notes that dangerous winter weather patterns including punishing winter gales, advancing cold, and shortened hours of daylight for sailing operations would not have been conducive to prolonged voyages. Adding that today, even in the summer, winds in the region could be unpredictable, unstable, and inconsistent, thus positing the need to maximize sail use, whenever possible (Englert, 2016). As mentioned above, Skuldelev 1 sported a 90m^2 sail; given that that sail could not be stowed while at sea, wind was likely the primary nautical factor on extended voyages for such vessels (Englert, 2016, Crumlin-Pedersen, 2016). This supports the modeling of a ship under sailing rather than a ship with sail stowed; has major ramifications for the size of the object under scrutiny.

Information Processing, Cognitive Maps and their Role in Wayfinding

The Shetland Islands, as is the case with the Faroes and Orkney Islands, are land masses which consist solely of islands, bays, islets, and skerries (Gammeltoft, 2010). Gammeltoft (2010) argues that it is these same geographic features that are central to life in island communities, not only for the local inhabitants but also to travelers navigating the waters that surround them. They can be viewed as fixed points within an otherwise unceasingly dynamic aquatic environment. It has been argued that the names of islands, holms and skerries may well represent some of the oldest placenames in the archipelagos (Gammeltoft, 2010). The names of these locations constitute a body of linguistic knowledge which, due to its descriptive and often functional nature, has seen near constant usage and relevance over time (Gammeltoft, 2010). This geographical lexicon, if you will, could then be used to generate, inform, and expand upon an individual's understanding of a region's geographic make up, their 'cognitive map' (Golledge, 1999). This metaphor of a cognitive map is used to describe the internal representation of the environment (Golledge, 1999). Mental maps are directly linked to spatial information processing: the way human actors conceptualize their environments and mentally assemble those embodied experiences over time and space, as well as how memory, and second-hand information can influence the implementation of that knowledge (Bernardini & Peeples, 2015; Golledge, 1999).

For the purposes of this section the way mental maps can inform, and influence wayfinding activities and behaviors is of primary focus. Going forward, the basic premise being laid out is that human locomotion in a given environment is intentional, goal-driven, and adaptive. Wayfinding can broadly be defined as the selection and following of a planned route of travel through a given environment (Golledge, 1999). The ease with which a given route can be followed, when considering general route complexity or environmental factors that could represent time delays or physical danger, is referred to as its *legibility* (Golledge, 1999). In instances in which repeated the use of the same route is necessary, due to cultural factors, or the physical legibility of the route, placenames associated with prominent points on the landscape can help accelerate route-learning processes such as the development of mnemonic markers (Gammeltoft, 2010; Golledge, 1999).

In order to remember the various stages of such a journey, such as the physical layout of the route and the experienced environment, are built upon in an integration process in which new information can be identified, processed, and refined into an individual's cognitive map (Golledge, 1999). Bernardini and Peeples (2015) suggest that familiar locations can act as visual anchors (reference points) in an individual's cognitive map, around which other environmental information is based. According to Bernardini and Peeples, (2015) the location's distinctive features, topographic prominence, or cultural salience can all play a role in their selection as prominent aspects of the landscape. When considering potential sailing routes that may have connect various insular locations across the Irish Sea and North Atlantic, it is likely that reference points for an individual's cognitive map along these routes included geographic features such as islands, holms, bays, to headlands or promontories as well as built features such as coastal settlements or outposts (Westerdahl 2006; Thirslund, 1997). In terms of navigation this methodology is known as pilotage (Indruszewski et al. 2006).

It has been noted by Indruszewski et al. (2006), Thirslund (1997), and Westerdahl (2006) that both prior to and during the Viking Age, pilotage, that is sailing within sight of land and making use of various points along the landscape, was the primary method employed for navigation. However, with the advent of the Viking Age sailing vessels began crossing not only the North Sea, but the North Atlantic; voyages over such long distances necessitated extended periods of travel out of sight of land. Thirslund (1997) brings attention to the importance of navigational knowledge, sailing directions in particular, to the westward expansion that took place during the Viking Age. Thirslund (1997) discusses a set of sailing directions described in the Icelandic Saga the *Hauksbok,* written between 1302 and 1310 CE, which details the route from Norway to Greenland. The text indicates the distance that a ship sailing directly due west, on route from Hernam, Norway to Hvarf, Greenland, should keep from Shetland, the Faroes and Iceland respectively; in order to maintain their proper course (Thirslund, 1997). This would suggest that the same principles used in coastal navigation and cognitive mapping were still employed, when possible, on longer voyages.

If we look at Gustas and Supernant's (2016) investigation of maritime travel along the Northwest Coast of North America, we are reminded that Least Coast Path Analysis allows for the input of not only environmental and physiological, but also cultural variables, that may have been viewed as a 'cost' to movement. This is important because when we calculate the relative cost imparted on an actor when they move through space it is insufficient to conceive only of those costs as being strictly in the traditional topographical realm. On primary goal of Gustas and Supernant (2016) research was not only to evaluate the least cost path on seascapes, but to do so by considering the cultural agency of maritime movement and its influence on movement costs. If we were to apply such a methodology to the North Atlantic, many points of departure and landfall detailed in the Icelandic Sagas are easily identifiable headlands (Thirslund, 1997). The practice of latitude sailing, referred to by the Thirslund as 'equal altitude sailing', was practiced by Viking Age navigators on east-west and west-east bound voyages (Thirslund, 1997) In such instances, navigation is assumed to have been based on the observation of the celestial bodies, in which the altitude of a given celestial body, would hold true over the course of the whole voyage. The 'Leitharstjaerna', or leading star, which we know today as 'Polaris,' the North Star is one well documented example (Thirslund, 1997). Indruszewski et al. (2006) remind us that the process of navigation in the past was not a science, but an art: the application of multifaceted knowledge to a practical task: guiding a sailing vessel safely from its origin to its destination.

It has been argued by both Thirslund (1997) and Indruszewski et al. (2006) among others, that there was no formal process that enabled the Viking navigator to develop the cognitive maps, knowledge, and skills necessary to adequately steer and operate a sailing vessel, outside of a longstanding oral tradition and observational learning. Would-be navigators were taught how to observe and adapt to the dynamic nature and volatile phenomena of the sea, and how to safely reach their desired destination (Indruszewski et al. 2006; Thirslund, 1997). One might argue that the safety of the ship and crew takes precedence on any sailing voyage, be it for trade, resource acquisition, or conflict. It is only reasonable to assume that not all reference points used in the past had inherently positive associations, or even visually identifiable characteristics. According to Golledge (1999) cognitive maps are developed in response to feedback from environmental conditions, as well as from the addition of second-hand information. Based on this, it is likely that a navigator's cognitive map would include not only prominent points, but also any features or phenomena that might prove dangerous along a given route, such as, tidal races, or subsurface obstructions such as rock shelves, rocky pinnacles, or skerries.

If the coastal landscape of the Shetland Islands were to be described in a word, it would be 'rocky'. The coast and its environs consist of stark eroding cliff faces, tidal caves, sea stacks, majestic archways, and submerged inlets, skerries, and outcroppings (Hall et al. 2021). These factors, coupled with the severe local and regional wave and tidal forces, particularly on the Atlantic Coast, make navigation in the isles decidedly difficult (Hall et al., 2021; USHO, 1915). Individuals within a coastal community, where any one of these environmental conditions may represented serious threat likely were taught from a young age how to identify locations that should be avoided within both the surrounding seascape and landscape, because for coastal and insular settlements, these were an ever-present aspect of daily life (Westerdahl, 2019).

The United States Hydrographic Office (USHO) produced a navigational pilot for the waters around Scotland; it provides a detailed accounting of the coastal sailing conditions in and around the Northern Isles (USHO, 1915). As it recounts the conditions around the southern end of Mainland, Shetland it explicitly states that the waters around West Voe -the deep bay between Sumburgh Head and Horse Island- should not be entered by sailing vessels because the Bay is exposed to winds out of the south (USHO, 1915). It goes on to state that, while both West Voe and Grutness Voe are, at times, used by local vessels so long as winds are favorable (that is, that wind blowing from the land out towards sea), neither a safe place to put down anchor (USHO, 1915). Given the light weight of clinker-built vessels these adverse outcomes could be avoided by dry docking, beaching longships rather than having them waiting at anchor in Grutness Voe.

Grutness Voe, was reported to have 'Pinnacle Rocks' at the entrance to the bay, at a depth of less two meters below the surface (USHO, 1915). While it is clear that this would prove hazardous for modern ships, the clinker-built vessels of the Viking Age had impressively shallow drafts, that is the portion of the ship that resides below the waterline, with some being a meter or less (Crumlin-Pedersen, 2016; Ossowski & Englert, 2009). It is also worth noting that, since that time, Grutness Voe has served as the primary landing site for in-bound and out-bound ferries to Fair Isle in the south because it is a sheltered bay (Morrison, 1973a).

The pilot notes that in the event that weather condition change, so that the wind blows cold and strongly out of the east, a northbound vessel moving along the eastern side of Sumburgh Head, should change course and round the Atlantic side of Mainland and take shelter in Quendale Bay, which lies on the Atlantic coast of Mainland, just above the archaeological site of Old Scatness, about a mile overland from Jarlshof (Bond & Dockrill, 2016; USHO, 2015). However, grave warnings are given regarding the tidal race that lies offshore of Sumburgh Head and Horse Island (Morrison, 1973a; USHO, 1915). During spring tides, which occur every two weeks with the full and new moon, the tidal stream reaches a speed of 7 knots, and under the right conditions, the roost can cover an area up to three nautical miles wide (USHO, 1915). While during neap tides, which occur once every 14 days, it is often no more than half a nautical mile wide at a speed of 4 knots (USHO, 1915). Instances of ships becoming caught in the 'roaring roost way' and losing their way or being scattered by the unpredictable tidal currents Orkineyinga Saga and the navigation pilot (1915) recounts vessels being tossed about for days even in light weather (Morrison, 1973a).

It does not bode well for the navigator of a sailing ship that not only the exact extent, but also the location of the roost itself can change in accordance with the strength of the tidal stream

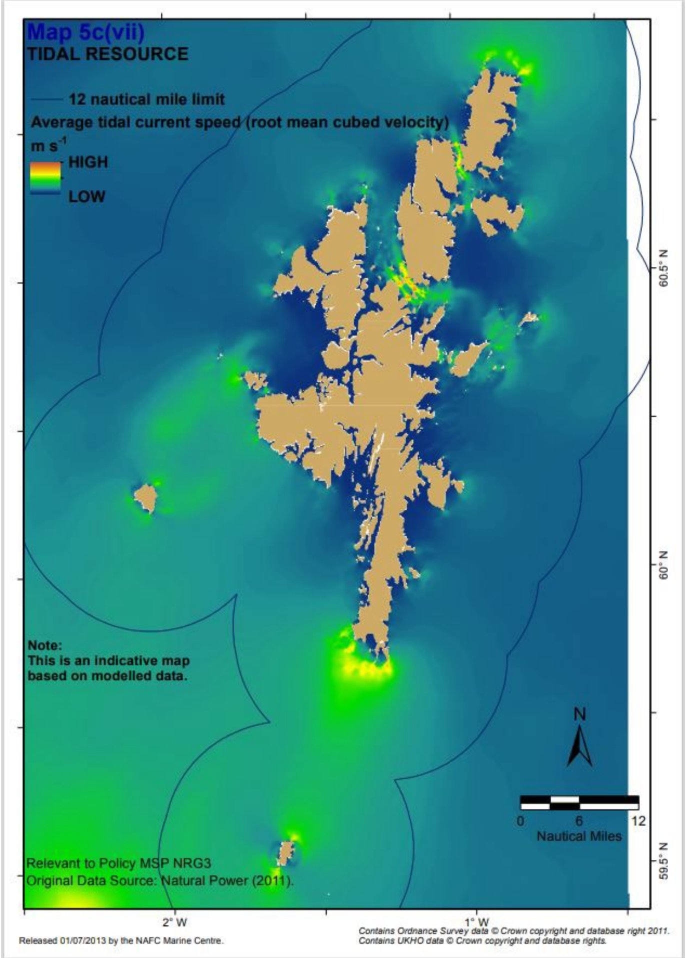


Figure 7.6: A tidal energy map produced by The Shetland Island Council that indicates the location of the Sumburgh Roost directly off the southern tip of Mainland, Shetland (neon yellow-green).

and the opposition of wind and current (USHO, 1915). While it is known to occur often off the shore from Sumburgh Head, conditions can also cause it to occur just to the west side of Horse Island, which lies approximately one nautical mile to the southwest of Sumburgh Head (Morrison, 1973a; USHO, 1915). Taking all this into account, it is reasonable to assume that navigators of Scandinavian vessels in the region would have given the roost a wide berth whenever possible. For this reason, the maritime area encompassing the Sumburgh Roost, was assigned null values during the LCP analysis. With the assumption that sailors would be aware of the dangers of the Roost and typical weather patterns of the area, and justifiably avoid the area. The Shetland Island Council's tidal energy map indicating the location of the Sumburgh Roost directly off the southern tip of Mainland, Shetland can be seen in Figure 7.6.

Maritime Least-Cost-Path Analysis

The basic steps involved in a GIS based Maritime Least-Cost-Path Analysis, for a sea-based voyage, presented in this research, are a blending of those employed by Indruszewski and Barton (2008) and Gustas and Supernant, (2016). Those steps are as follows: First, three cost surface raster grids were created, in which the value of each cell represents the relative costs, in this case, resistance to movement, for the area under investigation. For the purposes of this model these values will be based on current velocity and directionality as well as the visual prominence of coastal promontories, this will be discussed further in the section on landmarks, features, and the visual structure of landscapes.

This is followed by the creation of an accumulated cost distance grid, where each cell within the grid represents the total costs incurred by traveling from the designated starting location (origin point) to all the other locations in the study area. Next, a backlink grid (a cost-direction surface) is developed using the accumulated cost surface that indicates the costs incurred by directionality of travel in each grid cell. In a land-based Least Cost Path analysis this would be seen as the greater energy cost associated with traveling upslope versus the reduced cost when traveling downslope. For this aquatic model however, as Gustas and Supernant (2016) note, slope literally does not exist in aquatic environments. Although many researchers have used the concept of slope to model directional movement (Indruszewski and Barton (2006; 2008) and Leidwanger (2013) among others) it was decided that two cost surfaces modeling both current directionality in a singular direction and their speed in m/s in that given direction would be used in place of slope for the purposes of these analyses.

Once this is complete, the desired sailing route is calculated by determining which path minimized the friction on the vessel as it traveled across the accumulated cost surface from the point of origin to the desired end location. The path of least resistance is the modeled sailing route. To ensure that the ship's desired sailing route did not cross any land area, these locations were treated as null areas throughout the course of the analysis.

Visual Recognition of Coastal Landmarks as Weighted Movement Costs

In their discussion on the social significance of visually prominent landmarks, Bernardini and Peeples (2015) suggest prominent, familiar locations have the potential to skew a viewer's perception of distance or time to the surrounding area by taking on 'visual gravity' and acting as visual anchors (reference points). According to Bernardini and Peeples, (2015) the location's distinctive features, topographic prominence, and perceptual or cultural salience can all play a role in their selection as visually prominent aspects of the landscape. To put it another way, they influence the development of an individual or group's similarly oriented mental maps. Therefore, certain 'visual anchors' may be identified that have the potential to impact the distance the intended sailing route comes to the associated section of the coast. For the purposes of the prescribed sailing route, the headland of Sumburgh Head is taken to have been a visual anchor given that it is not only a prominent headland, but also the southernmost tip of Mainland Shetland.

Adjusting the Sea Surface Data

In order to create a sea surface model, I acquired data from a sea surface model available from the Copernicus Marine Services website (https://resources.marine.copernicus.eu/products). The files I selected were a subset of the Atlantic-European Northwest Shelf- Ocean Physics Reanalysis model. This ocean simulation model included data of ocean current velocity and directionality, as well as a number of other variables, from 1993 to the present day. For the purposes of this research, I selected two datasets from this: Eastward Sea Surface Velocity and Northward Sea Surface Velocity. Both of these datasets were measured in m/s set to a depth of 0 to 15m. I specified that they only include data that spanned a 20-year period from December 31th 2000 to December 31th of 2020. This was done so that the data could be more readily extrapolated in order to cover broader temporal spans of 100 years and avoid the possibility of annual inconsistencies.

In addition to this, the geographic extent of these files was reduced to enhance processing speeds and better conform to the study area. Both files consist of bands spanning from 61.0°N to 58.5°S and from –3.7°W to –0.3°E. This allowed for the inclusion of the Shetland and Orkney Islands within the scope of the analysis. These NetCDF files were brought into ArcMaps using the Make NetCDF Raster Layer (Multidimensional) tool. As the files were already originally georeferenced using GCS_WGS_1984, their coordinate system was not altered. This tool converted these data sets into two raster layers, one representing Northward flowing current velocities (vo_NCurrents) and another representing Eastward flowing currents (uo_ECurrents measured at 1 m/s, (see figures 7.7 and 7.8).

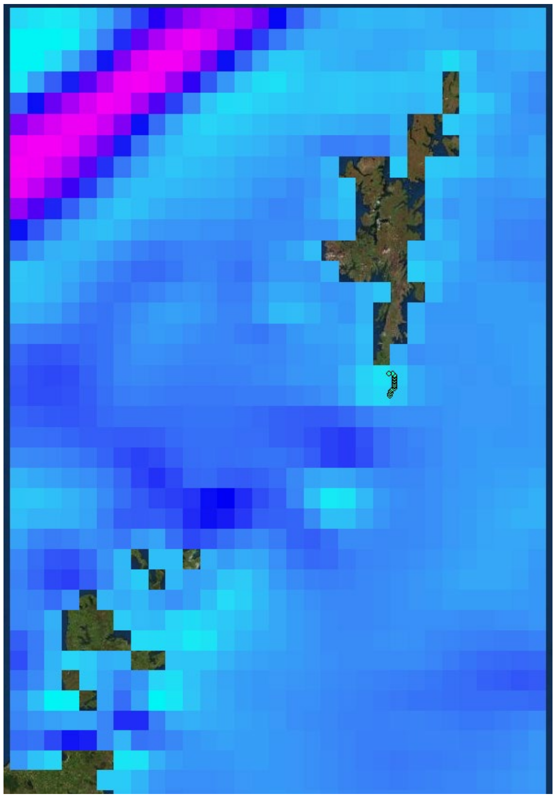


Figure 7.7: Original extent and resolution for the Copernicus Marine Data uo_ECurrents

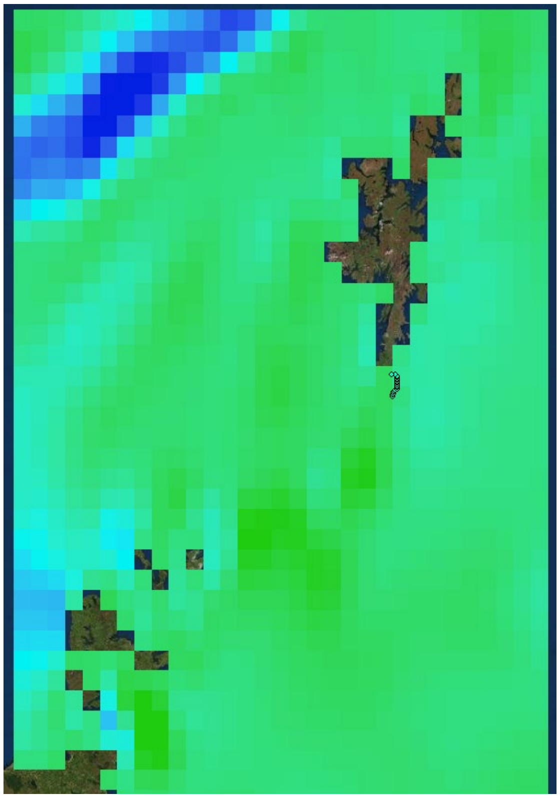
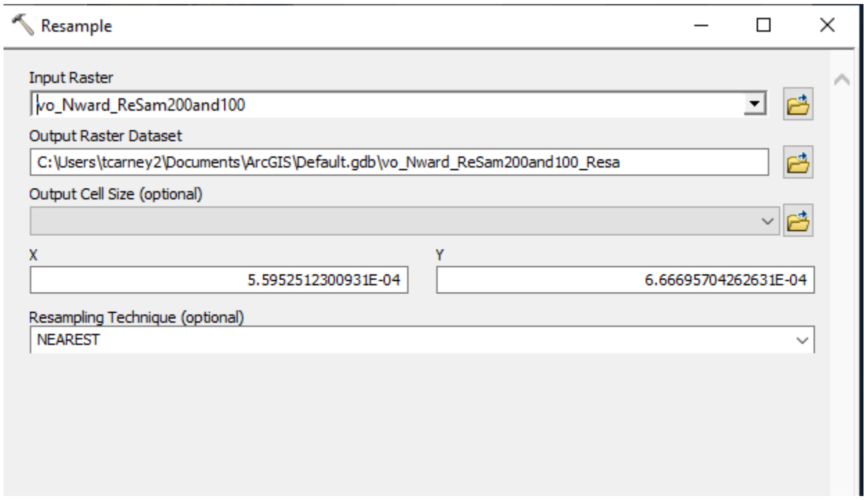


Figure 7.8: Original extent and resolution for the Copernicus Marine Data vo_NCurrents



Input Raster: vo_Nward_ReSam200and100

Output Raster Dataset: C:\Users\tcarney2\Documents\ArcGIS\Default.gdb\vo_Nward_ReSam200and100_Resa

Output Cell Size (optional):

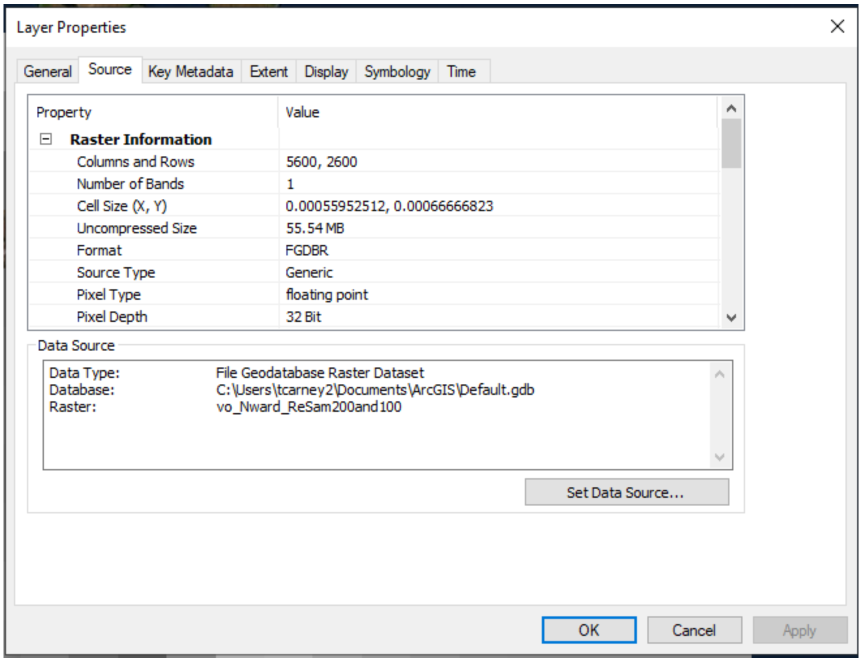
X: 5.5952512300931E-04

Y: 6.66695704262631E-04

Resampling Technique (optional): NEAREST

Figure 7.9: The Z Values were adjusted using the Resample tool to reduce their resolution without impacting their values.

The Copernicus current velocity dataset resolutions were in decimal degrees (0.111° × 0.067°). It was quickly noted that there was a discrepancy between their Y value resolution in their properties table. The properties table stated the pixel size for the Y values were 0.067°, or 7,446.313m, while the raster pixel size calculated by the measuring tape tool indicated this value was doubled: 14,892.626m. This was due to the number of columns generated for the data, rather than the actual pixel size, as the pixel size clearly states half that of the value displayed visually. Once these values were identified and understood, it was decided that, in order to remove overlap from non-maritime areas, the spatial resolution of the cells would be reduced while preserving their associated values.



Property	Value
Raster Information	
Columns and Rows	5600, 2600
Number of Bands	1
Cell Size (X, Y)	0.00055952512, 0.00066666823
Uncompressed Size	55.54 MB
Format	FGDBR
Source Type	Generic
Pixel Type	floating point
Pixel Depth	32 Bit

Data Source

Data Type:	File Geodatabase Raster Dataset
Database:	C:\Users\tcarney2\Documents\ArcGIS\Default.gdb
Raster:	vo_Nward_ReSam200and100

Figure 7.10: Here we can see that the resampling both impacted the cell size as well as the number of columns and rows representing the data, as anticipated.

The approximately 12kmx7km bands were divided into smaller units while maintaining the original resolution of the data using the

Resample Tool (See Figures 7.9 and 7.10). The cell size for the X values were divided by 200 and the Y values by 100. Resulting in roughly 62.84mx74.09m cells. While these sizes are not ideal, given that they are not neatly divisible or of equal values, they were reduced to this scale in order to allow for the removal of current data that overlapped with non-maritime areas, which would be a primary concern in the Maritime Least Cost Path Analysis. As a result, with this reduced spatial resolution of the cells, the ship will not travel overland, which would have occurred previously with the original roughly 12 km x 7km wide bands.

Selecting a Sailing Route

A number of archaeological sites throughout the western Viking world have been discussed thus far. However, by considering archaeological sites in the Orkney Islands allows for the investigation of a historically and archaeologically supported southern sailing route, without the need to place too much analytical stress on the current velocity data. As a longer sea voyage would likely increase the risk of inaccuracies associated with the resulting sailing route. As such, three archaeological sites that were mentioned above in the discussion on the artifactual links between Jarlshof and other localities in the North Atlantic and the British Isles were selected as source locations for the Maritime Least Cost Path Analysis. The locations that were selected as sources for the analysis included the multi-period settlement at Quoygrew on Westray, which like Jarlshof, also had a Viking Age Norse component (Barrett, 2012b). Similarly, the multi-period Pictish and Norse settlement on the Brough of Birsay, off the northwestern coast of Mainland, Orkney (Harrison, 2013), as well as the large Norse drinking hall at Skaill, on Rousay which is estimated to date to the 10th to the 12th centuries CE, and like Jarlshof appears to have also been built on a settlement mound near the sea (UHIAI, 2019; Hamilton, 1956).

Figure 7.11: Polygon feature classes created to overlay the Shetland and Orkney Islands.

Extracting Land Areas and the Tidal Race

Once the raster files were resized, polygon feature classes of the Shetland Islands, Fair Isle, and the Orkney Islands were created titled 'LandArea' (see Figure 7.11). Many of the major islands were assigned specific names in an addition field added to the shape file to distinguish them from one another. A second polygon feature class was then created that corresponded to the size of the study area (see Figure 7.12). All the polygon features were clipped out of this overlaying layer so that the outline of the islands could be more easily distinguishable now that the cell size of the original current rasters had been reduced. Unfortunately, the course size of the original current raster files left some areas with NoData values. Fortunately, this was not the case for the source or

Figure 7.12: The 'LandAreaReverseMask' polygon feature class was used to remove the current data that covered the land surfaces to increase the overall accuracy of the analysis. This also allowed for the newly adjusted pixel size to become readily visible.

destination locations, but they were, nevertheless covered in raster data. The Extract by Mask tool was used on the 'LandAreaReverseMask' and each of the resized Eastward and Northward current raster layers to remove the excessive raster pixels from within the boundaries of the islands. This also allowed the new spatial extent of both current velocity rasters to be readily observable, (compare Figures 7.7 and 7.8 with Figure 7.12).

After this, Shetland Island Council's tidal energy raster file was added to the map in order to identify the location of the Sumburgh Roost (See Figure 7.6). Due to the dangerous conditions this tidal race presents it was elected to exclude it from the analysis, by assigning it NoData value (Morrison, 1973a; USHO, 1915). The same method employed above to extract pixels from the landscape was again used to extract raster values from the Northward and Eastward current data layers.

Reclassifying Currents

It was decided that an Eastward flowing current would be beneficial until passing 9 original pixels (12,336.429m wide each), or 111.027.861km, from the eastern edge of the boundary of the analysis, (See Figure 7.13). This distance would place a vessel to the eastward side of Mainland Shetland; therefore, any movement farther east would increase energy expenditure for a sailing party. The values for the Eastern and Western sections of the eastward current raster layer were extracted and then their values were reclassified to a common scale, that was shared with the northward current raster layer and Euclidean Distance raster layer.

When reclassifying the western portion of the eastward current data layer and the entire northward current data layer, it was decided to convert the original values (i.e., current speed in m/s) into values between 1 and 10. With the slowest currents being valued at 10 and fast a value of 1 for both of those layers. This scale was selected so that, in the end, the scale across all three

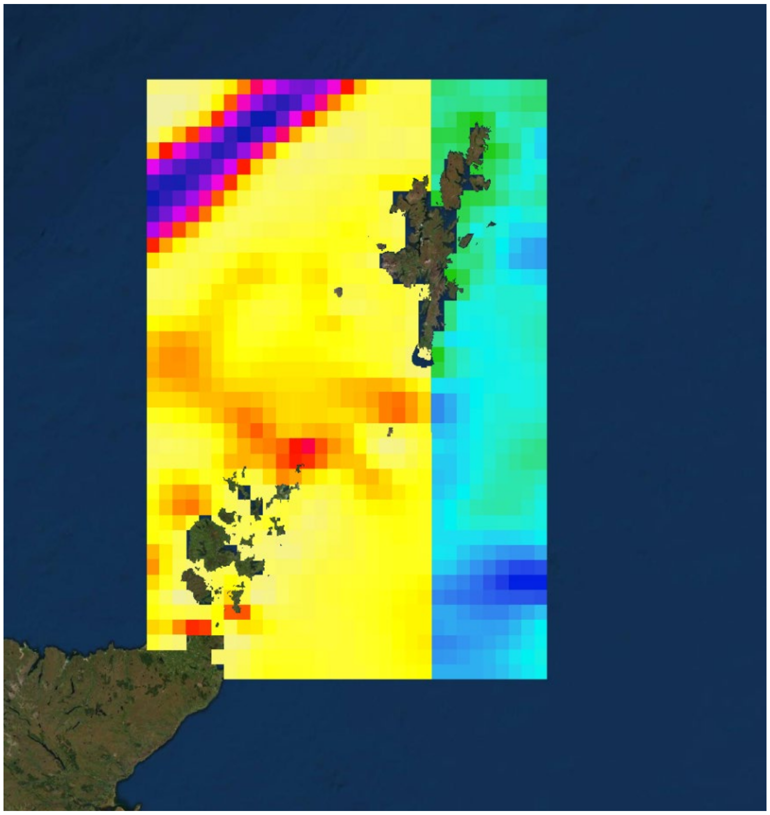


Figure 7.13: Eastward flowing currents after they were separated from one another, and prior to reclassification and recombining them.

friction surfaces would be consistent (see discussion below regarding Euclidean Distance). Whereas the Eastern protion of the eastward flowing current data set received the opposite treatment with slow current speeds being replaced with a 1 and fast currents receiving a 10. Mosaic to New Raster was then used to recombine the Eastern and Western parts of the east flowing currents. The Eastern and Western parts of the eastward flowing current layer can be seen, (still separated), in Figure 7.13.

Euclidean Distance Coastal Corridor

The Euclidean Distance tool was used to create a raster that expressed the distance from the 'LandArea' polygon with 50m cell size, a value that is relatively in line with the current velocity raster cell sizes. The land area was then extracted. This new raster file was then reclassified into 10 classes and the breaks were added at 5km intervals up to 45km and everything past that being rated as a 10 (see Figure 7.14).

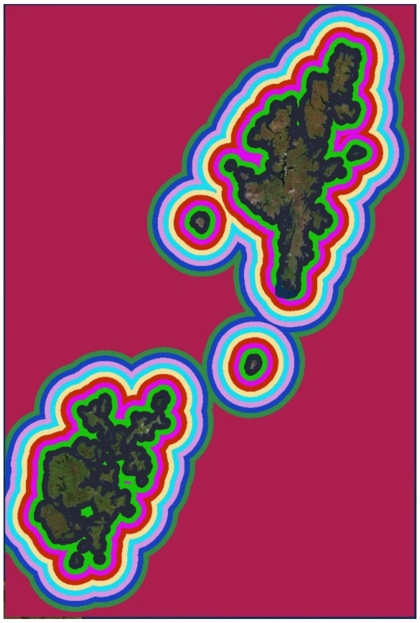


Figure 7.14: Euclidean Distance Surface detailing distance from the coast at 5km intervals up to 45km distant.

To account for the visual and physical proximity necessary to navigate using pilotage techniques, (i.e., sailing in sight of land), these sailing corridors were assigned greater values as they radiate out from the land, with 5km being a 1, 10km being a 2 and so on. The processing extent was set to be the same as the eastward and northward current velocity raster layers. Once this was done, the Sumburgh Roost tidal race was extracted from the Euclidean Distance Raster using the Extract By Mask tool. This was done in order to account for the importance of viewing the headlands at Sumburgh Head, while also accounting for significant the dangers represented by the Sumburgh Roost (USHO, 1915), (see Figure 7.15).

Figure 7.15: Portion of data extracted from all cost surfaces to represent the strongest portion of the Sumburgh Roost.

Weighing Surface Costs

Raster Calculator was used to combine the various surface layers into three combined surface layers that were each weighted separately. The ‘All-Things Equal’ weighted cost surface provided a baseline in which the factors considered were not assigned varying levels of importance. As such, all friction surfaces were assigned 33.33% of the weight. This general process was repeated for two other weighted calculations. The second process run was termed

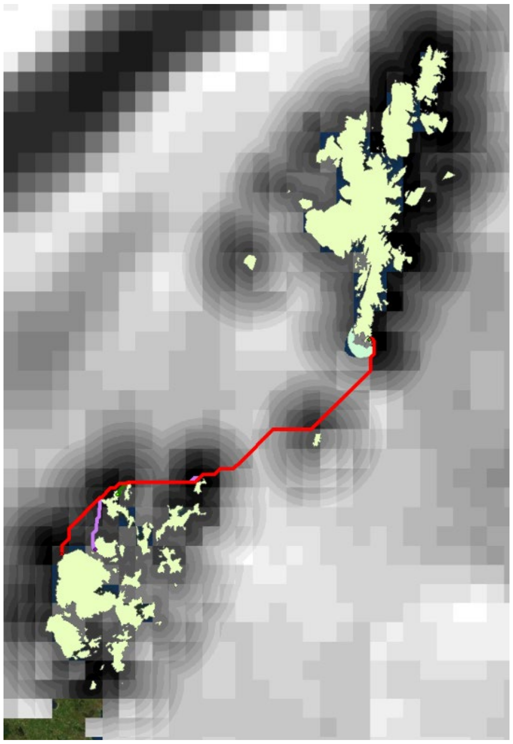


Figure 7.16: All Things Equal weighted cost surface. All friction surfaces were assigned 33.33% influence on the model.

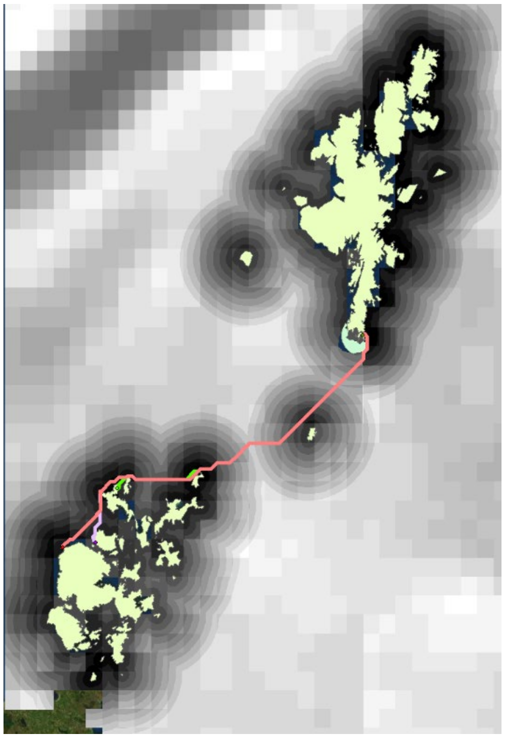


Figure 7.17: Cultural Knowledge weighted cost surface. Euclidian Distance friction surface was assigned 50% and the Eastward Northward Current Velocity friction surfaces were each assigned 25%.

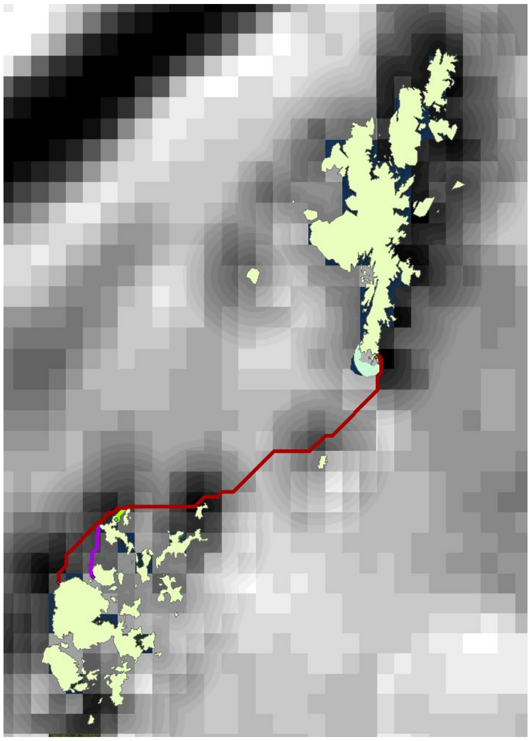


Figure 7.18: Seamanship weighted cost surface, the Eastward Northward Current Velocity friction surfaces were each assigned 40% while Euclidean Distance was assigned 20%.

'Cultural Knowledge'; in this cost surface distance from the coast was weighted at 50% while both current directional speed layers, North and East, were assigned 25%, respectively. This was done to account for the navigational aspects of coastal sailing (i.e., the use of waypoints or prominent coastal features along a route to maintain a proper course). This put greater weight on the cost distance away from land than to the velocity and directionality of the currents. The final calculation considered the current directionality and velocity to be of greater importance. This weighted cost surface was called ‘Seamanship’, and it placed 40% on the eastward and northward current friction surfaces and only 20% on the Euclidean Distance surface. This was done to model a greater reliance on ocean current speed and directionality, while still considering the navigational benefits of sailing within sight of land. These combined weighted surfaces can be seen in Figures 7.16, 7.17, and 7.18.

Cost Distance, Cost Direction, and Cost Path

These weighted raster surfaces were then used as inputs for the Cost Distance tool alongside the selected source data, which was the point feature classes created to represent three Viking Age settlements in the Orkney islands. As mentioned above, the origin points for the sailing routes included the Brough of Brisay, which could also conceivably serve as a shared point for the nearby archaeological site of Buckquoy on Mainland, the Quoygrew settlement on Westray, and the Viking Age Hall recently discovered at the Skaill Farmstead on the Isle of Rousay (UHIAI, 2019). Each of these points were to the Cost Distance tool inputs along with the ‘All-ThingsEqual’ weighted cost surface raster; a backlink raster was generated indicating the directions available to the ship from its source location. The accumulated travel costs for each cell back to the source are also calculated. This process was repeated for each weighted surface at each of the source locations for a total of 18 outputs. These outputs included: nine weighted cost distance raster files, and nine associated back linked weighted direction raster files.

Once the cost distance and cost direction backlink raster files were created, they could be used as inputs in the next step of the analysis as well as the ‘Destination’ point feature class, which was placed at the head of Grutness Voe. With these inputs the Least Cost Path for each of the nine routes could be run. An additional step was taken to rerun the final Maritime Least Cost

Path analyses using the Cost Path as Polyline tool. This allowed the output to be a polyline rather than a raster which allowed for better legibility when it came time to visualize all nine potential routes over such a large distance. (Compare Figure 7.19 with Figure 7.20).

Figure 7.19: Raster Maritime Least Cost Path route outputs from the Brough of Birsay to Jarlshof. Note the lack of clarity in the displayed path.

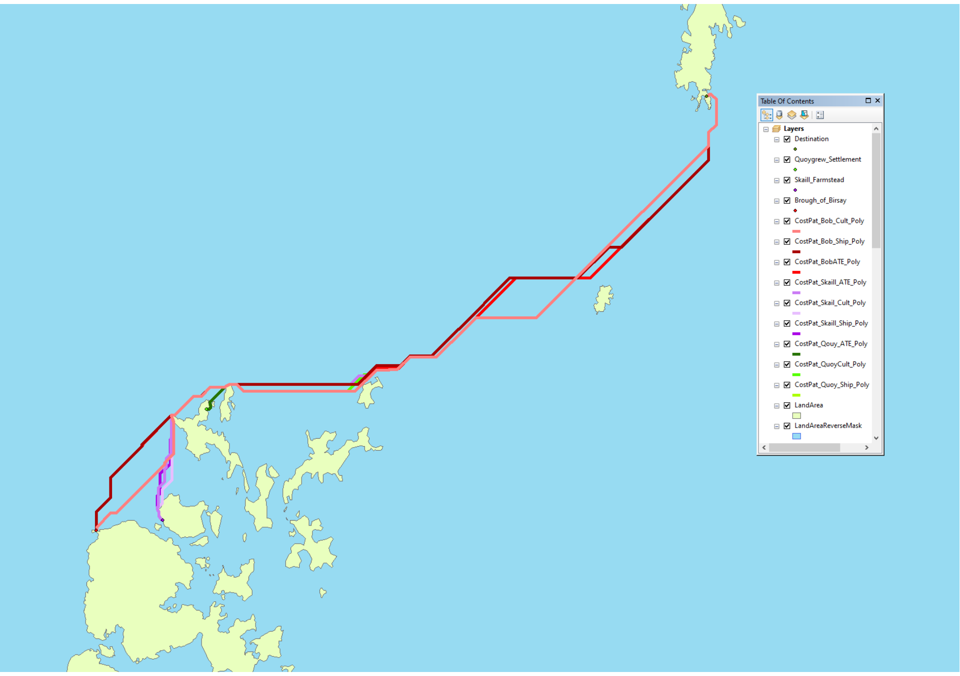


Figure 7.20: Polyline Maritime Least Cost Path route outputs for all weightings and all source locations.

Fuzzy Cumulative Viewshed Analysis

Sea Surface Height Adjustment

The estimation of past sea height was possible with the help of Marisa Borreggine, Evelyn Powell and their colleagues in the Mitrovica Group, Department of Earth and Planetary Sciences at Harvard University who provided local sea height estimation data for the period under investigation. Unlike typical paleoenvironmental models, designed to estimate past sea height in which sea levels in the past are assumed to have varied overtime in accordance with a "eustatic" value, that was averaged on a global scale. Borreggine et al., (2022), challenge this traditional methodology, arguing that significant changes in past sea height have, and continue to take place

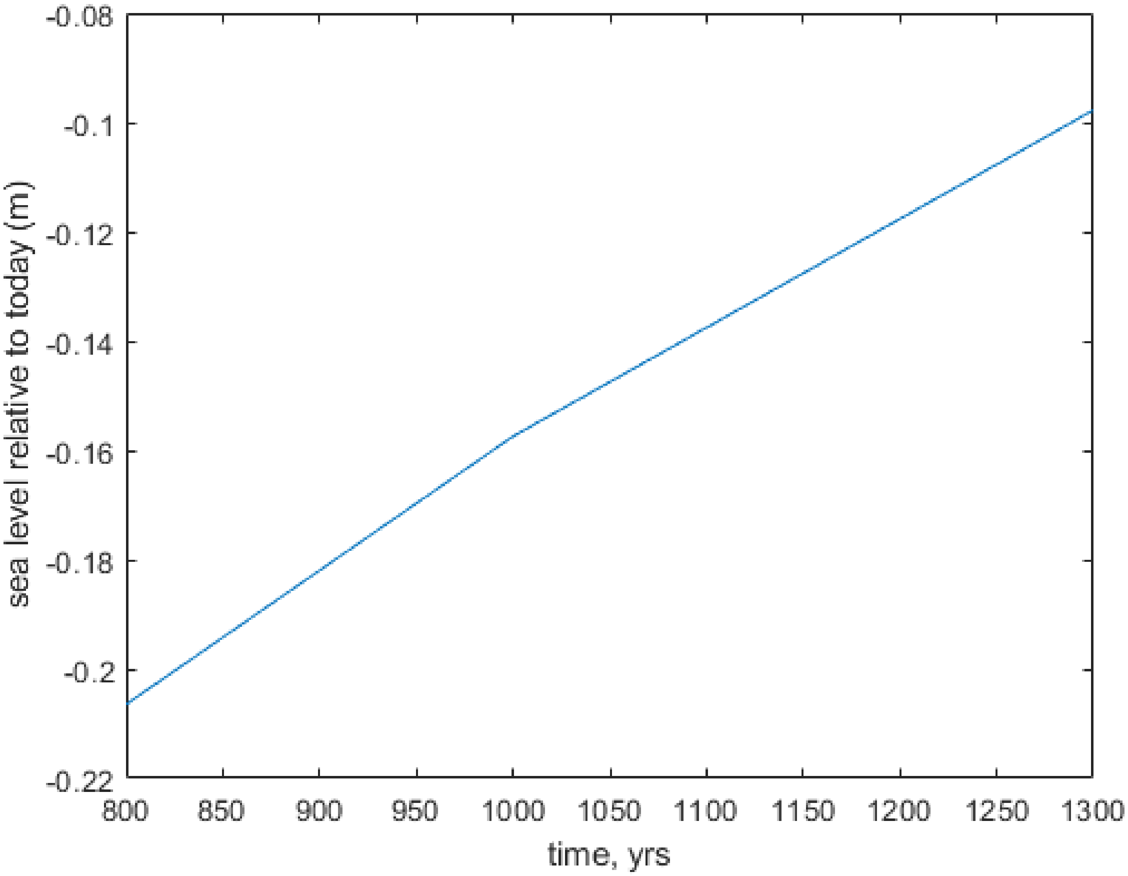


Table 7.1: Graph of past sea level changes from 800-1300 CE in meters as they relate to modern sea surface height for the area around south Mainland Shetland.

regionally due to isostatic rebound. It is for this reason that their help was enlisted to establish a specific local sea height estimate for the area around Shetland.

Based on the sea surface model developed by Berregione et al., (2022) the difference in sea level height from around 800 CE when compared with modern day levels was 0.20646m (just over 8in) below the current sea level, (See Tables 7.1 and 7.2). The sea surface height rose consistently over the period of interest so that by 1300 CE the sea surface height was 0.09775m below the present-day surface height (just under 4 inches). The total change over this period was 0.10871m (≈ 4.28 in). These changes can be seen in the graph above and are also listed in table below. The relative change in sea height is not significant when we consider not only the dynamic the nature of the ocean surface, which can be variably above or below relative sea surface height as surface conditions are impacted by ocean currents, tides, and weather conditions, but also natural variability in the height of a potential observer. It was decided that the past sea height would not be adjusted per period, but instead be set at 0.1524m (6 inches) under the current sea height for all periods under investigation.

Sea Surface Height Change Over Time Relative to Modern Sea Surface Height

time (CE)	time (kyr)	RSL (past sea level - present sea level)
800	-1.2	-0.20646
900	-1.1	-0.18194
1000	-1	-0.15743
1100	-0.9	-0.13754
1200	-0.8	-0.11764
1300	-0.7	-0.09775

Table 7.2: Tabulated representation of past sea level changes from 800-1300 CE as they relate to modern sea surface height for the area around south Mainland Shetland.

This was done by importing a number of files from the previous analyses: the ‘LandArea’ and ‘LandAreaReverseMask’ polygon feature classes that were created during the MLCPA and the UrbanDEM raster files for each settlement phase (I-V) that were developed during the Settlement-based CVA. Extract by Mask was used to extract the extent of the LandArea polygon from the UrbanDEMs for each phase of occupation. This allowed for the separation of the land values from the non-land values captured in the LiDAR data from the Scottish Remote Sensing Portal (https://remotesensingdata.gov.scot/), (SG & JNCC, 2021).

The non-land values depicted in the UrbanDEM files can be seen as snap shots of the modern sea surface height. These values were extracted using the same masking method to determine the mean surface value. These 1m raster values ranged from 7.12m to –1.691m. The Spatial Analyst Zonal Statistics tool was used to find the mean of height value of the non-land raster or sea surface data. The mean value of sea surface data was determined to be –0.573457 which was taken to represent the modern sea surface height. Raster Calculator was used to subtract 0.1524m (6 inches) from that value. This places the sea height at just above the anticipated sea height for 1000 CE, however this method creates a singular flat surface, a method that does

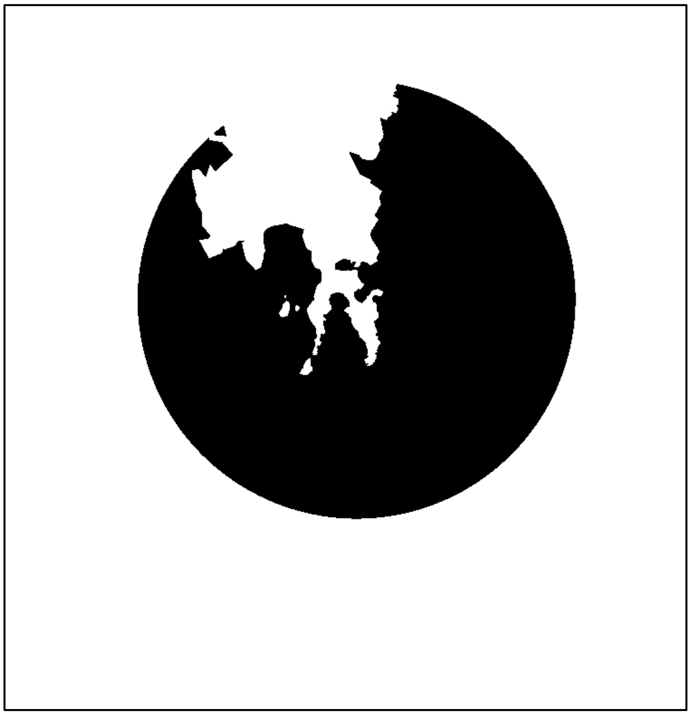


Figure 7.21: 32km diameter DEM of the calculated past sea height for the area around south Mainland Shetland. The scale of this was cropped prior to running the Diachronistic Fuzzy Cumulative Viewshed Analyses.

not reflect the dynamic variation in oceanic conditions which constantly impact sea height. Due to this, and the natural variability in individual observer height, this averaging of sea heights was seen as an acceptable compromise for this analysis. This height of -0.725857m was established relative to the DEM data and its association to the sea surface levels as they were recorded in that data prior to adjustment. The past sea surface height was estimated to be –0.725857m for the purposes of the analysis. (See Figure 7.21).

Analysis Extent

A new Z enabled polygon feature class was created which would serve as the maximum extent of the FCVA analysis; this circle was assigned the radius (r=16000m), to encompass the horizon point at which a ship with a 10m tall sail would, under ideal conditions, be visible from an observer on coast who was 1.7m tall. The equation used for this according to Young, (2003) is:

$$D_{BL} < 3.57\left(\sqrt{h_B} + \sqrt{h_L}\right)$$

Young (2003) states the radius of the Earth to be 6378 km and observer (h) in measured in meters, then the distance to the horizon is 3.57 km times the square root of the height of the eye, which for our purposes is 1.7m. However, if generalized refraction is accounted for, the distance to the horizon is about 3.86 km times the square root of the height in meters. The Z information from 'PastSeaHeight' (-0.725857m) was assigned as the maximum height of the polygon feature class that represented the extent of the FCVA. In order to use this polygon as the past sea surface extent of the analysis, it had to be converted into a raster using the Polygon to Raster Tool. The Urban DEMs (I-V) that had been extracted from the modern sea surface were then recombined with the past sea surface raster using the Mosaic to New Raster tool to create a continuous surface. That merged raster file now showed both the height of the past structures, and also the past sea surface height on one raster layer; it that would serve as the basis for the FCVA analysis.

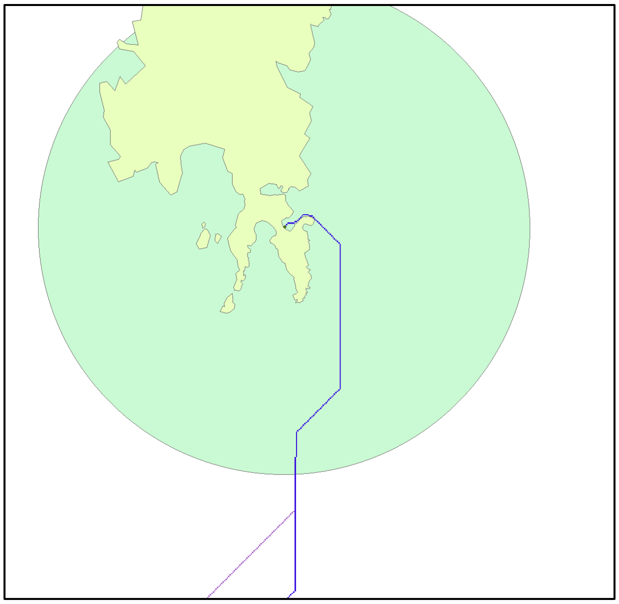


Figure 7.22: The 32km area where past sea height DEM was created is visible in pale green. The Maritime Least Cost Path routes all converge on a singular path within the boundaries of that area.

Euclidean Distance Path

It was determined that all the potential Least Cost Paths regardless of weighting conformed to the same route within the extent of the FCVA analysis (See Figure 7.22). The next step was to import one of the cost path polylines so that it could provide the route the ship would travel on the final leg of its journey towards the settlement. This polyline was clipped to the extent of the FCVA analysis. A single point feature class was created at the start of that polyline (i.e., the edge of the analysis) to serve as an observer on the ship entering the study area. A Euclidean Distance tool was used on that point to establish the distance from the ship to the destination point in Grutness Voe. The processing extent for the Euclidean Distance tool was set to be the same as the clipped sailing route polyline. Once the Euclidean Distance tool was run, the results were reclassified to reflect distance bands along the sailing route spaced at 1km intervals, where observer points would later be placed. The edges of the distance bands serve place markers for observer points as if the ship were moving through space along its selected route (See figure 7.23).

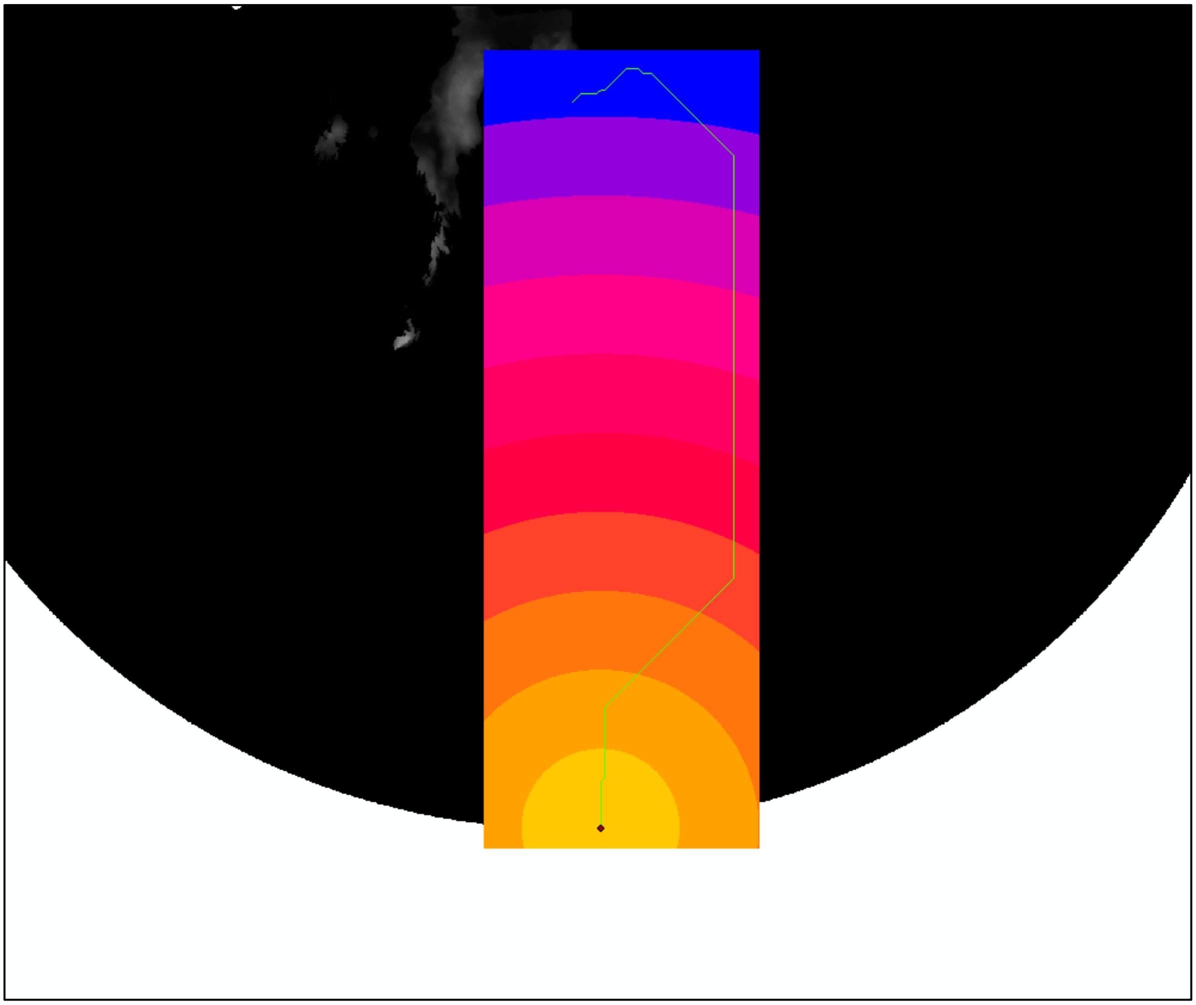


Figure 7.23: Reclassified Euclidean Distance Raster in which each band represents the movement of the Knarr 1km northward, towards the destination -the Norse settlement at Jarlshof. The outer edge of each band was used to place each observer point 1km apart along the sailing route with the exception of the origin and the destination points.

View From the Ship

Once the ideal sailing route is established to represent the perspective of the sailing vessel as it moves towards Jarlshof along the coastline. A Fuzzy Cumulative Visibility Analysis, (FCVA) was implemented. FCVA was developed by (Lock et al. 2014) in order to model pedestrian motion through the landscape under study by treating the analysis as if the actor was moving from cell to cell; calculating visibility in all directions as they went. As mentioned earlier in the section on wayfaring and cognitive mapping, the underlying assumption being made here is that seafarers would have intentionality behind their selected path of movement, as well as, the decisions that were used to justify, or were related to, those movements. If the number of Old Norse place names in the Shetland Islands is any indication, it is logical to assume that seafarers would identify potential way points or prominent landscape features along the prescribed sailing route and use them as mnemonic markers for return journeys (Fellows-Jensen, 2012; Gammeltoft, 2010).

The idea of topographic prominence, put forward by Llobera's (2001), suggests that as an actor moves past prominent points on the landscape, and their perspective changes, those prominent points are more likely to be seen for extended periods, while less prominent points become obscured or are lost from view (Higuchi, 1983). It is intended that this process will be modeled using the FCVA, so that the gradual change in visibility will be accounted for by the advancement of the observer points northward along the sailing route.

As with the settlement based CVA, the observer points were created using new point feature classes for each of the 17 bands and an additional two were also created to mark the source and destination points of the route, for a total of 19 observer points. This feature class was assigned an additional attributes field to indicate which band, or specific location it belonged to. Another field was created: OFFSETA (observer height), which was kept consistent with the settlement observer height of 1.7m. Another field was added to the observer points attribute table: RADIUS 2, which was also kept consistent with the range used in the settlement based CVA analysis (4828.03m -3 miles-). The same observer points were used for each of the four subsequent analyses to determine whether the visibility of the settlement from the water changed over the course of the settlement's occupation. In order to save on processing time, the original

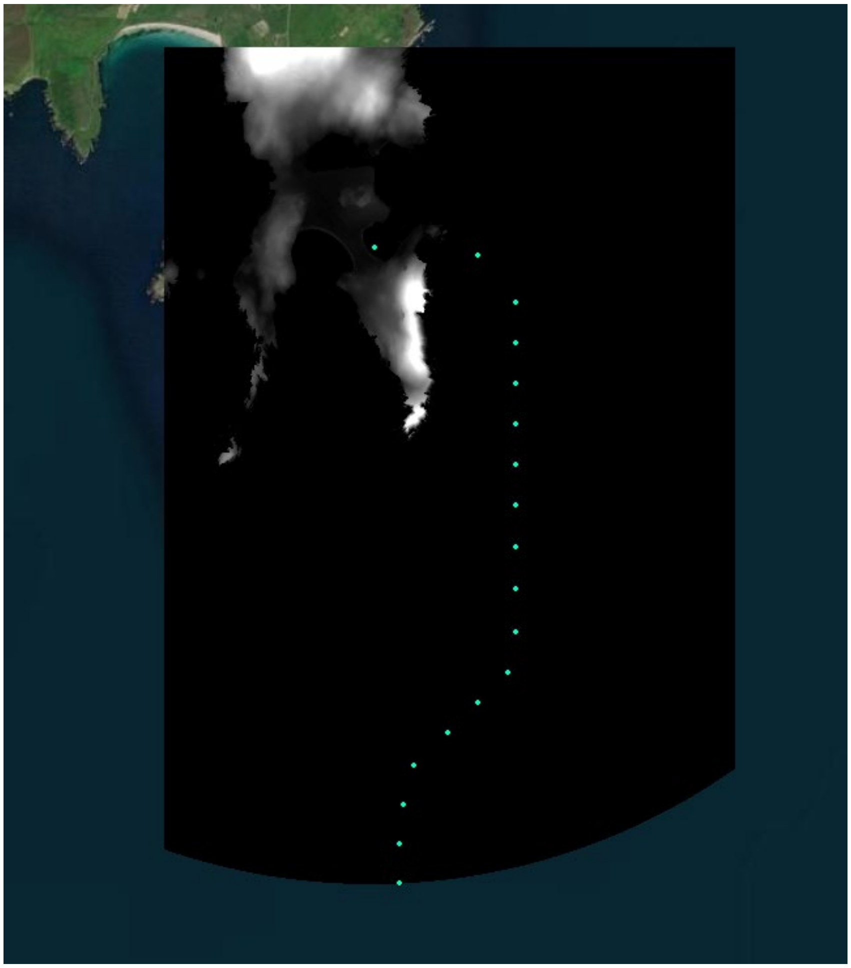
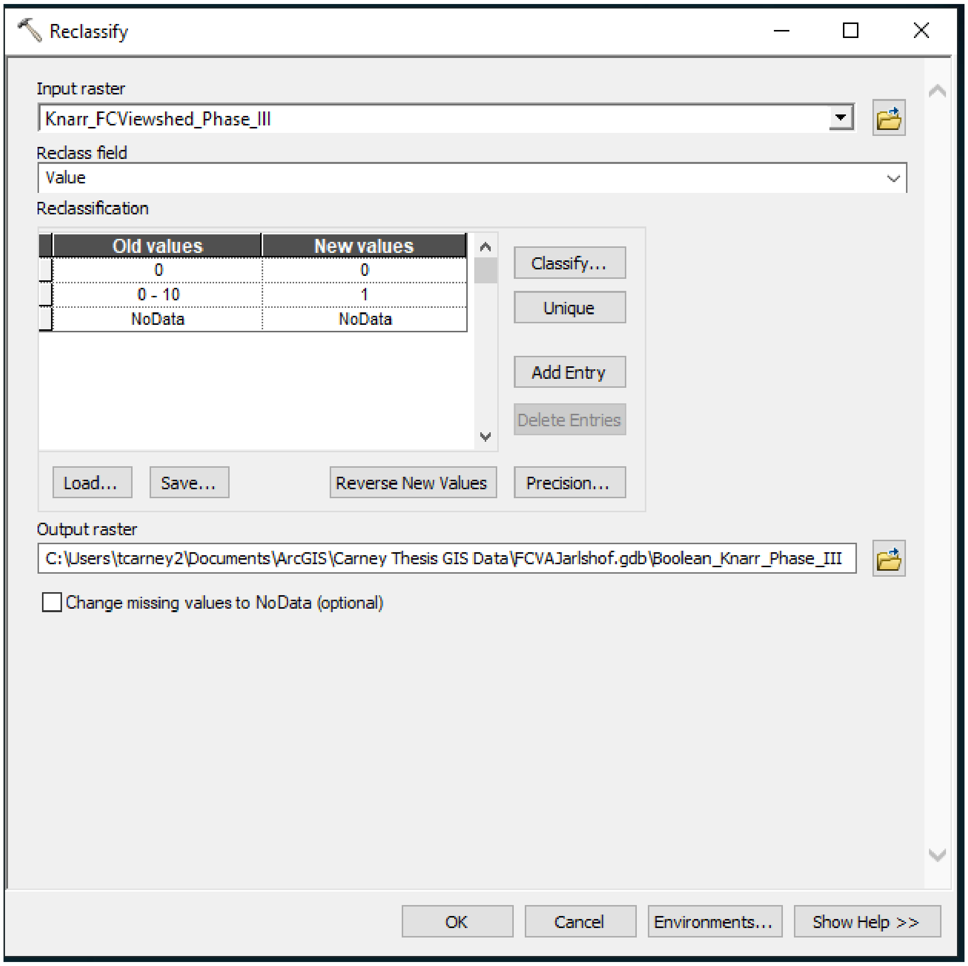


Figure 7.24: The final extent of the merged land and sea DEMs used for the five FCVAs. The Observer Points can be seen in light blue leading from the edge of the study area up to the settlement.

32km diameter study area for this analysis was reduced to an area that more closely bounded the viewshed extents, (compare Figure 7.22 with Figure 7.24). The viewshed was then run using these observation points and the combined UrbanDEM and past sea height raster layer.

As with the Cumulative Viewshed Analysis conducted on the settlement, once the analyses were complete, their data fields were reclassified using the Reclassify too in order to convert them into Boolean Rasters. By assigning the viewsheds binary values [0,1] what is and is not visible along the route traveled by the ship can be evaluated for each phase. As with the other Viewshed analyses a ‘Percent_vis’ field was added to the output raster using field calculator to assign the field the SUM value of the Count field as discussed above (see Figure 7.25). With this done, each of the five Fuzzy Cumulative Viewsheds, representing travel during each phase of occupation examined in this research, could have their percent visibility compared with one another.



Input raster: Knarr_FCViewshed_Phase_III

Reclass field: Value

Reclassification

Old values	New values
0	0
0 - 10	1
NoData	NoData

Output raster: C:\Users\tcarney2\Documents\ArcGIS\Carney Thesis GIS Data\FCVAJarlshof.gdb\Boolean_Knarr_Phase_III

☐ Change missing values to NoData (optional)

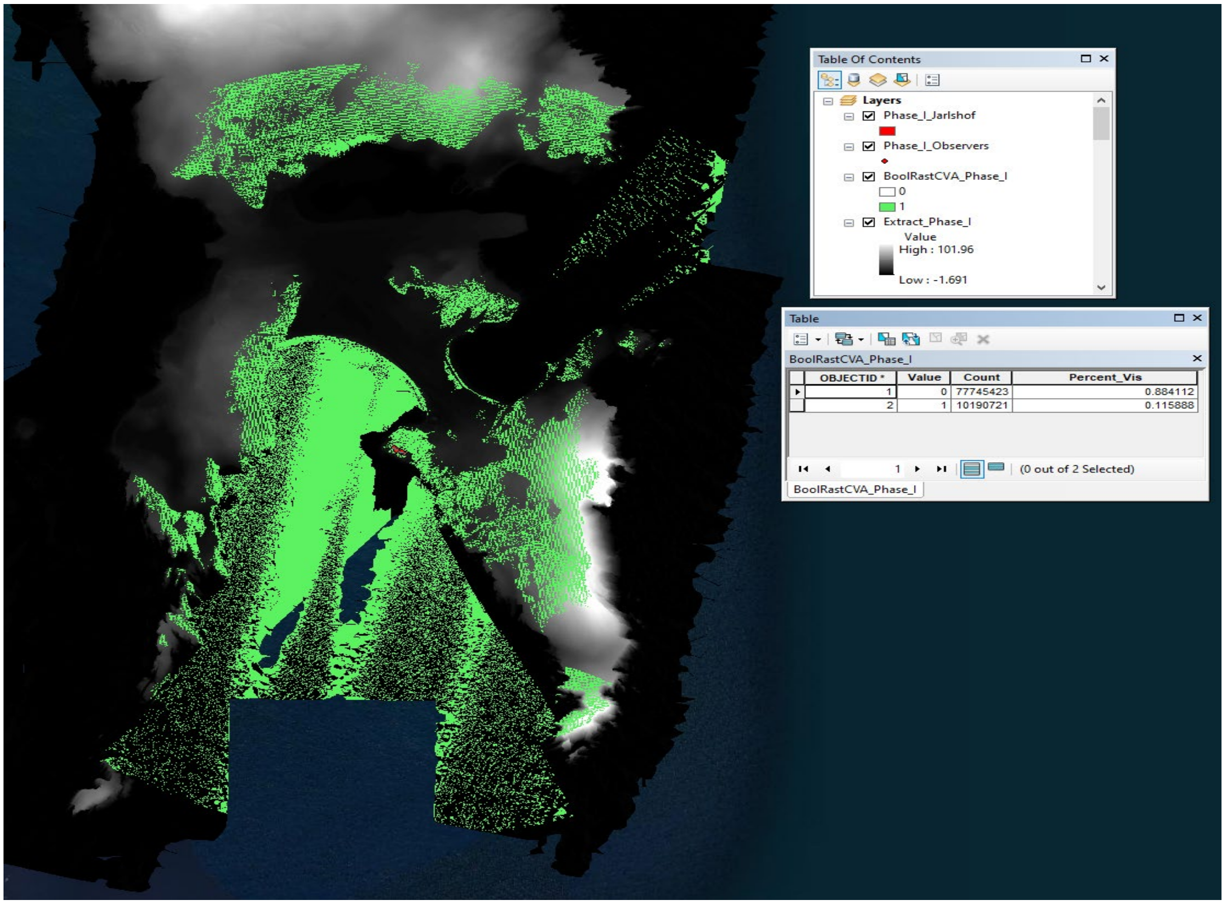
Figure 7.25 Reclassifying the Phase III FCVA viewshed into a Boolean Raster.

CHAPTER 8: RESULTS

The results of the CVA, MLCPA, and FCVA are detailed in this section. All values provided have been rounded to the nearest hundredth. Distance values have been listed in both meters and kilometers.

Settlement-Based Cumulative Viewshed Analyses

Once the results of the CVA were converted into a Boolean Raster, the percent visibility of the analysis was determined. 88.41 percent of the cells were not visible from the seven observer points, while 11.59 percent of the cells were visible. (See Figure 8.1)



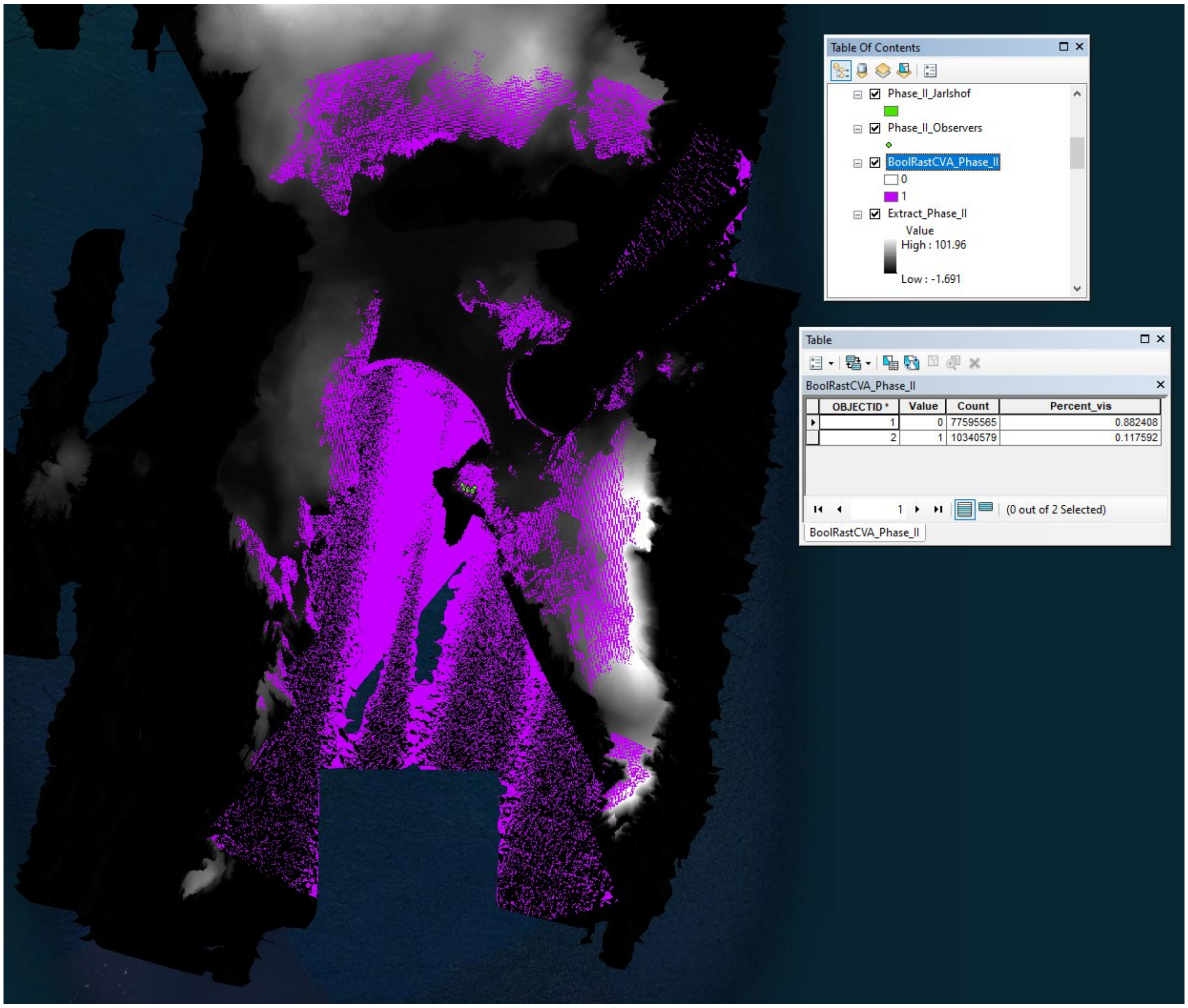
BoolRastCVA_Phase_I

OBJECTID *	Value	Count	Percent_Vis
1	0	77745423	0.884112
2	1	10190721	0.115888

(0 out of 2 Selected)

BoolRastCVA_Phase_I

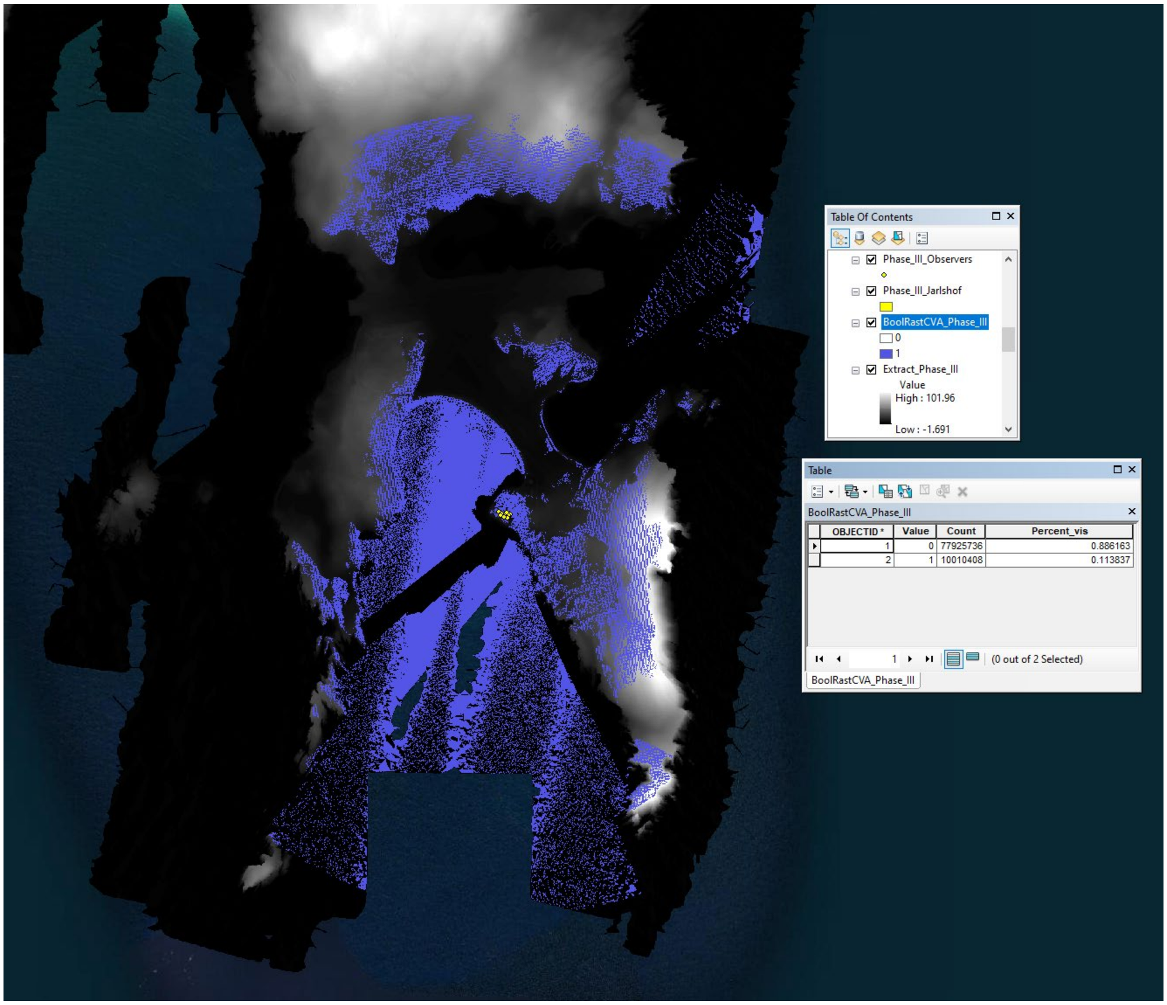
The results for the phase II CVA was based on 11 observation points. From those points, 88.24 percent of the cells were not visible, and 11.76 percent of the cells were visible, (See Figure 8.2).



OBJECTID *	Value	Count	Percent_vis
1	0	77595565	0.882408
2	1	10340579	0.117592

Figure 8.2: Settlement Cumulative Viewshed Phase II. The purple represents the visible surfaces both on land and at sea.

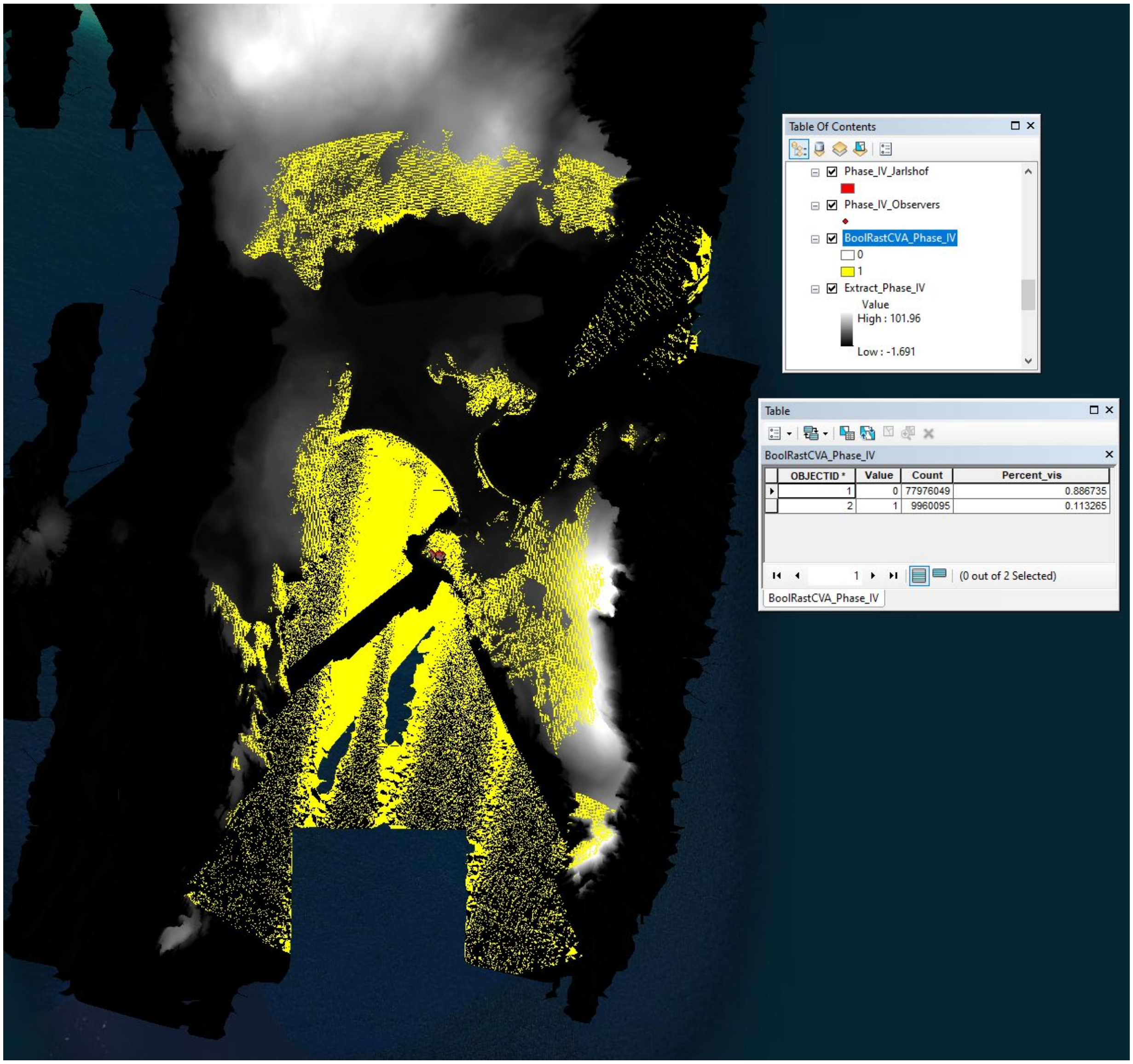
The CVA for the third phase of occupation (Phase III) was based on 16 observation points and resulted in 88.62 percent of the cells being not visible, and 11.38 percent being visible, (See Figure 8.3).



OBJECTID *	Value	Count	Percent_vis
1	0	77925736	0.886163
2	1	10010408	0.113837

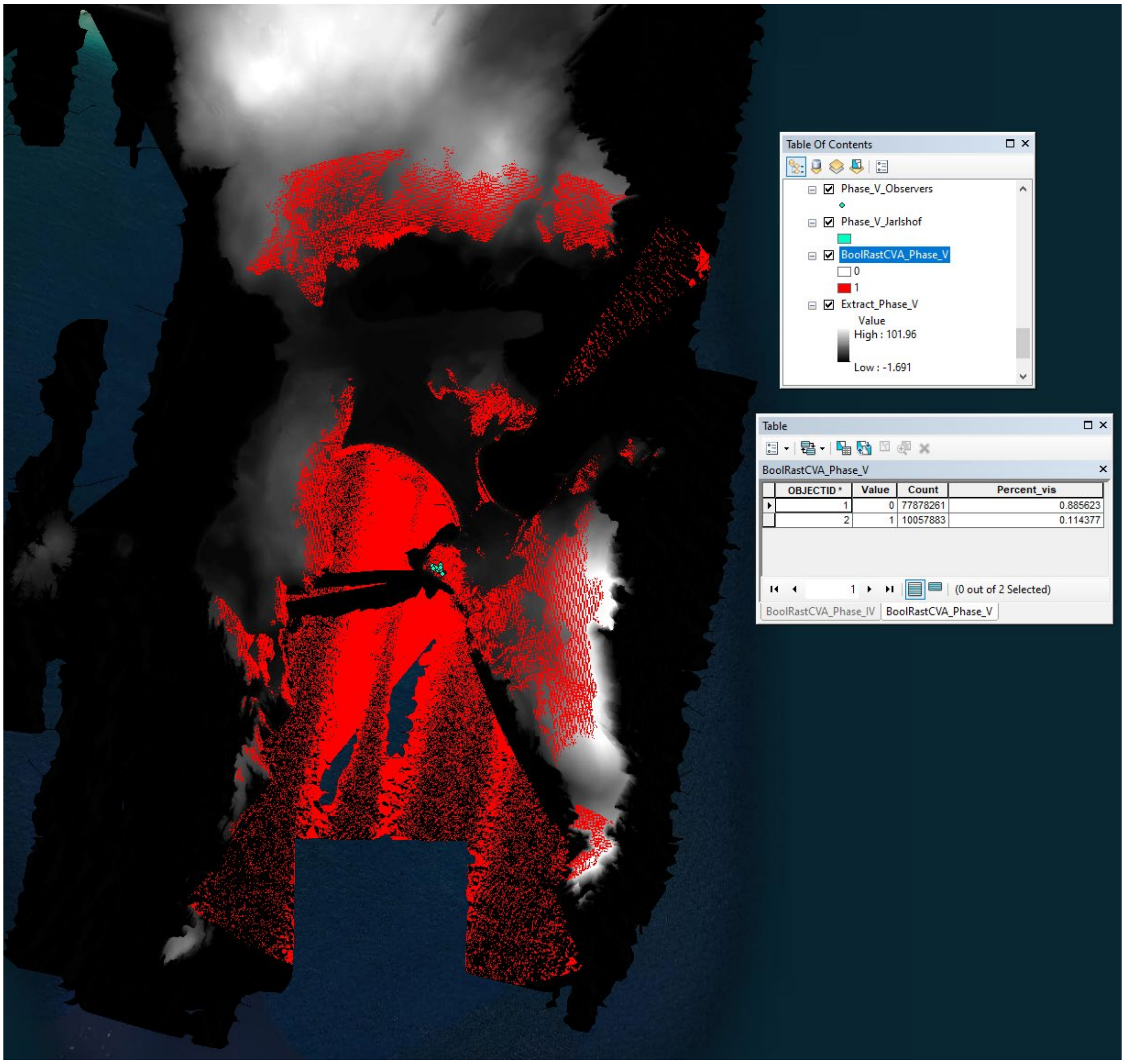
Figure 8.3: Settlement Cumulative Viewshed Phase III. The blue represents the visible surfaces both on land and at sea.

The fourth phase's (Phase IV) CVA considered the combined viewsheds of 18 observer points. The results of Phase IV's CVA was 88.67 percent of cells were not visible and 11.33 percent of cells were visible, (See Figure 8.4)



OBJECTID *	Value	Count	Percent_vis
1	0	77976049	0.886735
2	1	9960095	0.113265

The final settlement CVA was conducted on Phase V and its 14 observer points. The results of this were as follows: 88.56 percent of cells were not visible while 11.44 percent of cells were visible, (See Figure 8.5)



OBJECTID *	Value	Count	Percent_vis
1	0	77878261	0.885623
2	1	10057883	0.114377

Figure 8.5 Settlement Cumulative Viewshed Phase V. The red represents the visible surfaces both on land and at sea.

Table 8.1 displays the results of the CVA in terms of the percent visibility for each Phase of occupation examined in this research. When considering the results present in Table 8.1, it is the changes in the percentage across phases was examined rather than the percentages of visible and not visible cells for each phase of occupation. This will be elaborated on further below.

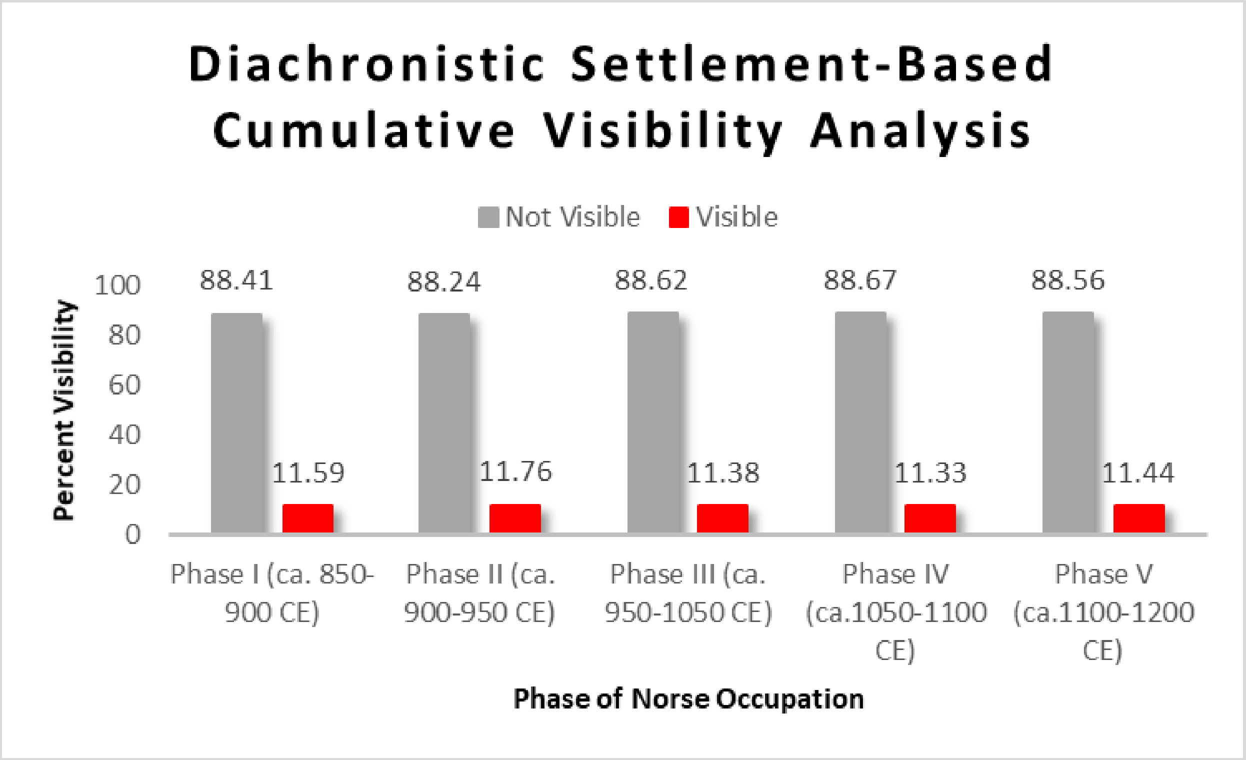


Table 8.1: The above graph displays the percent visibility for each of the five phases of occupation at Jarlshof that were investigated in this research.

Maritime Least Coast Path Mobility Analysis

All Things Equal

When considering the routes from each of the source locations in the Orkney Islands, using the All-Things Equal weighted cost surface the following results were recorded: for the Brough of Birsay the cost path route's total evaluated cost was: 1,611,622.88. The total shape length was 322170.33m. For the sailing route coming from the Viking Age Hall at Skaill Farmstead, the total accumulated cost was 1,573,424.50. The total length of that route was 309826.63m. The total evaluated cost for the Quoygrew route was 1,343,012.38. The total length of this route was 255147.54m.

Figure 6.6 Maritime Least Cost Path routes evaluated using the All Things Equal weighted friction surface. The route from each settlement has a different color scheme. Green polylines represent routes between Quoygrew and Jarlshof while, orange represent the route from Skaill, and blue from the Brough of Birsay.

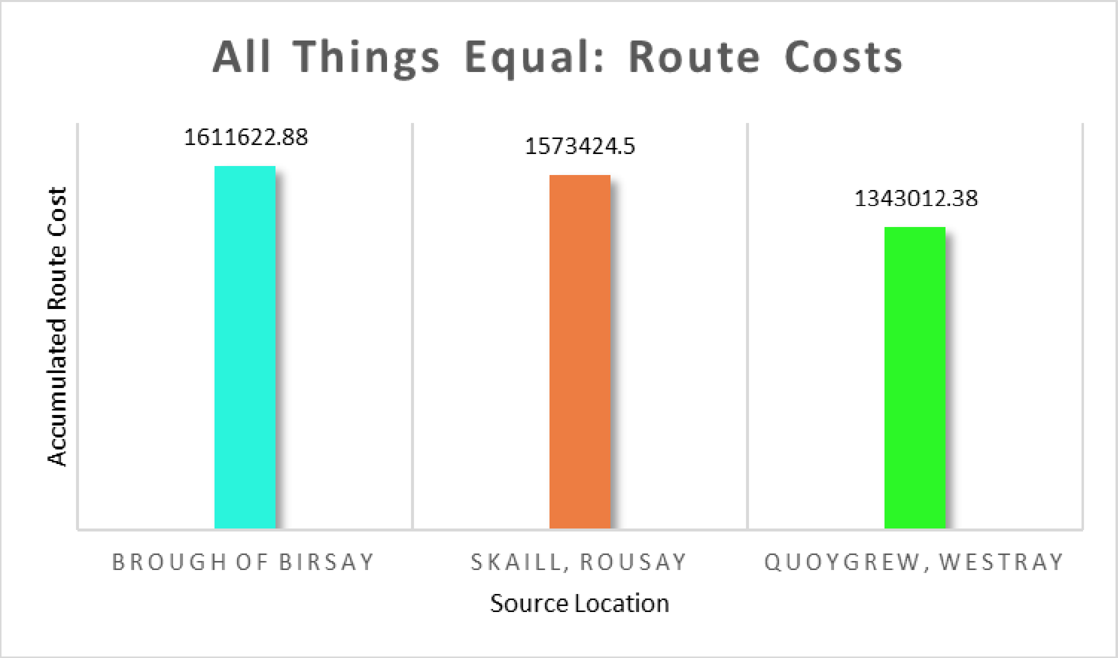


Table 8.2: This graph demonstrates the total costs incurred on each of the sailing routes when all of the friction surfaces were assigned equal weighting (33.33% for each of the three surfaces).

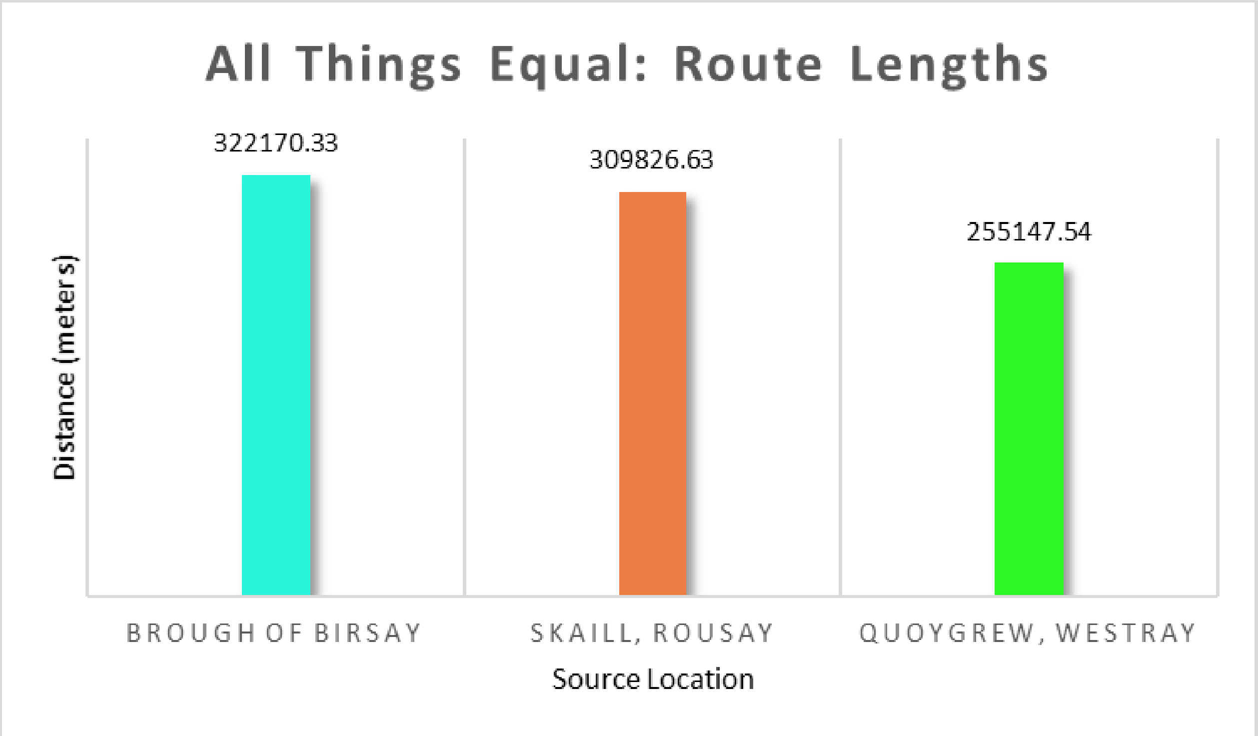


Table 8.3: This graph demonstrates the length of each of the sailing routes when each of the friction surfaces were assigned equal weighting. (33.33% for each of the three surfaces).

Cultural Knowledge: Euclidean Distance

The routes from each of the source locations in the Orkney Islands, using the Cultural Knowledge weighted surface had the following results: the sailing route that originated at the Brough of Birsay had a total accumulated cost of 1,487,173.75. The total length of that route was 323102.19m (approx. 323.1km). The total evaluated distance cost from the Viking Age Hall at Skaill Farmstead, totaled 1,441,309. The length of that route totaled 309575.23m (approx. 309.58km). The evaluated total distance cost from the Quoygrew settlement was determined to be 1,251,315.75, and the total length of that route was 254211.59m (approx. 254.42km).

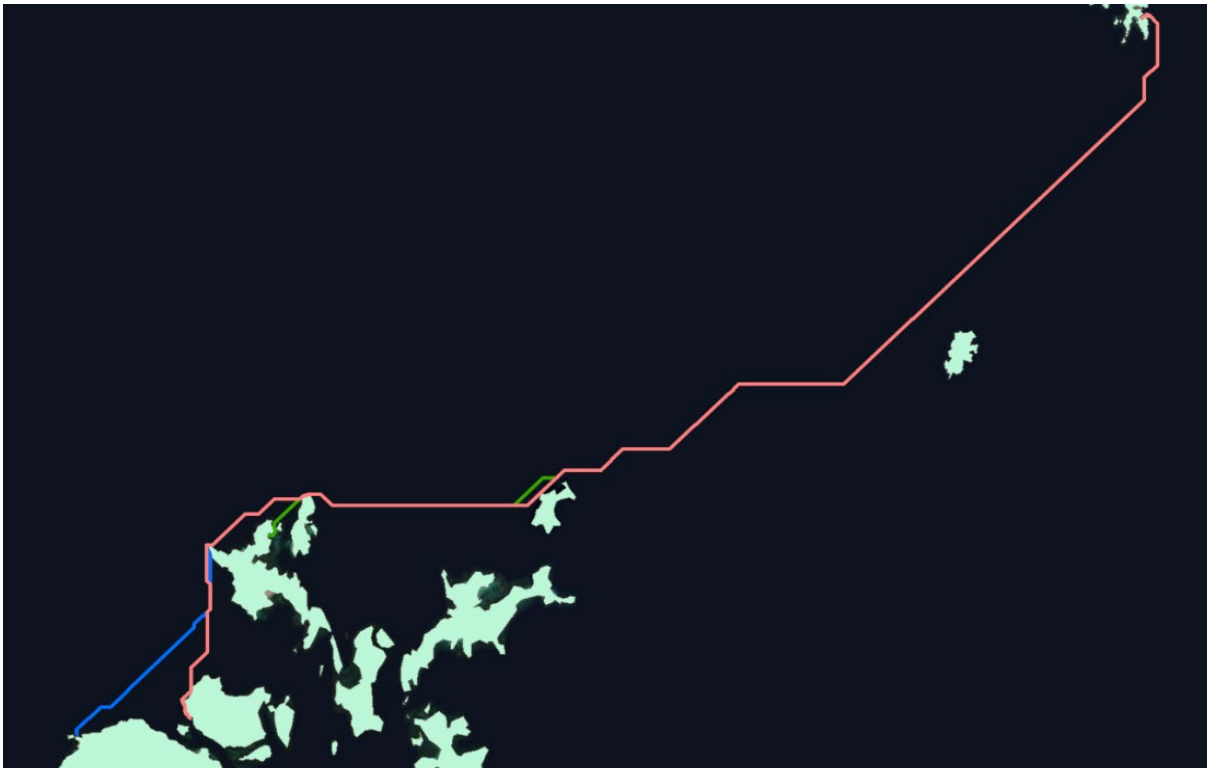


Table 8.7 Maritime Least Cost Path routes evaluated using the Cultural Knowledge weighted friction surface. The route from each settlement was assigned the same color scheme as discussed in Fig.8.6: Green polylines represent routes between Quoygrew and Jarlshof while, orange represent the route from Skaill, and blue from the Brough of Birsay.

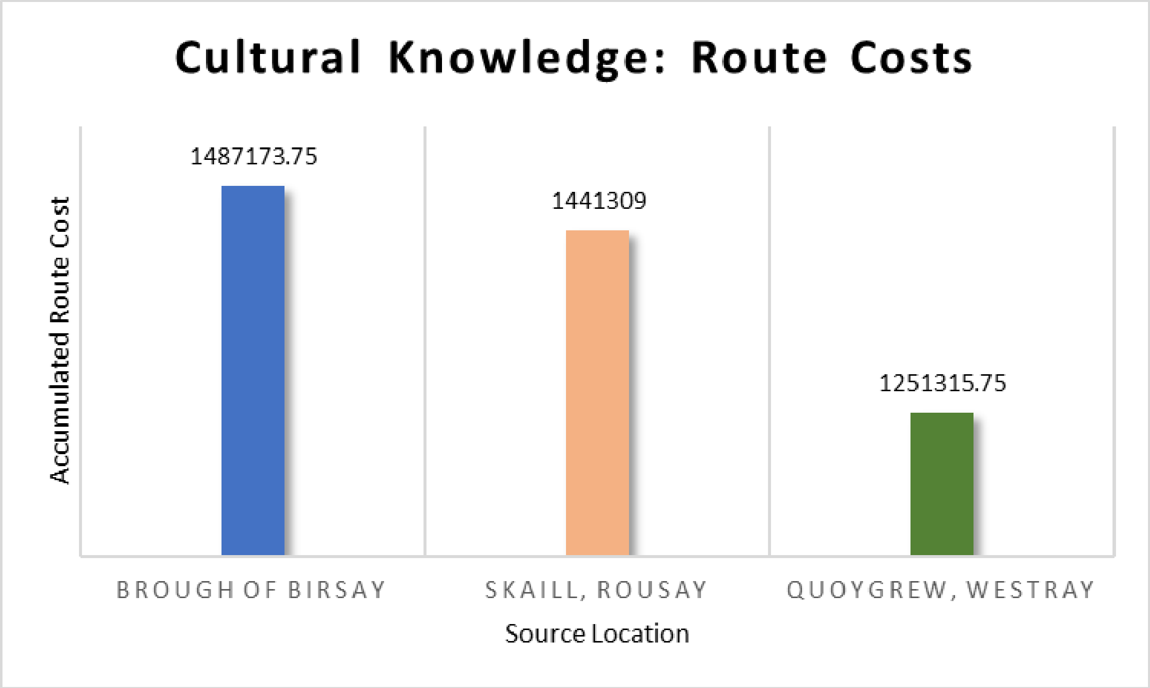


Table 8.4 This graph demonstrates the length of each of the sailing routes when the Euclidean Distance friction surface was assigned greater weight than the current velocity and directionality surfaces. (50% for Euclidean Distance and 25% for each of the current friction surfaces).

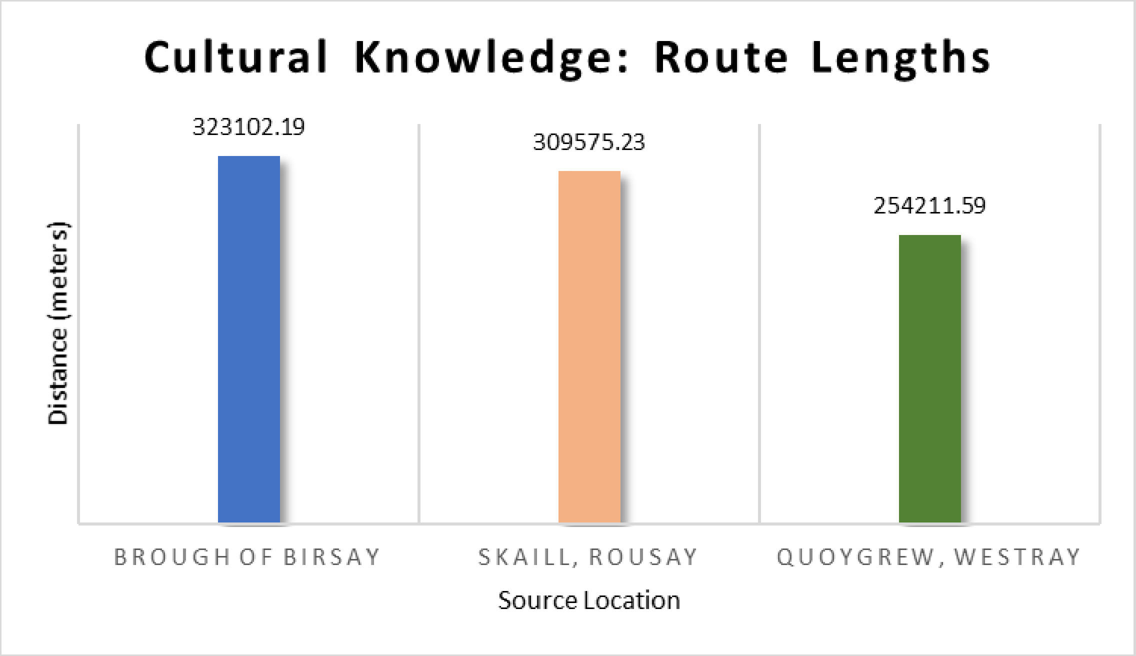


Table 8.5: This graph demonstrates the length of each of the sailing routes when the Euclidean Distance friction surface was assigned greater weight than the current velocity and directionality surfaces. (50% for Euclidean Distance and 25% for each of the current friction surfaces).

Seamanship: Current Velocity and Directionality

The results of the analysis for the Seamanship weighted cost surface were as follows: the total cost of the sailing route from the Brough of Birsay was 1,700,852.75. The length of that associated sailing route totaled 322170.33m (approx. 322.17km). The total accumulated cost value recorded for the route that originated from the Viking Age Hall at Skaill Farmstead, was 1,672,048.63 and the overall length of that route totaled 309826.63m (approx. 309.83km). The sailing route from Quoygrew settlement had a cost distance value of 1,410,102.75 and the total length of the route was 255147.54m (approx. 255.15km).

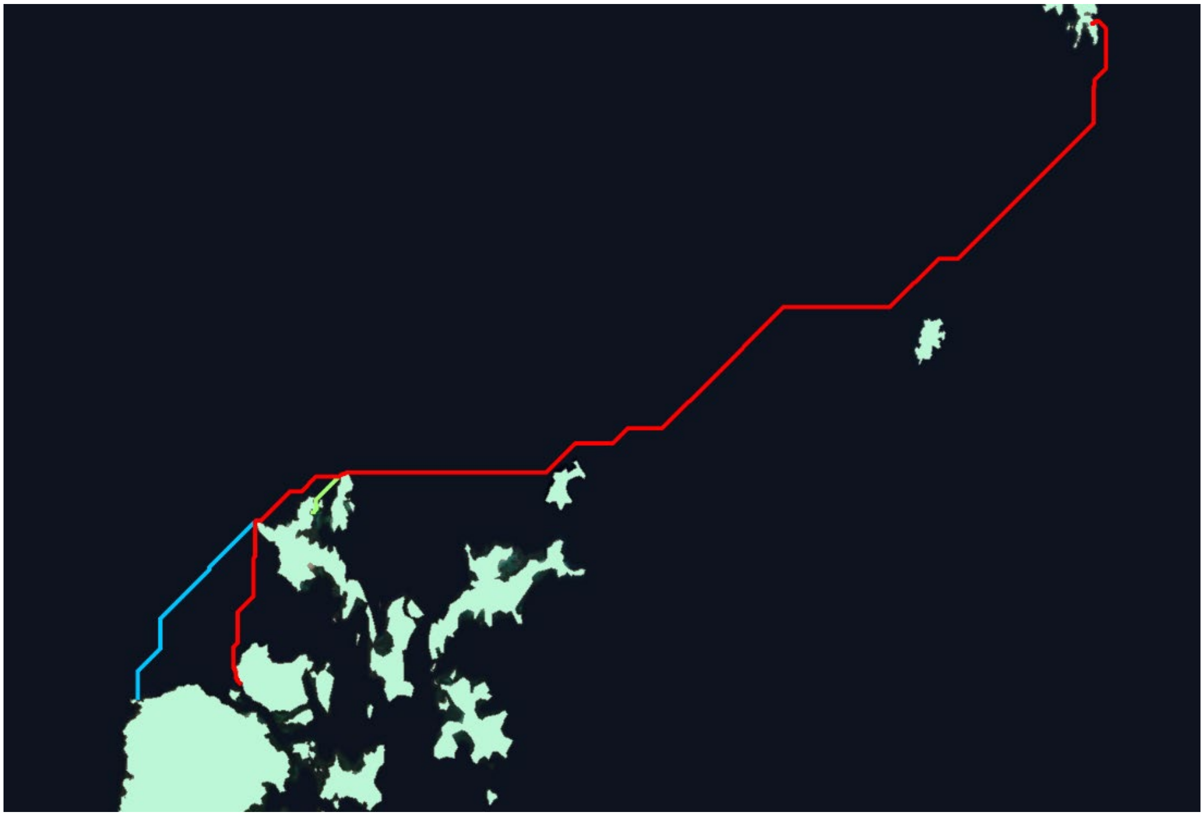


Figure 8.8 Maritime Least Cost Path routes evaluated using the Cultural Seamanship weighted friction surface. The route from ea ch settlement was assigned the same color scheme as discussed in Fig.8.6 and 8.7: Green polylines represent routes between Quoygrew and Jarlshof while, orange represent the route from Skaill, and blue from the Brough of Birsay.

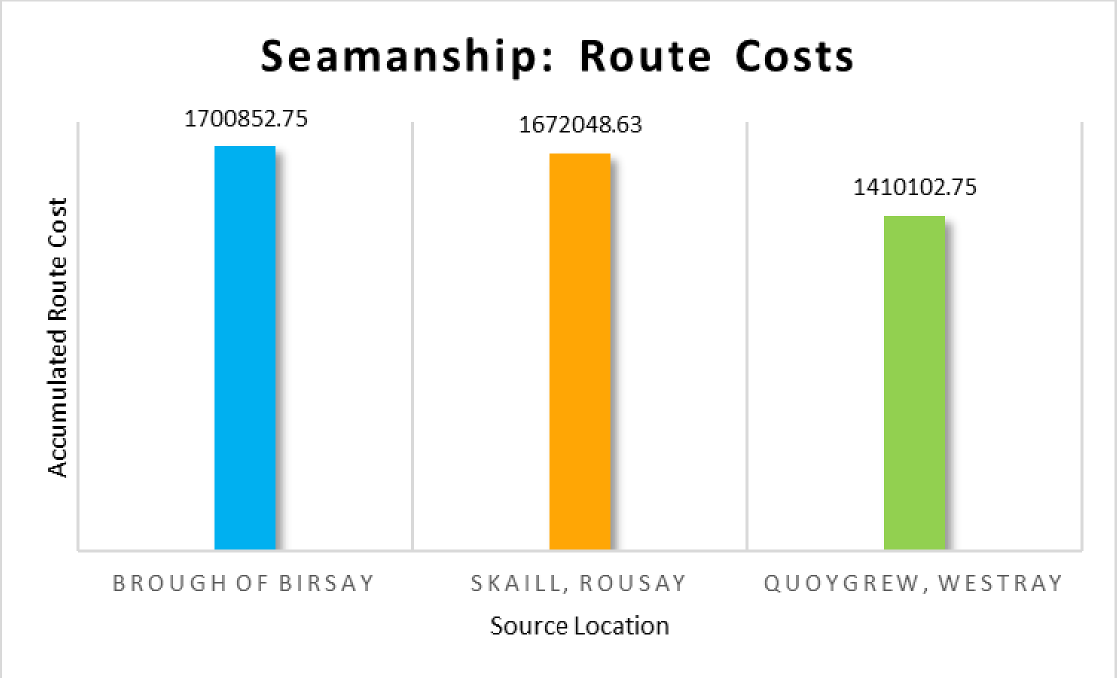


Table 8.6 This graph shows the estimated travel costs associated with each of the sailing routes when the current velocity and directionality friction surfaces were given greater weight than the Euclidean Distance surface. (40% for both the eastward and northward current friction surfaces and 20% for Euclidean Distance).

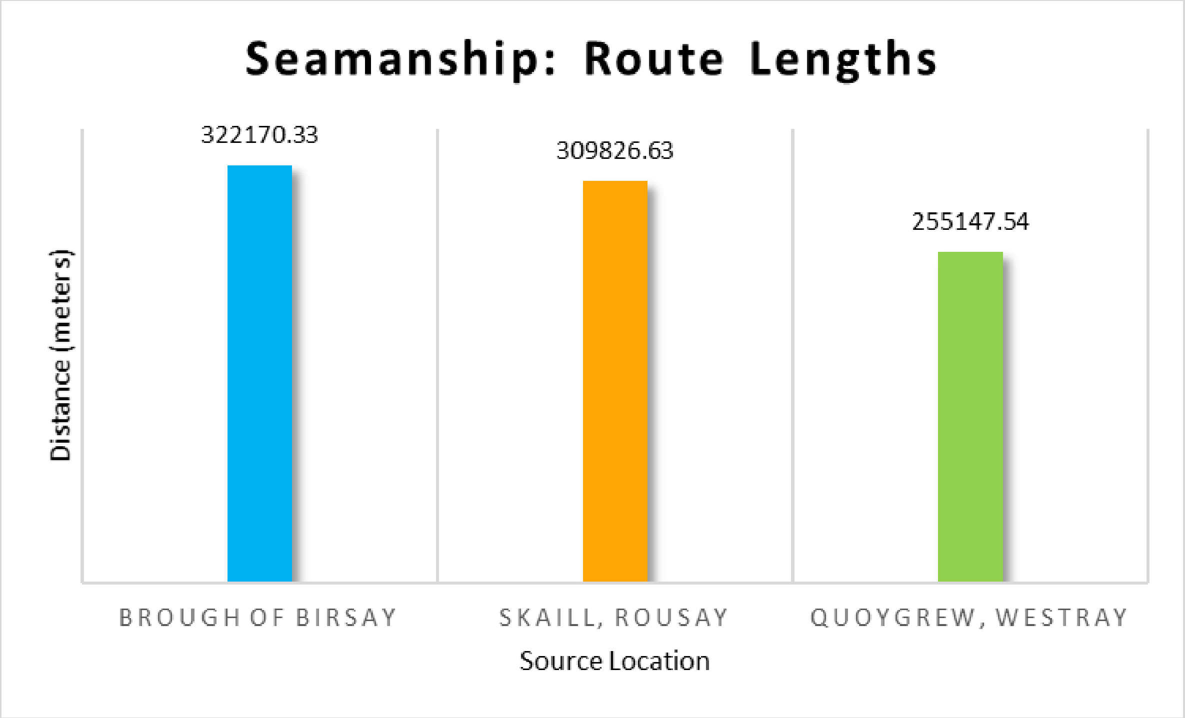


Table 8.7 This graph depicts the estimated length of each of the sailing routes when the current velocity and directionality friction surfaces were given greater weight than the Euclidean Distance surface. (40% for both the eastward and northward current friction surfaces and 20% for Euclidean Distance).

Source Route: Brough of Birsay

To frame these results another way, they have also been grouped based on their source locations rather than their weighted surfaces. The results from the Brough of Birsay for the three weighted surfaces are detailed here: The All-Things Equal weighted surface route from the Brough of Birsay had total accumulated cost of 1,611,622.88. The total route length was 322170.33m (approx. 322.17km). Using the Cultural Knowledge weighted surface from the Brough of Birsay resulted in a total distance cost of 1,487,173.75 and a total route length of 323102.19m (approx. 323.1km). The Seamanship weighted cost surface from the Brough of

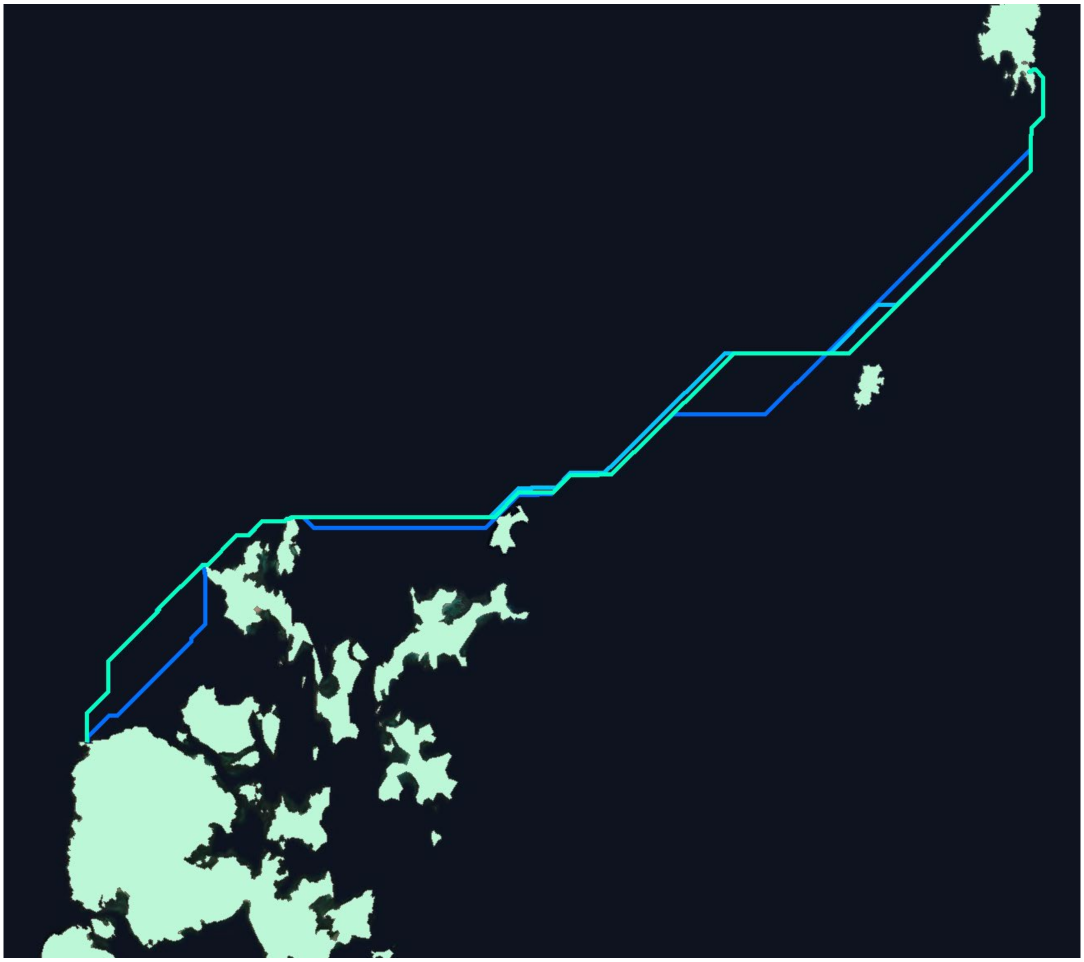


Figure 8.7 The Maritime Least Cost Path routes originating from their source location at the Brough of Birsay, Orkney and ending at Jarlshof, Mainland Shetland. Each of the different shaded blue polylines represents a different weighing of the route. Tables 8.8 and 8.9 indicate the relationship between the shades of blue and their associated weighted cost surface.

Birsay had an accumulated cost of 1,700,852.75 for the route and a length of 322170.33m (approx. 322.17km). The average route length, based on all three weighted cost surfaces, from the Brough of Birsay in Orkney to Jarlshof in Shetland was 322480.95m (approx. 322.48km). The mean cost value of those three potential routes was 1,599,883.13.

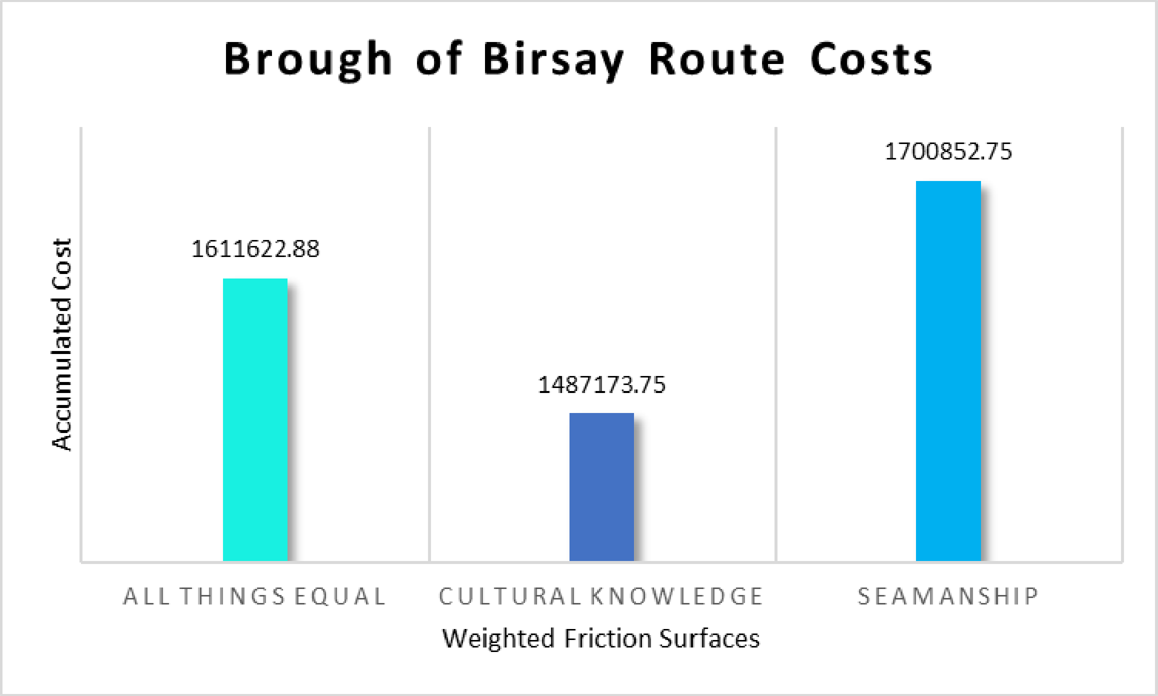


Table 8.8: This graph depicts the accumulated costs associated with each of the different weightings of the combined friction surfaces from the Brough of Birsay, Orkney to Jarlshof on Mainland Shetland.

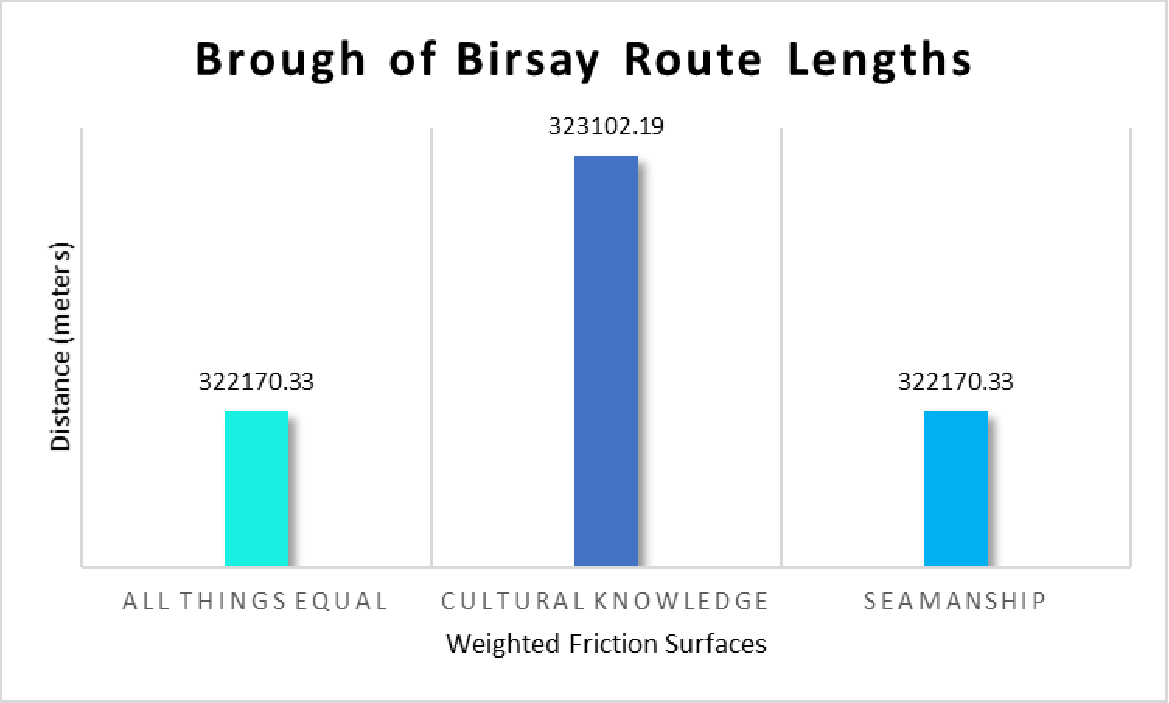


Table 8.9 This graph shows the length of the routes for each of the different weightings of the combined friction surfaces that originate at the Brough of Birsay, Orkney and end at Jarlshof on Mainland, Shetland.

Source Route: Viking Age Hall at Skaill

All of the results recorded from the route between the Viking Age Hall at Skaill and the settlement at Jarlshof have been recorded here as a group. The results from that All Things Equal cost surface from Skaill indicate that the accumulated cost was 1,573,424.50 and the length of that route was 309826.63m (approx. 309.83km). The total accumulated travel costs incurred on a vessel traveling from the Viking Age Hall at Skaill Farmstead to Jarlshof, when using the Cultural Knowledge weighted friction surface, totaled 1,441,309. The length of that same route totaled 309575.23m (approx. 309.58km). The accumulated travel cost recorded for the Viking

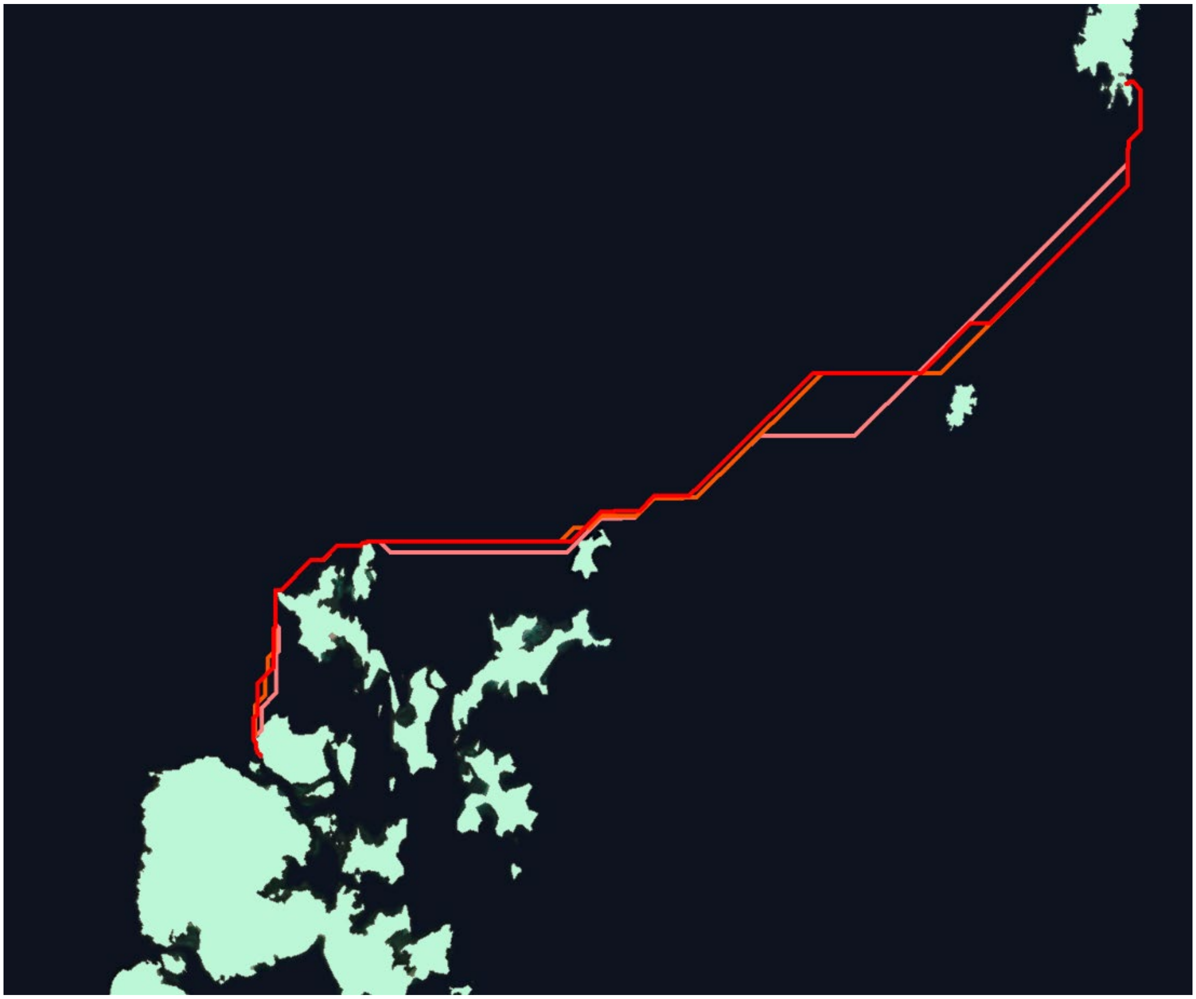


Figure 8.10: The Maritime Least Cost Path routes that originating from their source location at the Viking Age Hall at Skaill Farmstead, Rousay, Orkney and ending at Jarlshof, Mainland Shetland are depicted above. Each of the different shaded orange polylines represents a different weighing of the route. Tables 8.10 and 8.11 indicate the relationship between the shades of orange and their associated weighted cost surface.

Age Hall at Skaill using the Seamanship weighted surface was 1,672,048.63 and the overall length of that route totaled 309826.63m (approx. 309.83km). The mean route distance for all of the weighted cost surfaces from the Viking Age Hall at Skaill, on the Isle of Rousay to Jarlshof, Mainland Shetland, was 309742.83m (approx. 309.74km). The accumulated cost for this journey when all weighed cost path results were averaged was 1,562,260.71.

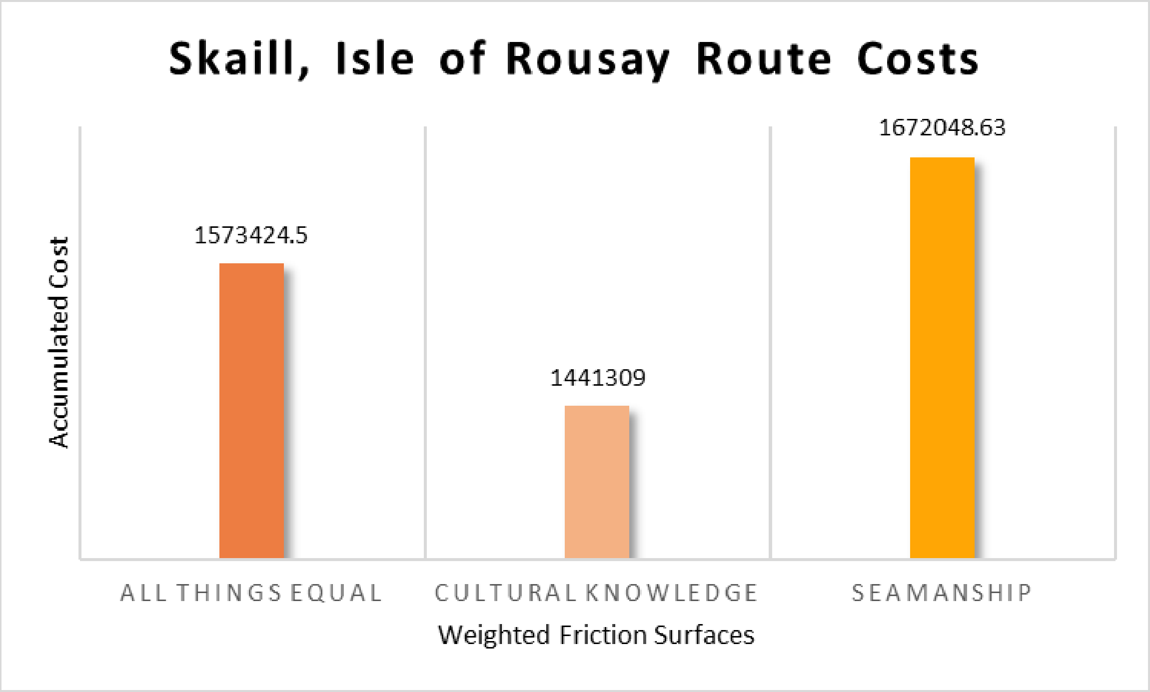


Table 8.10: This graph shows the accumulated cost values for each of the different weightings of the combined friction surfaces that start at Skaill, Rousay, Orkney and end at Jarlshof on Mainland, Shetland.

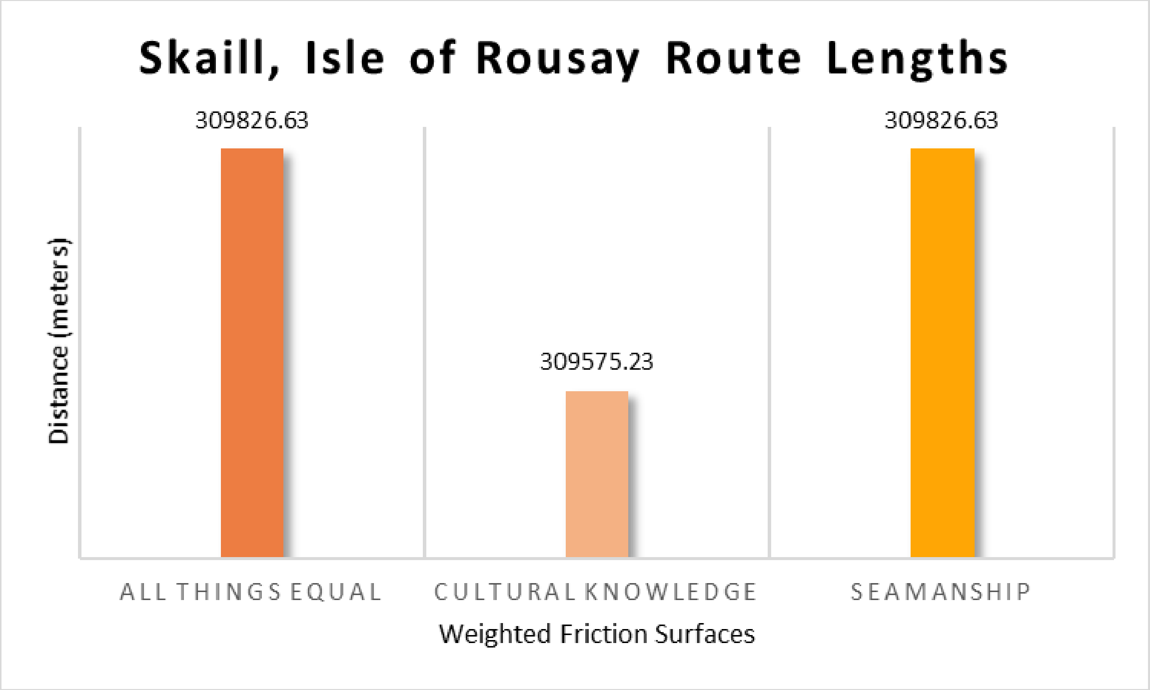


Table 8.11: This graph shows the length of the routes for each of the different weightings of the combined friction surfaces that originate off the coast from the hall at Skaill Farmstead on Rousay, Orkney and end at Jarlshof on Mainland, Shetland.

Source Route: Quoygrew Settlement

The results presented here are for the routes associated with the Quoygrew settlement for each of the different weighted surfaces. The total accumulated travel costs cost for the All-Things Equal route out of Quoygrew was 1343012.38 and its total length was 255147.54m. The Cultural Knowledge cost surface route had an accumulated cost of 1251315.75, and the total length of 254211.59m from Quoygrew to Jarlshof. The Seamanship cost surface sailing route from Quoygrew settlement had a cost distance value of 1410102.75m and the total length of 255147.54m. The mean value for the length of all routes that begin at Quoygrew on Westray, Orkney to Jarlshof, Mainland Shetland was 254835.5567m (approx. 254.84km). The average accumulated cost for a journey from Quoygrew to Jarlshof was 1,334,810.293.

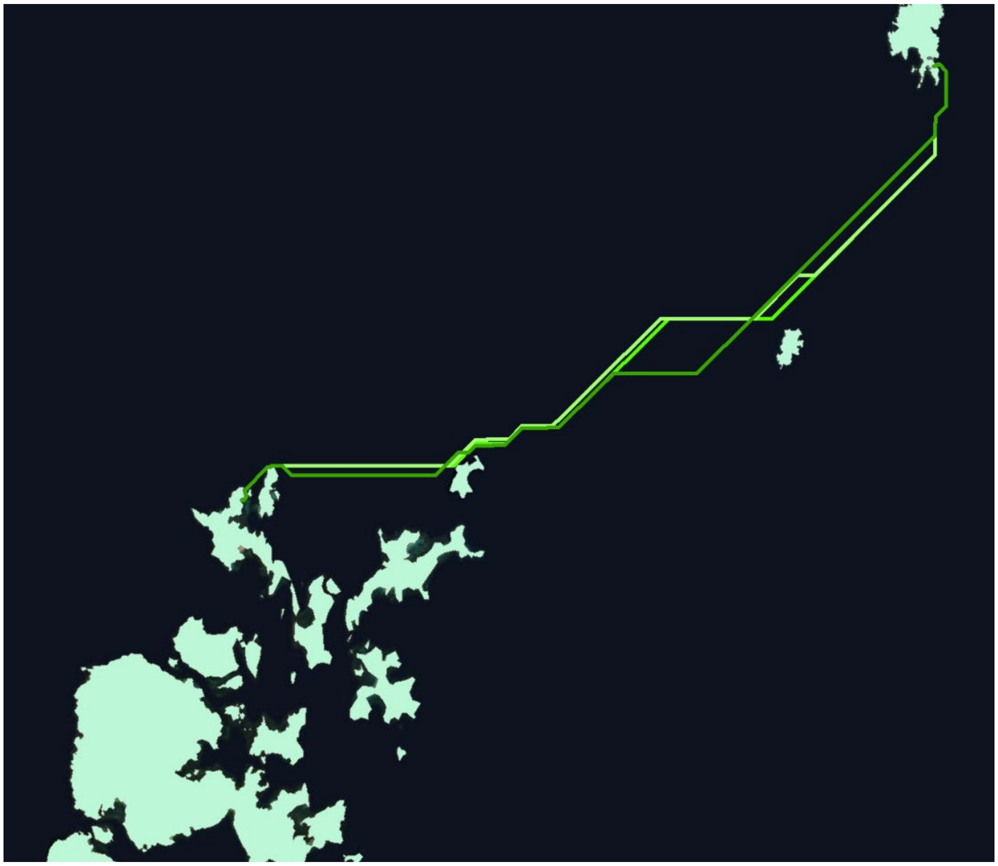


Figure 8.11: All of the Maritime Least Cost Path routes that originate from their source location at Quoygrew settlement on Westray, Orkney and ending at Jarlshof, Mainland Shetland are in the image above. Each of the different shaded green polylines represents a different weighing of the route. Tables 8.12 and 8.13 show which of the shades of green are associated with each of the weighted cost surfaces.

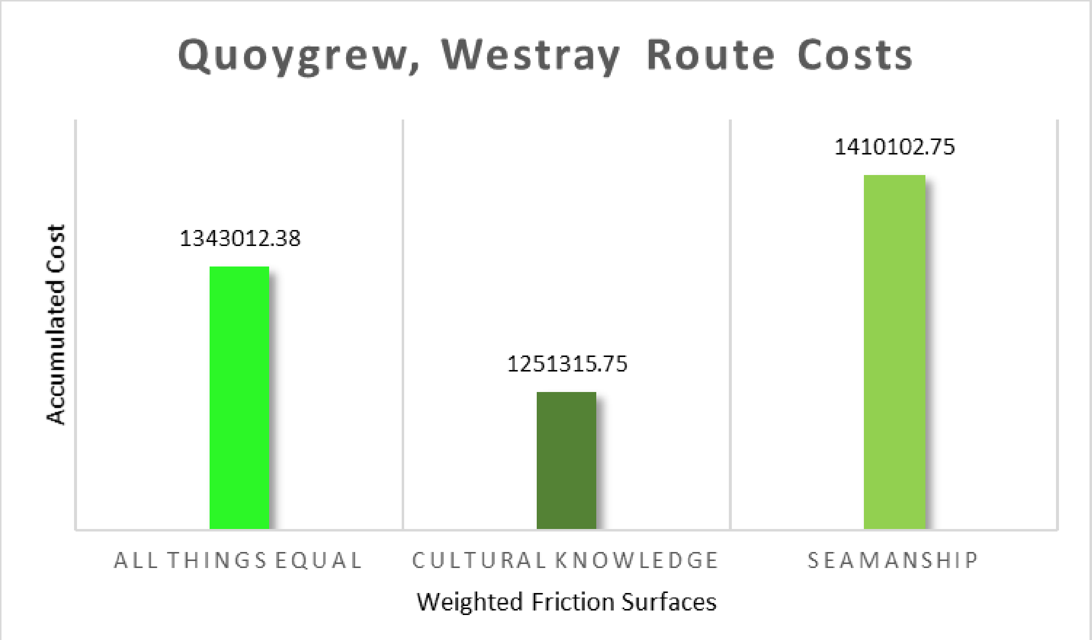


Table 8.12: The above graph expresses the accumulated costs incurred by a sailing vessel traveling from Quoygrew to Jarlshof for each of the differently weighted friction surfaces.

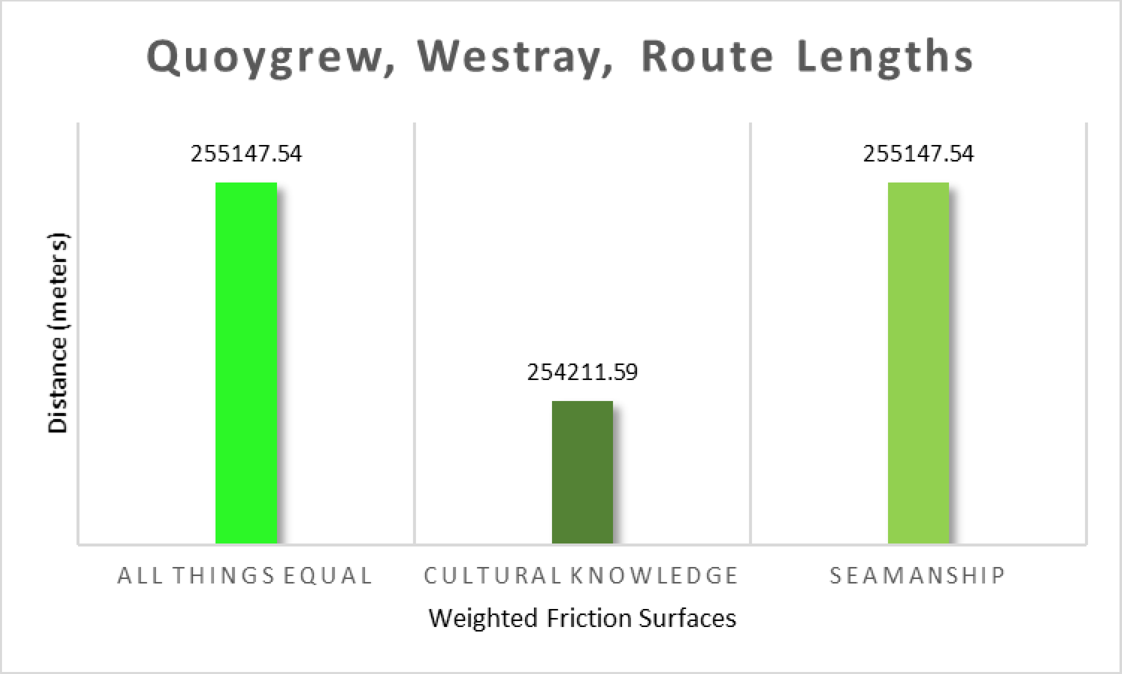


Table 8.13: The graph presented above provides the three potential route length in meters for a sailing vessel traveling from Quoygrew to Jarlshof for each of the three weighted friction surfaces.

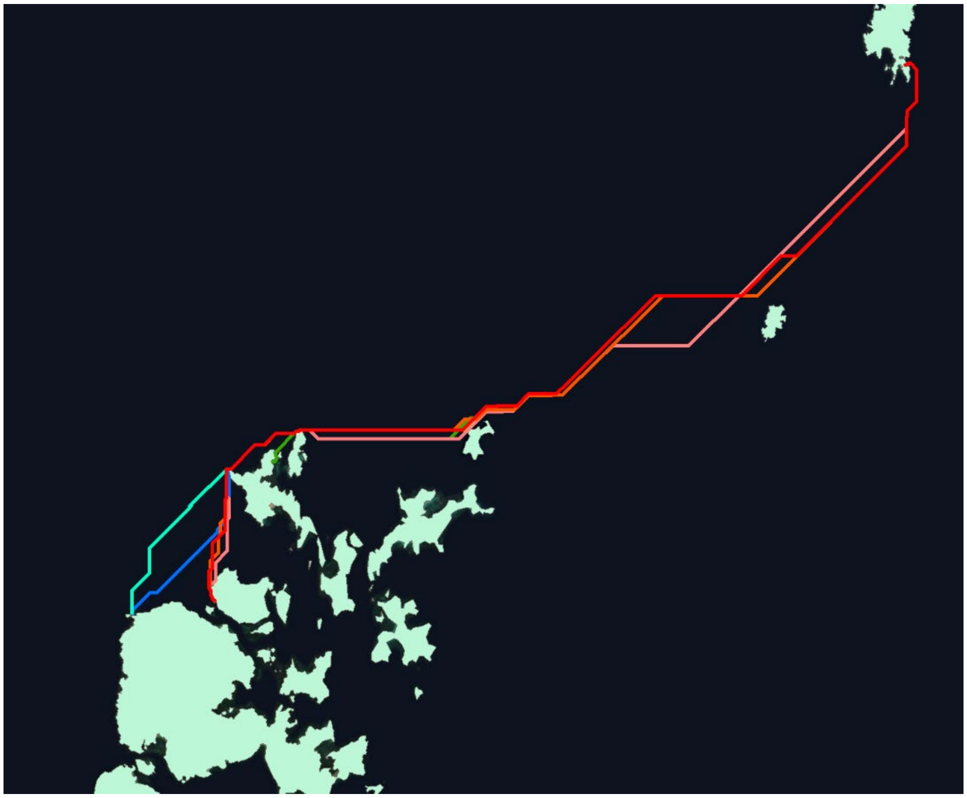
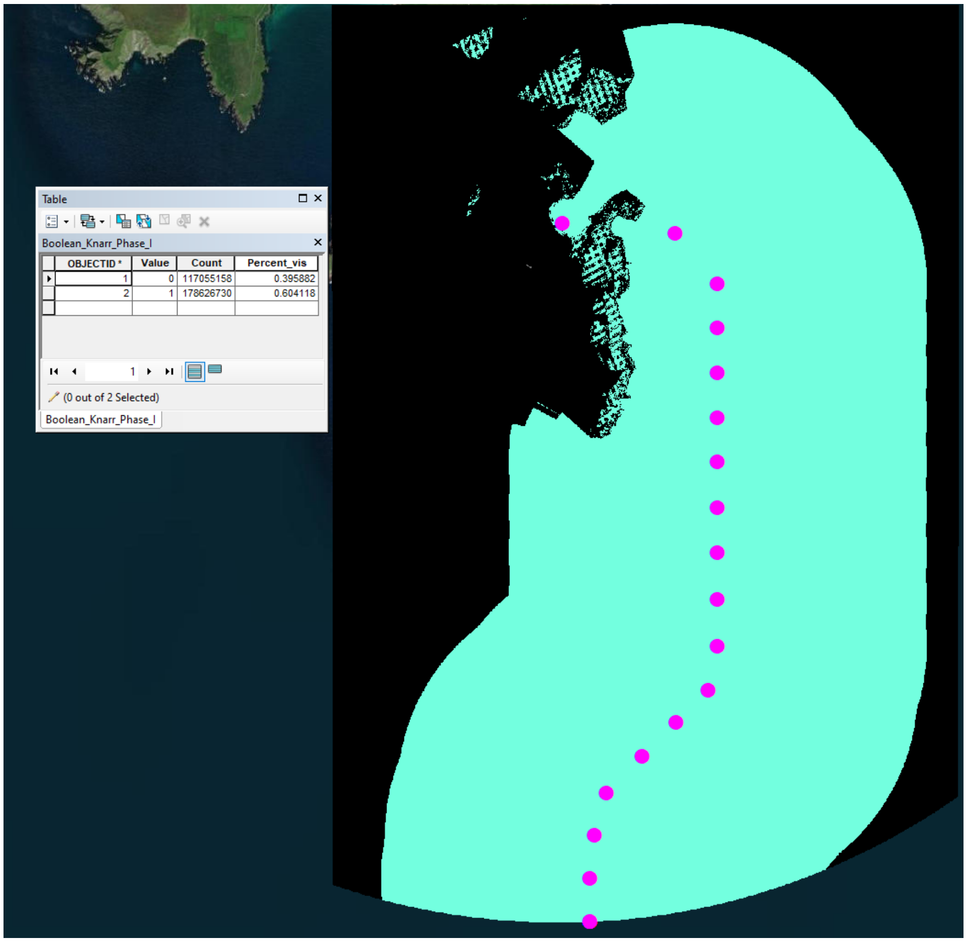


Figure 8.12: The above image shows all of the potential routes discussed here-in (9 in total). Each of these multi-colored polylines shows a potential sailing from one of the three Viking Age archaeological sites in the Orkneys to the Norse farmstead at Jarlshof, Mainland, Shetland.

Ship-based Fuzzy Cumulative Viewshed Analyses

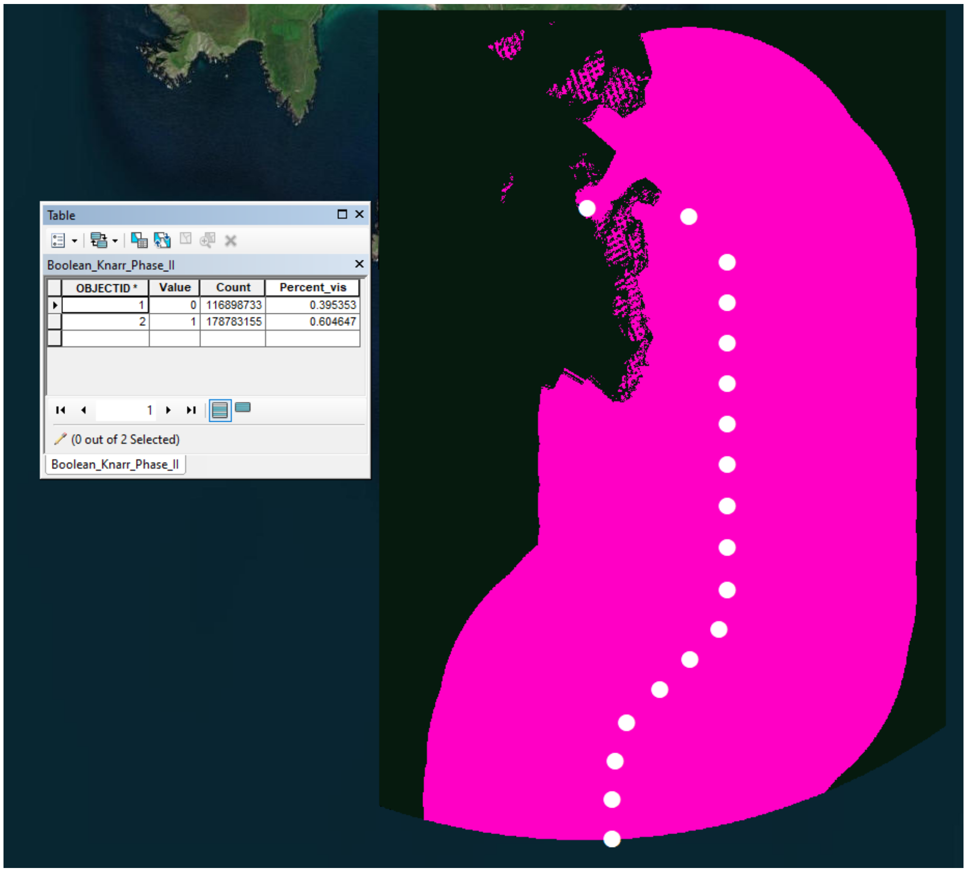
It is of primary interest to note that the settlement at Jarlshof, regardless of the Phase observed, was firmly in the portion of the analysis that was *not visible* from any of the Knarr observer points. The FCVA results for Phases I, III, IV, and V all returned the same percent visibility results: 60.41% of cells were visible and 39.59% of cells were not visible (see Figure 8.13). It should be noted here that this high percentage of visibility is not in direct correlation with the percentage of observable land features. Rather, it is indicative of the percentage of the study area as a whole that is visible, and most of the observable surfaces within the study area are derived ocean surfaces, which are perfectly flat providing 100% visibility for 8 of the 18 observer points. This remains true for all five runs of the analysis. The impact of this on the



OBJECTID *	Value	Count	Percent_vis
1	0	117055158	0.395882
2	1	178626730	0.604118

Figure 8.13: The above image shows the results of the Phase I Fuzzy Cumulative Visibility Analysis, the results of which mirror those of Phases III, IV, and V (not pictured).

percentage results will be discussed below. One abnormality in these analyses occurred in Phase II, in which observable land area demonstrated a slight increase of 0.05%. This means Phase II had 60.46% of cells visible and 39.54% of cells not visible (see Figure 8.14). Despite the use of nearly identical input data (aside from the insertion of the settlement structures), the results of the Phase II analysis returned an increase 156,425 visible cells. No other portions of the land portion of the DEM data were altered from their original elevations at any point, over the course of this or any of the other analyses. To be clear, this anomaly had no impact on the overall visibility of the settlement at Jarlshof from the perspective of a sailing ship, as the site still remained firmly out of visibility as with the other four phases.



OBJECTID *	Value	Count	Percent_vis
1	0	116898733	0.395353
2	1	178783155	0.604647

Figure 8.14: This image shows the results of the Phase II FCVA, here pictured because of the abnormality of the results.

CHAPTER 9: DISCUSSION

Settlement-Based CVA

The results of the architecturally based cumulative visibility analysis indicate a surprising degree of consistency throughout all periods of occupation. The percent-visibility for all periods did not waver even half a percentile. As motioned above, the percent-visibility results were as follows: Phase I at 11.59%, Phase II at 11.76%, Phase III at 11.38%, Phase 4 at 11.33%, and Phase V at 11.44%. The following section will discuss in detail the results of these individual analyses for each occupational phase and how they relate to one another.

As we look at the results from the first phase of the settlement-based CVA we see a relatively high degree of visibility to the south both in terms of visible land area and in terms of visible seascapes. The exception to this is the area directly surrounding the settlement to the south and west. These areas would have been blocked due to the placement of the Norse settlement on the northeastern slope of the settlement mound. There is also a marked lack of visibility to the north specifically in low lying areas where visibility is impeded by rises and hills that are closer in proximity to the settlement. One of these areas of no-visibility is the location of the modern airport. In the original DTM data this area was deliberately flattened in order to remove the modern structures. However, a perfectly flat surface does not accurately reflect the contours of the pre-historic landscape. Since these precise contours and elevations are unknown, it is possible that this area would have had improved visibility in the past when compared to the DTM data. This topographic variability would likely have increased the overall visibility, at least to some degree, not only on the Phase I viewshed, but for all five viewshed Phases. As stated above, the Phase I results indicate the second highest percent visibility score of 11.59%. Given that there were few built environmental impediments to the viewsheds in this period, these results are to be expected.

In Phase II, which spanned 900-950 CE, several additional structures were added including outbuildings 1F, 1E, and House 2. The second phase had an increased the number of observable cells by .17%. This is the highest percent visibility of any of the five phases. The portion of West Voe directly to the south of the settlement that previously had no visibility was reduced during this period. However, during the third phase we see a decrease of .38% in overall visibility dropping the percent visibility to 11.38% for that Phase (below the percentage presented in Phase I). During this phase, an observable band of no-visibility appears to the southwest of the settlement, spanning the waters of West Voe. This is due to the erection of the barn, which did not have a doorway at its southern end. While this did adversely impact the percent visibility, for the site as a whole, it did not impede the lines of sight from the settlement towards the mouth of West Voe to the south or of any other major land areas or sea lanes.

The fourth Phase saw a decrease in the percent visibility of .05%. This is likely due to the erection of outbuilding 4 directly to the west of House 3. This structure impeded the lines of sight from the observer points located at the northern entrance to House I and the western doorway of House 3. However, the northward facing doorway of Outbuilding 4 would have counteracted this to some degree. This decrease did not have any significant impact on relative sea lane visibility.

The fifth and final phase of occupation saw a .11% increase in overall visibility from Phase IV. Phase V was marked by an improved view of the land directly above Grutness Voe Beach as well as a slight northward shift in the orientation and decrease in the scope of the no-visibility band that crossed West Voe. This increase in likely due to a number of factors, including the decreased size of Outbuilding 4, and the erection of Houses 6 and 7 between the western end of House 1 and the eastern end of Outbuilding 1C. It is also possible that the major structural changes to House 1 and House 3, might have also played a role in the increased visibility in this period.

To summarize, two hypotheses were formulated for this first analysis, one was proven true, while the other was proven false. The first hypothesis stated that the placement of the site within the built and natural environment would offer an enhanced observation due to the site's increased elevation in relation to its immediate surroundings. This hypothesis proved true, the results suggest that even though the erection of new structures had the potential to block off or impede overall visibility of the surrounding landscape and seascape, this did not occur in any significant way. This could be due to the selection of the initial site location, on the slope of the settlement mound, that allowed for enhanced visibility of the surrounding landscapes and seascapes. It is possible that the maintenance of this high degree of visibility was a conscious decision made by the site's occupants to maintain lines of sight of their surroundings.

It was also hypothesized that the percentage of visible area from the settlement would improve as the settlement continued to grow in scale and affluence over the course of the site's occupation. As the results clearly demonstrate, this was not the case, at least in terms of the percentage of visibility, which decreased from Phase II to Phase III and from Phase III to Phase IV. It should be noted that, two structures in particular were identified as potential causes of this decreased percentage, the barn in Phase III and Outbuilding 4 in Phase IV. Despite not corresponding directly with the anticipated results, the relative consistency of the overall visibility from the settlement, across all phases of occupation, suggests that the ability to observe their surrounds may have been of primary interest to the occupants at Jarlshof.

This is not the only potential impetus behind the site's placement on the landscape. According to Harrison (2013), Norse settlers in the Northern Isles of Scotland may have selected sites that were previously or contemporaneously occupied by indigenous populations as a means of legitimizing their claims to their new homes within an already occupied landscape with its own physical, social, and political nuances. Therefore, the high degree of visibility from the settlement of both the seascape and landscape can be seen to confer both defensive and authoritative benefits, in terms of landscape control, to the site's occupants (Martindale & Supernant, 2009; Sevenant & Antrop, 2007).

Interpreting the MLCP Analysis

The results of the MLCP returned surprisingly consistent result in terms of the distance traveled when comparing the effects of all three potential route weightings on each respective route. For the Brough of Birsay route, both the All Things Equal and Seamanship weightings resulted in a total distance of 322,170.33m. Despite slight variations in the selected paths, both route distances were the same down to the centimeter. The Cultural Knowledge route was slightly longer with a 323,102.19, but with a lower overall cost (see below). The route from Skaill, on Rousay displayed comparable results, in that the overall distance for the All Things Equal and Seamanship weightings had the exact same values (309,826.63). However, the Cultural Knowledge route length was slightly shorter with a distance of 309,575.23m, a difference of 251m. The findings from Quoygrew indicated that the distance results for the All Things Equal and Seamanship weighted surfaces were equivalent to one another (255,147.54) and that the Cultural Knowledge route had a lower overall distance (254,211) was 935.95m, just under a kilometer. It is possible that the direction of the route, all bearing to the north east, would encourage cutting closer to shorelines as this was both a reduced cost (Euclidean Distance) and also decreased overall distance as all source locations were located to the south west of Jarlshof. Future investigations might well consider how locations to the north or south east of the site might have impacted these findings.

Based on the results of the MLCP analysis, the influence of the weighted combined friction surfaces on relative route costs were as follows: All-Things Equal weighted cost surface presented the closest accumulated route costs out of the three different weightings with lowest variable costs between the farthest route -Brough of Birsay- and the shortest route -Quoygrew, on Westray-. This amounted to a difference of 268,610.5 between the two routes. Given that all the friction surfaces were assigned equivalent values, this was to be expected. The Euclidean Distance-based weighted cost surface 'Cultural Knowledge' (50% Euclidean Distance and 25% to both the northward and eastward current friction layers) had the strongest influence on the route that originated from Quoygrew Settlement, the shortest of the three routes.

This can be seen in the movement of the ship along coastlines, for example when passing North Ronaldsay and Fair Isle, the routes from Quoygrew more closely hugged the coastlines when compared to the routes that originated at the Brough of Birsay and Skaill on Rousay. Although, the routes from Skaill, on Rousay and the Brough of Birsay both followed the cost around more closely on this run, than in the other two weighted options. It was also noted that this layer returned the lowest overall route costs for travel from all source locations to their destination. To be clear, the lowest route costs do no directly weigh in on the time duration of the voyage, in fact coming closer to land would likely reduce movement speed due to the risks inherent in navigating coastal waters (USHO, 1915).

When current velocity was given priority, (40% eastward current velocity, 40% northward current velocity and 20% Euclidean Distance), all routes, regardless of their origin point, maintained the same route all the way to the destination point. This suggests that the longer the voyage takes, particularly over open water, the more current velocity would take an active role in decision making. However, the weighted combined friction surfaces for the Seamanship weighting demonstrated the highest accumulated costs out of all three analyses.

To summarize, there was a general consensus between all source routes and all weightings as to the general path to follow to reach Jarlshof. Said path involved following the westward edge of the Orkney coast traveling to the north east and passing by the westward side of Fair Isle before arriving at Grutness Voe to the north east of Jarlshof, Shetland. Most of the fluctuations seen in these potential paths were due to the source's variable distance from the destination. The distances traveled along each of the routes were consistent when the rate and directionality of the currents were given 33.33% (or greater) weighting. Conversely, when the Euclidean Distance was factored in at 50% or greater, the cost of these routes increased with distance, despite being relatively low in comparison to current-heavy weightings.

As a point of clarification Euclidean distance was assigned a decreased cost because land needed to be visible for the purposes of navigation. The closer to the shore the lower the cost because of the ability of a navigator to identify key topographic features or waypoints would increase the closer they were to said objects. However, this suggests that the more frequently an individual navigating in coastal waters had to verify or identify a coastal landmark the longer the duration of the voyage. For example, if a navigator was unfamiliar with the area, they would need to expend more time to travel the route in order to identify specific waypoints. However, this would also improve their knowledge of their surroundings and contribute to the construction of their mental map for the area (i.e., the less likely they are to become lost on the return journey).

It can be postulated that, the higher the accuracy of a ship navigator's metal map, (i.e. the more frequently the individual travelled a particular route), the less frequently they would have to sail close enough to shore to identify specific landmarks or way points. Instead, it would be reasonable to assume that the sequence of the islands themselves might well be enough information for a navigator to follow a familiar route. This would also reduce any risks incurred by venturing too close to unfamiliar coastlines, where subsurface geologic features or tidal currents could prove dangerous or even deadly as with the Sumburgh Roost (USHO, 1915).

The longer a voyage is, the higher the likelihood that the vessel will have to cross certain expanses without the aid of land-based waypoints. Indeed, Thirslund, (1997) notes that several of the Viking Age sailing routes between Iceland and Mainland Norway recorded in the Sagas are said to have relied on singular sightings of either the Shetlands or the Faroes on the horizon in order to maintain their course. The better a navigator knew the waters and coastal features of an area farther that were far from their home port, the lower the costs, in terms of reduced time, danger, and energy expenditure, for the journey. If we were to think of this in terms of interconnectivity, so long as sailing routes were maintained by navigators and sailors knowledgeable of the local character of the seascapes and coastal landmasses along a route, then the origin and destination points along that route would have a greater likelihood of remaining connected.

In closing, regardless of what navigational methodologies were employed (reliance on local wind and current conditions, or focusing more heavily on pilotage), the overall character of the route remained fairly consistent even when considering the various source locations. One detail of key importance to the following discussion section is that, regardless of the route taken, or the weighting applied to said route, once a sailing vessel came within 16km of Jarlshof, their least cost path conformed to a singular route. As mentioned in Chapter 7, this distance coincided with the maximum extent of the FCVA.

FCV Analysis Interpretations

There are two primary take aways from the results of the Fuzzy Cumulative Viewshed Analysis. Firstly, across all occupational phases under investigation, the settlement was not visible from the sea. This means that intervisibility between a ship sailing the sea-lanes and the settlement was not a factor that contributed to the site's accessibility and thereby its connectivity. This ran contrary to the initial hypothesis that the visual prominence of the site would increase with time as the settlement grew, thus improving the site's percent visibility from the perspective of a ship-based observer. Although this proved to not be the case from the sea, it is still possible that the visual prominence of the site did increase from the perspective of a land-based observer, however that was not assessed in these analyses.

Secondly the cliff faces and coastal characteristics of the landscape surrounding the site were clearly visible from the perspective of a ship-based observer. Additionally, when the height of the horizon is considered, Sumburgh Head would have been visible above the horizon long before the vessel entered the study area (Young, 2003). This would suggest that, since the settlement itself is not visible from the sea lanes to the east, or from the waters of Grutness Voe, that the location of the site would have to be identified by other means. For example, its location on the landscape relative to various coastal and topographic features such as the promontories of Sumburgh Head to the south and Compass head to the east, the mouth of West Voe or Grutness Voe, the low-lying land bridge to the north of the site where Sumburgh Airport now stands, or more generally at the southern tip of Mainland Shetland.

As discussed above, intimate knowledge of these waters, the surrounding islands, skerries, inlets, and voes, would better facilitate travel to and from the site. In his discussion of Viking Age sailing and navigational practices, Thirslund (1997) postulates that the initial settlement of the islands of Northern Scotland and the North Atlantic would have relied a great deal on luck and associative knowledge to navigate their untested waters. As the USHO, (1915) pilot warns for various locations within the Northern Isles, unsounded and untested waters present dangers to the unwary and should be avoided when at all possible. Thirslund (1997) suggests that it is likely that any information gained during the early expeditions into uncharted waters would be held in confidence and passed on begrudgingly, to maintain an advantage over other groups. An advantage that they would no doubt hold until so many ships had sailed the area that knowledge of its dangers and safe harbors became common knowledge. For these reasons, I would argue that the lack of intervisibility between the observers on the ship and at the settlement can be seen as a factor that would have necessitated interconnectivity.

Problems with Early Excavations

Dating Issues

Although many of the challenges to dating the occupational phases at Jarlshof have been mentioned throughout the text as needed, this section is intended to bring attention to all alterations to Hamilton's (1956) dating sequences that detailed elsewhere. All of the early excavations at the site (Bruce, 1906-1907; Curle, 1935; Childe, 1937-38; Richardson, 1938-39 as cited by Hamilton, 1956; Hamilton, 1956) took place during a time when radiocarbon dating was either not developed or was not readily available for use in archaeological practice (Bond & Dockrill, 2016). This means that the dates recorded by these early excavators were largely based on personal or professional knowledge of the subject matter, or the typological identification of various artifacts.

Owen (2004) reminds us that typologically dating Viking Age assemblages, both in and outside mainland Scandinavia can be, in a word, problematic. She argues that this is particularly the case in Scandinavian diasporic settlements because artifacts have the potential to have traveled far from their place of origin as with trade goods, but also the antiquity of the artifacts prior to their arrival at a given site can vary widely in the case of family heirlooms or plundered ecclesiastic or secular goods (Owen, 2004). Although she was discussing items interred in burials, it is applicable to many other Viking Age contexts such as settlements.

It is therefore not surprising that later researchers such as Fanning (1994) and Bond and Dockrill (2016) have advocated for the reassessment of the early phases of the Norse settlement at Jarlshof. Over the course of this research, a number of chronological inconsistencies were noted between Hamilton's (1956) dating chronology and the work of later researchers. These led to the adjustment of some of the dates provided by Curle, (1935) and later Hamilton (1956) for the settlement occupational phases, specifically Hamilton's Phase I – Phase III.

According to Hamilton (1956) Phase I of the Norse settlement likely began sometime between 800 CE and the mid-9th century CE. He based his assessment in part on the presence of a gilt bronze harness mount recovered from midden material underneath the foundations of House 2 [SQ. 18] which had parallels with similar Celtic artifacts recovered western Scotland and Irish contexts as well as from burials dated to the early 9th century in mainland Scandinavia (Hamilton 1956). However, as Owen (2004) noted this provides an approximate date for the age of the artifact itself, not necessarily the context in which it is recovered from. Hamilton's (1956) other reasoning for this early date was due to the general assumption that the settlement of the

Northern Isles, due to their proximity to mainland Scandinavia, were likely settled before other regions of the British Isles.

Recent investigations of other early settlement locations in Shetland such as Old Scatness, Underholl, and Belmont suggest that although initial contact may have been taking place in the first half of the 9th century CE, but the establishment of the Scandinavian settlements likely occurred in the latter half of the 9th century CE (Bond & Dockrill, 2016; Larsen, 2016). The presence of the presumedly looted gilded harness mount draws interesting parallels with the first documented overwintering of Viking armies and raiding parties taking place in Dublin, Ireland in 841 CE, England in the winter of 850-851 CE, and in Frankia from 852-853 CE (Barrett, 2010). Based on these associations, the dates for Phase I were set at 850-900CE.

Due to the revision of the Phase I dates, they now overlapped with Hamilton's (1956) dating sequence for Phase II, however Hamilton's dating of the second Phase is based largely on stratigraphic grounds. He notes that the close proximity of House 2 to House 1 is suggestive of the division of the settlement in the second generation of occupants due to inheritance rights (Hamilton, 1956). Hamilton (1956) also suggested a 50-year gap between the first and second generation due to the scale of midden accumulation beneath the foundation of House 2. With these things in mind, the dates for Phase II were changed from 850-900CE to 900-950CE to reflect their stratigraphic and spatial associations to the first phase.

The third phase was also adjusted in a similar manner to reflect the clearly defined stratigraphic sequences between Phase II and Phase III. This resulted in the change of Hamilton's (1956) Phase III dates from 900 as Hamilton's (1956) interpretation to 950CE. The end date for this phase (1050CE) was based on the presence of a Ringerike style gilt bronze strap

(Hamilton, 1956). The Ringerike art style is a Scandinavian iconographic style common from 1000-1075 CE (Graham-Campbell, 2013: 117-132; Hamilton, 1956:154). Other artifacts dated to this same age range, specifically stirrup-ringed crutch-headed pins, have implications for the dating sequence at Jarlshof. Evidence for the production of stirrup-ringed pins in Ireland, date from the early 11th century CE into the early 12th century CE (Fanning, 1994). Secure contexts for these pins from Dublin, where many were initally manufactured, were dated to the early to mid-11th century on the grounds of both absolute and numonic dating, at the High Street and Fishamble Street excavations (Fanning, 1994). The stirrup-ringed pin, 1406 from Jarlshof conforms to an early 11th century date range (Hamilton, 1956).

However, the stirrup-ringed pins 1289 and F918 which are stylistically nearly identical to finds from Fishamble Street, Dublin, were associated with midden deposits Upper Slope Midden associated with Phase I at Jarlshof (Fanning, 1994; Hamilton, 1956). Given that the Upper Slope Midden was scattered over a large portion of the settlement mound to the south of the settlement, the possibility exists that these two finds represent palimpsests (possibly caused by placement of the irregularly place burials from later periods that were identified by Bruce (1906-1907) that were later exhumed and reinterred elsewhere. The stratigraphic sequencing of the site, both within the context of the Norse occupation and in association with earlier Iron Age occupations at the site, remains unchanged, unlike specific aspects of the dating sequence detailed above (Bond & Dockrill, 2016; Larsen, 2016).

Recording Inconsistences

Unlike in modern archaeological practice, where the metric system has now become the standard for scientific research and documentation, the early excavations at Jarlshof by the landowner John Bruce (1906-1907), and archaeologists Alex Curie (1935), Gordon Childe

(1937-38) and J.R. Richardson in 1938-1939 and J. R. C. Hamilton, (1956) all employed imperial units of measure (i.e., feet). While a simple conversion can generally alleviate most of the issues inherent in this, early excavations also tended to vary in the degree of accuracy that was taken both in terms of excavation practices and documentation. While this will not be discussed in depth, some examples from Bruce (1906-1907) will be provided to showcase some of the difficulties imparted to later researchers and excavators.

His account offers approximations on the duration, extent and depth of excavations such as, and these are paraphrased, 'After about five years' almost constant digging,' and 'about 60 ft to each side of the Broch,' or 'the highest part of the broch's main wall is about 7 feet in height,' (Bruce, 1906-1907:11-17). These approximations, while useful to gain a general sense of the place and the scope of work, fail to accurately account for variability in height or the precise extent of each structure, while at other times he provides exact measurements down to half inches or the diameters of certain spaces or features. This level of inconsistency likely carried over to artifact recovery and descriptions, despite statements that the utmost care was taken, without explicit documentation of the methodologies employed by his four-man excavation team (Bruce, 1906-1907). Although documentation improved during the excavations by Curle (1935), Child (1937-38), Richardson, 1938-1939 and Hamilton (1956) it is impossible to know what might have been lost both to the sea prior to 1897 or over the course of the first five years of exploratory excavations at the site.

Methods Selected

LiDAR DSM and DTM data vs Point Cloud Data

As stated above, 1m resolution DSM and 1m resolution DTM data files for the southern portion of Mainland Shetland were acquired through the _ data portal. These files provided 1m resolution raster data for the study area. Having spoken via email with the Digital Documentation Manager at Historic Environment Scotland, I was informed that they also had even higher resolution Point Cloud data available for Jarlshof. However, given that Point Cloud data would not only require substantial processing power to be able to utilize, but also require that I familiarize myself with an entirely new software, such as Cloud Compare. With these considerations in mind, it was decided that the 1m resolution DTM and DSM raster data would be utilized for the analyses. Given that each of the five FCVA analyses required 17.5 hours of processing time, this was likely a wise decision.

Implications of Missing Westward and Southward Current Data

While the northward and eastward currents did not have high velocities, no values exceeded 1 m/s, the westward and southward currents for the region remain an unknown factor. No doubt their values would have impacted the weighting of the model, and if this analysis were to be repeated, acquiring current data from all four cardinal directions would be ideal and provide a more accurate weighting of the costs of movement. Unfortunately, the source data from Copernicus Marine Data Portal did not have westward or southward flowing current velocity data for the region. Had southward and westward current velocity data been available, they would have each been added as additional cost friction surfaces for use in the Maritime Least Cost Path Analysis.

Accuracy of Past Seascapes

The DTM data acquired from https://remotesensingdata.gov.scot/ included not only topographic LiDAR data, but also portions of the modern sea surface (SG & JNCC, 2021). These values were maintained in the CVA so that the variable impacts of the dynamic surface could be accounted for. This was not the case for the FCVA where the past sea surface was assigned a singular average height of -0.725857m for the entire study area. This does not take into account the constantly changing surface of the ocean, or in turn how that surface might impact the relative visibility of a ship sailing across it. However, the comparison between these two sets of results can provide some indication of how the sea surfaces in the CVA might be extrapolated to the past sea surface results of the FCVA. As it stands, both the CVA and FCVA were based on ideal visibility conditions, and the ocean conditions for the FCVA were also idealized in that they represent a perfectly calm sea.

The current velocity data acquired from Copernicus Marine Service (https://resources.marine.copernicus.eu/products) covered a twenty-year span from December of 2000 to December of 2020. While this limited the potential impacts of any abnormal seasonal storms for a particular year. The multi-year nature also allowed for the easier extrapolation of the current data backwards in time. However, as these data were the average of 20 years' worth of currents, it did not allow for the exclusion of seasons that would have made sailing conditions unlikely such as late fall into early spring. Therefore, this could have also had an impact on the routes identified in the FCVA. This same data set, while of primary importance to the development of the MLCPA, it did present a number of shortcomings. The primary limitation of the data being the coarseness of its resolution. While resampling was preformed, so that the data could be more readily applied to this research, this resampling had no effect on the quality of the source data which covered roughly 12 x 7 km bands. While discussing resampling, I would be remiss to not discuss the difficulties involved with that process, (i.e., the inability of the data to be directly brought into a standard resolution with the other friction surface variables, despite numerous attempts to do so). That being said, the scale of the original data from Copernicus Marine Services does allow for its potential use in later research, as discussed further below. In the case of that eventuality, reexamination of the data and further inquiry into its idiosyncrasies will be necessary.

Accuracy of Past Landscapes

Morrison, (1973a) noted the presence of an underwater rock platform that extended an average of 150m to the southwest from the modern coastline at Jarlshof. He argues that the land to the seaward side of the Iron Age broch could have contained additional structures of various stages of human occupation at the site, noting that Viking Age boat shelters or *Naustr* (ON) had yet to be identified at the site despite ample evidence of fishing and boat repair at the site (Hamilton, 1956; Morrison, 1973a;1973b). Additionally, many Viking Age burials in the Northern Isles, such as the cemetery at Westness, Rousay, in the Orkney Islands, were located on or near promontories (Graham-Campbell & Batey, 1998; Sellevold, 1999). The possibility of the settlement having, at one time, extended farther to the southwest into what is now West Voe, would likely have little to no impact on the mobility analysis given the strong tidal race at the mouth of the bay, preventing access to the settlement from the sea.

The increased extent of the settlement, and the potential for additional structures, would likely have had impacts on the land based cumulative visibility analysis and possibly on the ship based fuzzy cumulative viewshed analysis. Additional architectural features would increase the likelihood of additional doorways, thus increasing the number of observation points. However, the creation of an additional landmasses and the subsequent placement of potential structures would have been the happy marriage of conjecture and serendipity. Therefore, the decision was made to simply acknowledge the potential extent of the site's past land surface here without making any adjustments to the GIS model.

CHAPTER 10: REMARKS ON SENSITIVE SUBJECTS

Nationalists, Enthusiasts, Madmen, and Scholars: Avoiding or Engaging with Potential Implications

This chapter focuses on the origins of historical and archaeological interest in the Vikings as well as the implications that these origins have on modern research on the Viking Age. As with all scientific disciplines that today find the perspectives of founder or early practitioners to no longer be in line with modern sensibilities or professional practices, the field of archaeologists has come a long way from the stocking of curio cabinets with questionably acquired antiques and cultural items or haphazardly employing heavy machinery ala Heinrich Schlieman (Johnson, 2020). This is especially true for the scientific investigation of Vikings, both in terms of the progress that has been made, and the risks inherent in disseminating modern research findings.

When someone brings up the topic of Vikings it is not difficult to conjure up an image in our minds with little if any hesitation – bearded fair-haired ferocious warriors adorned with furs, horn-helm, and, of course, a sword. Afterall, Vikings have become a pop-cultural reference readily visible on sports team helmets, company logos, and in television ads and feature films (Fitzhugh & Ward, 2000; Hall, 2007). Despite its virulence in popular culture the images depicted in these formats, much like the one you conjured up, are to varying degrees an inaccurate representation. The desire to know more about the life ways and beliefs of Viking Age Scandinavia began only a few centuries after Iceland and other regions of mainland Scandinavia converted to Christianity in the 11th century. Many of the impressions we have today find their origins in early histories of Scandinavian royalty recorded by Christian monks like Saxo Grammaticus' *Gesta Danorum* and the works of secular historians like Snorri Sturluson's *Heimskringla* both produced during the 1200s CE (Hall, 2007).

Deep Roots in Romanticism and Nationalism

Renewed interest not only in these texts, but in the ancient Nordic past more generally began again during the Renaissance in opposition to the classic Greek and Roman civil models (Hall, 2007). Over time, this interest in rediscovering and celebrating the Viking past was reignited during the Enlightenment fueled by nationalistic and Romantic sentiments (Fitzhugh and Ward, 2000). In 1646 the Latin translation of the *Poetic Edda*, a collection of Old Norse Poetry including the *Hávamál*, or the "Words of the High One" a collection of teachings on social and cultural etiquette written from the perspective of Odin conveying knowledge, arrived in France (Crawford, 2019; Hall, 2007). The intricate rhyming patterns and metaphorical language of these poems inspired wider appeal among a broader Germanic audience intent on a Proto-Germanic past (Hall, 2007; Fitzhugh and Ward, 2000).

An interest that was only further in flamed after 1814 with the end of the Napoleonic Wars breeding an ardent desire to escape from the aftermath of that conflict into the romanticized glories of days long gone (Fitzhugh & Ward, 2000). This invigorated interest in the past did not stop at literature; Scandinavian scholars such as Christian Jürgensen Thomsen began reexamining ancient antiquities and the developing chronological and typological schemes and methodologies that would form the basis for much of modern archaeological practice (Fitzhugh & Ward, 2000). Fantastic discoveries, particularly those of incredibly well-preserved Viking ships, such as the Oseberg, Tune, and Gokstad vessels, captured the imagination of not only scholars, but of the general populace as well (Bonde & Christensen, 1993; Bonde & Stylegar, 2016).

At this same time, with the advent of the Industrial Revolution, Nationalism began to take deeper roots in the Nordic counties. By the 1870s social clubs in Sweden and elsewhere required members to Viking costumes for annual balls and other social events; horned and winged helmets lent a neo-gothic flair to their outfits that has managed to maintain a firm grasp on the imaginations of later generations (Hall, 2007). Richard Wagner's appropriation of Old Norse mythology im his ca. 1874 operatic Ring Cycle once again brought the glories of a broadly construed heroic Germanic past to the forefront of the general populace as well as the association with winged helms (Hall, 2007). If this was the extent of the damage done it could well go unremarked, outside of a few imbittered grumbles from academics, but this was not to be.

In 1899 H. S. Chamberlain put forward the idea that all German peoples were member of an 'Aryan' race, one superior to others, this idea would later go on to be conflated with the archetypical image of physically powerful blonde-haired blue-eyed Norsemen (Fitzhugh & Ward, 2000). This racist ideology reached its zenith in the economically crippling aftermath of post-World War I Germany, with the rise of Hitler's National Socialist Party (Fitzhugh & Ward, 2000; Goodrick-Clarke, 2004; Hall, 2007). Nazi propaganda through the war relied on this mythical Proto-Germanic past as justification for the unification of all Germanic peoples under one rule (Fitzhugh and Ward, 2000; Goodrick-Clarke, 2004; Hall, 2007). The link between Germany's expansion was repeatedly linked to the Viking expansion across much of Eastern and Northen Europe (Hall, 2007).

With the end of the Second World War public and academic interest in Vikings declined considerably, not only in Germany, but also in Scandinavia (Fitzhugh & Ward, 2000). Nevertheless, the nightmarish interpretations formed in those dark days of history, unfortunately also took root in the public eye and there are numerous Alt-Right, Nationalist, and White Supremacist groups that still hold many like-minded beliefs (Fangen, 1998). It is for this very reason that we as archaeologists must be increasingly proactive and intentional in how we express, discuss, and disseminate our research regardless of the subject of study, but perhaps even more so when the risk of misuse and appropriation can have detrimental effects.

A Way Forward

Neil Price (2015) points out that the way Vikings are perceived today, and thus how they are studied, is distinctly different from the way they were perceived even twenty years ago. He notes that they are no longer the one-dimensional berserker warrior of antiquity; they have gained 'depth and resolution' (Price, 2015:7). Nevertheless, these past perspectives have a lasting hold on our imagination; there are many who still believe that all Viking Age Scandinavians were Vikings, and that they all wore horned helmets and when their blood was up, they would cavort about in animal skins waving swords and axes -see Fatur (2019) and Heath (2021) for two recent perspectives on berserker warriors-. On the other hand, Margaryan et al. (2020) have put forward a though provoking new take on what it might have meant to be a Viking.

Margaryan et al. (2020) posit that being a Viking was less a matter of genetic ancestry, and more of a 'job description', an argument supported by their genetic analysis of what was assumed to be a series of archetypical Viking burials. Margaryan et al. (2020) found that the interred individuals were not always of Scandinavian descent, and that many came from other genetic origins including individuals of British Isles and Sammi descent (Indigenous population of Scandinavia, Finland, and portions of Siberia), suggesting that 'Viking' identity was not limited to individuals whose genetic ancestry was exclusively Scandinavian. They reiterated the overwhelming evidence for genetic admixture of British Isles and Scandinavian ancestry among North Atlantic populations, especially during the initial settlement of Iceland and Greenland (Margaryan et al., 2020). These findings help the process of deconstructing the longstanding view of 'Vikings' and 'Northmen' as the pinnacle of genetic purity amongst many white supremacist groups both past and present (Fangen, 1998; Fitzhugh & Ward, 2000; Goodrick-Clarke, 2004; Hall, 2007).

In recent years we've seen a remarkable uptick in public interest in Vikings and the Viking Age more broadly. They have become the central focus of several live-action television series both on traditional day-time television such as History Channels original series *Vikings* (Hirst et al., 2013-2020) which ran for six seasons, the British Broadcasting Corporation (BBC) series *The Last Kingdom* (Butchard et al., 2015-2022) which has currently run for 5 seasons, and the streaming service Netflix's original series *Vikings: Valhalla* (Hirst et al., 2022). Vikings have also been portrayed in various other forms of multi-media in recent years including video games like *Assassin's Creed: Valhalla* (Ubisoft, 2020)*, God of War* (Santa Monica Studio, 2018)*, Hellblade Senua's Sacrifice* (Ninja Theory, 2018), and *Vikings - Wolves of Midgard* (Game Farm, 2017) as well as in a variety of films such as Robert Eggers' *The Northman* (Perry & Gabriele, 2022).

The Northman has been lauded as one of the most accurate representations of Vikings ever to be depicted the silver screen (Perry & Gabriele, 2022). This is in part due to Egger's efforts to incorporate not only historical, but also archaeological evidence into the film; three historical consultants were recruited to inform the film including Neil Price (Perry & Gabriele, 2022). All these various forms of multi-media depictions have varying degrees of historicity, but nonetheless are important to discuss because they are one of the main ways the general public consumes information about the Viking Age outside of cursory Google searches, which can also return a wide range of results to the unwary. While *The Northman* can arguably be seen as a goal in terms of the incorporation of archaeological and historical consultation into multi-media formats, it is not often a major focus of such companies. Even so, the dissemination of modern research findings in the field of Viking research has a number of potential implications to consider, both in terms of its past as a discipline, and in terms of the audiences who will consume and possibly re-interpret the results of those findings.

CHAPTER 11: CONCLUSIONS

In the introductory chapters of this thesis, it was observed how researchers in recent years have approached maritime archaeology and the investigation of insular and coastal landscapes (Cooney, 2003; Cordell, 1989; Crouch, 2010; Cunliffe, 2001; Farr, 2006; McNiven, 2010; Terrell, 2010; Westerdahl, 2006). Particular attention was paid to the various perspectives on how we might better conceptualize the use of past landscapes and seascapes to better understand the lived experiences of maritime societies of the past (Cordell, 1989; McNiven, 2010; Terrell, 2010). This thesis sought to reassess the way we conceive of the dichotomy of land and sea and to argue for recognizing them as two physically distinct aspects of the same lived environment in which coastal zones can be viewed as connecting points rather than barriers or boarders to movement. Consideration of the integral part that seascapes play in the formation of, and association with, local and cultural identity (Barrett, 2012b; 2019; Cooney, 2003; Cordell, 1989; Cunliffe, 2001; Ford, 2011; McNiven, 2010). These aspects of cultural identity were considered through the lens of watercraft iconography as well as their use, both symbolic and literal, in various mortuary practices spanning across Northern Europe ranging temporally from the Bronze Age (1750 BCE) to the Viking Age (1066 CE).

Crouch, (2010) Farr, (2006) Terrell, (2010) and Westerdahl, (2006) found that sea played a vital role in the ability of insular sites to stay connected with one another, specifically that the maintenance of said sailing routes contributed to the centrality of such sites. With the advent of the Viking Age, we see the diaspora of a Scandinavian maritime society into new Geographic areas. This setting provided an ideal opportunity for the application of my research ideas, specifically the interrelated nature of landscapes and seascapes among maritime societies. This was done through the development of a joint mobility and visibility GIS-based model that aimed to assess interconnectivity between insular and coastal archaeological sites associated with the Scandinavian diaspora westward, which took place during the Viking Age (ca. 790 CE-1066 CE).

The multiperiod site at Jarlshof was selected for use in this research, because it represents an ideal case study for the investigation of insular interconnectivity over the course of the Viking Age, as evidenced by the archaeological record at the site as it relates to both local and long-distance trade and exchange throughout the Viking Age (Fanning,1994 Hamilton,1956; Hansen, 1993; 2003; Hunter, 2008). A wide variety of diagnostic artifacts were found at Jarlshof throughout all phases of occupation that were examined in this thesis (Hamilton, 1956). The artifacts discussed here in were Hiberno-Norse bronze ringed-pins, personal adornment items such as bangles, bracelets, and finger rings made from jet lignite and canal coal, and soap stone vessels and other items carved from steatite (Fanning,1994; Foster & Jones, 2017; Hamilton,1956; Hansen, 1993; 2003; Hunter, 2008; Larsen,2016; Sindbæk, 2019). It was argued that these various forms of evidence can be seen as expressions of interconnectivity, and these selected artifact types were not the only such evidence available for interconnectivity at the site including bone and ivory combs of Scandinavian origin, amongst other items (Hamilton, 1956). The discussion of these connections was the primary focus of chapter 5. Chapter 6 discussed the site's development over the course of the Viking Age and into the late Norse period (ca. 850 CE to ca. 1200 CE), which occurred in five distinct phases, documented by Hamilton, (1956).

Particular attention was paid to the site's initial placement on a settlement mound with components dating back to the Neolithic (Dockrill & Bond, 2009; Hamilton, 1956). As well as to the site's orientation and architectural changes over the course of Norse occupation at the site, as this had direct implications for the later visibility analyses.

In order to investigate the non-tangible networks that seemed to have bound these diasporic communities together, three inter-related GIS-based analyses had to be developed using ArcGIS Desktop 10.8.1, which was the focus of Chapter 7. These included a Cumulative Viewshed Analysis (CVA), which provided a settlement-based perspective that was firmly based in the architectural orientation of the site, which allowed for clear temporal distinctions. A Maritime Least Cost Path Analysis (MLCAP) which modeled potential sailing routes from three Viking Age archaeological sites in the Orkney Islands to the Norse settlement at Jarlshof. The results of this analysis also provided the ground work for the final visibility analysis. This analysis was a Fuzzy Cumulative Viewshed Analysis (FCVA) which provided the perspective of an observer sailing from the south towards the settlement at Jarlshof, using the ship-based mobility modeled in the MLCPA.

There has long been a dearth of information relating to the settlement and occupation of Scotland by Scandinavians during the Viking Age, when compared to other regions at the time such as France, England, and Ireland (Barrett, 2003; 2010; 2012a; Bond & Dockrill, 2016; Downham, 2007b; Ó Corráin, 2001). This thesis has aimed to contribute knowledge to this area, by approaching the settlement and occupation of the Northern Isles of Scotland from the perspective of insular interconnectivity, which in turn was evaluated through the use of a geospatial technologies.

Throughout the Norse occupation at Jarlshof, Mainland Shetland, UK (ca. 850 CE - ca. 1200 CE) the settlement maintained a relatively consistent degree of visibility of their surroundings. I argued that this could be a reflection of conscious decisions of the site's occupants to maintain views of the landscapes and seascapes that surround the site. The same did not hold true for the site's visual prominence from the sea, despite clear evidence of the site's continued growth and archaeological evidence for its occupant's participation in local and long-distance trade and exchange, (Fanning,1994 Hamilton,1956; Hansen, 1993; 2003; Hunter, 2008). This led me to conclude that the lack of intervisibility was not a factor that impacted the sites accessibility, and thereby its interconnectivity with other sites within the broader diasporic network.

It is reasonable to assume, given that the site itself was not visible from the sea, that it would have had to be identified by its relation to other waypoints, topographic features, or coastal landmarks. This would mean someone sailing to the site would have to know both the surrounding landscape and seascape in order to successfully reach it. The results of the MLCPA support these assertions; they indicate that the more familiar a navigator was with a particular route, the less time would have to be expended familiarizing themselves with specific waypoints or potential dangers (Thirslund, 1997; USHO, 1915). The longer the voyage, the greater impact this would have. With respect to interconnectivity, these findings support the assertions that the maintenance of sailing routes between insular locations required that sailors had working knowledge of the local character of not only the seascapes, but also of the coastal topography along a given route. In other words, the better a navigator knew the route between their port of origin and their intended destination, the greater the likelihood that those sites would remain connected, especially over longer distances.

Future Research

All of the major excavations that have taken place at Jarlshof are largely confined to the early to mid-1900s prior to the advent regular use of absolute dating methods in archaeological practice (Bruce, 1906-1907; Curle, 1935; Childe, 1937-38; J. S. Richardson 1936-1939 as cited by Hamilton, 1956; Hamilton, 1956). Fortunately for those early excavators, the windblown sands at the site allowed for a high degree of accuracy in term of the site's stratigraphic sequence (Hamilton, 1956). Never the less, there have been a number of issues raised regarding the dates assigned to different periods of occupation at the site (Dockrill & Bond, 2009; Fanning, 1994). While Bond and Dockrill (2009) took samples for radiocarbon dating from the Neolithic and Bronze Age components of the site, there is a lack of clarity in terms of absolute dating for the other site components, particularly, spanning from the Iron Age into the Medieval period. As such, the acquisition of samples to be used for radiocarbon dating, from these later occupational periods at the site, whether from new or preexisting samples would be of great benefit to the understand the site's chronology.

3D Simulation

In order to provide a more immersive experience, Three Dimensional (3D) simulations using GIS or other 3D software applications could be applied (Richards-Rissetto, 2017). Ideally, this approach could be applied to the FCVA portion of the analysis as this provides a joint mobility and visibility experience that could better represent the experiential aspects of both past landscapes and seascapes. This would also serve as an attempt to move this GIS-based analysis away from "detached objectivism" towards a "situated subjectivity" (Lock et al. 2014). Additionally, process necessary to achieve this, would provide an even deeper understanding of the settlement as well as of the ship, because of the need to render these features into a three-dimensional form. This process was tested out using Sketchup during an earlier semester of my master's work. Figure 11.1 depicts the end result of the 3D reconstruction of Phases II of Norse occupation at the site.

Expanding the Scope of Work

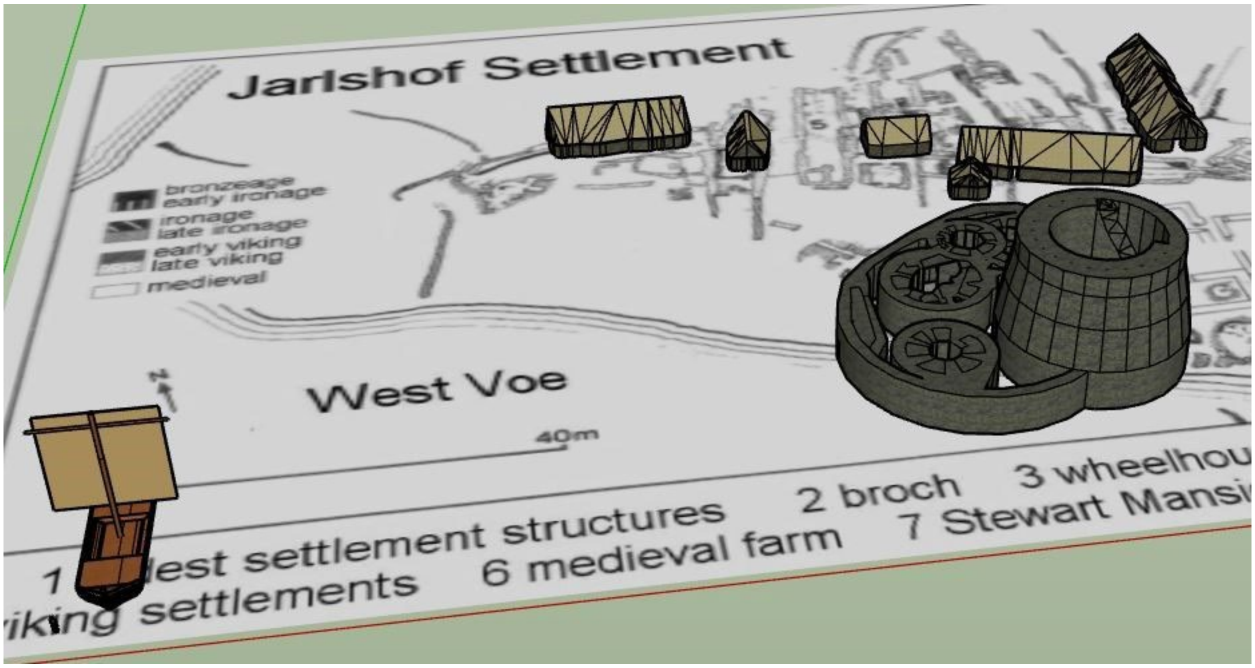


Figure 11.1 This image is a depiction of Phase II of the Norse occupation at Jarlshof, with the addition of a reconstruction of the Early Iron Age Broch and Skuldlelev 1 for scale.

In his discussion on Viking Age navigational practices, Thirslund (1997) notes that many of the Viking Age settlement locations detailed in the Sagas are located near coastal promontories. This suggests that working knowledge of not only local waters, but also the topography of far-off coastal landscapes was pivotal to the maintenance of local and long-distance sailing routes in this period. Given the findings of this thesis, that the lack of intervisibility between observers on land and sea, did not impact its interconnectivity (i.e., the archaeological record at the site's support for its occupant's engagement in local and long-distance trade), future work might consider how other settlements within these diasporic networks maintained their own connections (Fanning,1994 Hamilton,1956; Hansen, 1993; 2003; Harrison, 2013; Hunter, 2008; Sindbæk, 2012; 2019; Wallace, 2016).

The Viking diaspora into the British Isles and North Atlantic offers up a number of potential avenues for the implementation of GIS-based analyses that focus on the investigation of interconnectivity. For example, Hansen, (1993;2003) argued for the engagement of settlements in the Faroe Islands in long distance trade with Dublin, or other Hiberno-Scandinavian sites. Harrison's (2013) discussion of the placement of many Viking Age settlements in the Northern Isles on settlement mounds that seem to have visually dominated bays and sea approaches. Such research could also stem from another perspective, in which the focus on interconnectivity was centered on Dublin as a Viking Age trade emporium and its links to the broader diasporic networks in the west ((Fanning,1994; Hansen, 1993; 2003; Hunter, 2008; Sindbæk, 2012; 2019; Wallace, 2016).

A Land-based Perspective

Another approach to future research that might be considered, involves the further analysis of Jarlshof through a GIS-based lens. As the results of the FCVA indicate that the site was not visible from the sea, it is still possible that the visual prominence of the site did increase from the perspective of a land-based observer which would have implications for the site's defensibility and its visual prominence and there by its authoritative position on the landscape (Martindale and Supernant, 2009; Sevenant and Antrop, 2007). Therefore, the consideration of how a land-based observer might perceive the site through time is another potential avenue of research. This could involve not only the consideration of the late Iron Age and Viking Age sites in the immediate vicinity of Jarlshof, but could also be extended to other Viking Age farmsteads in the Shetland islands by way of comparison in terms of their prominence on the landscape from a land-based perspective.

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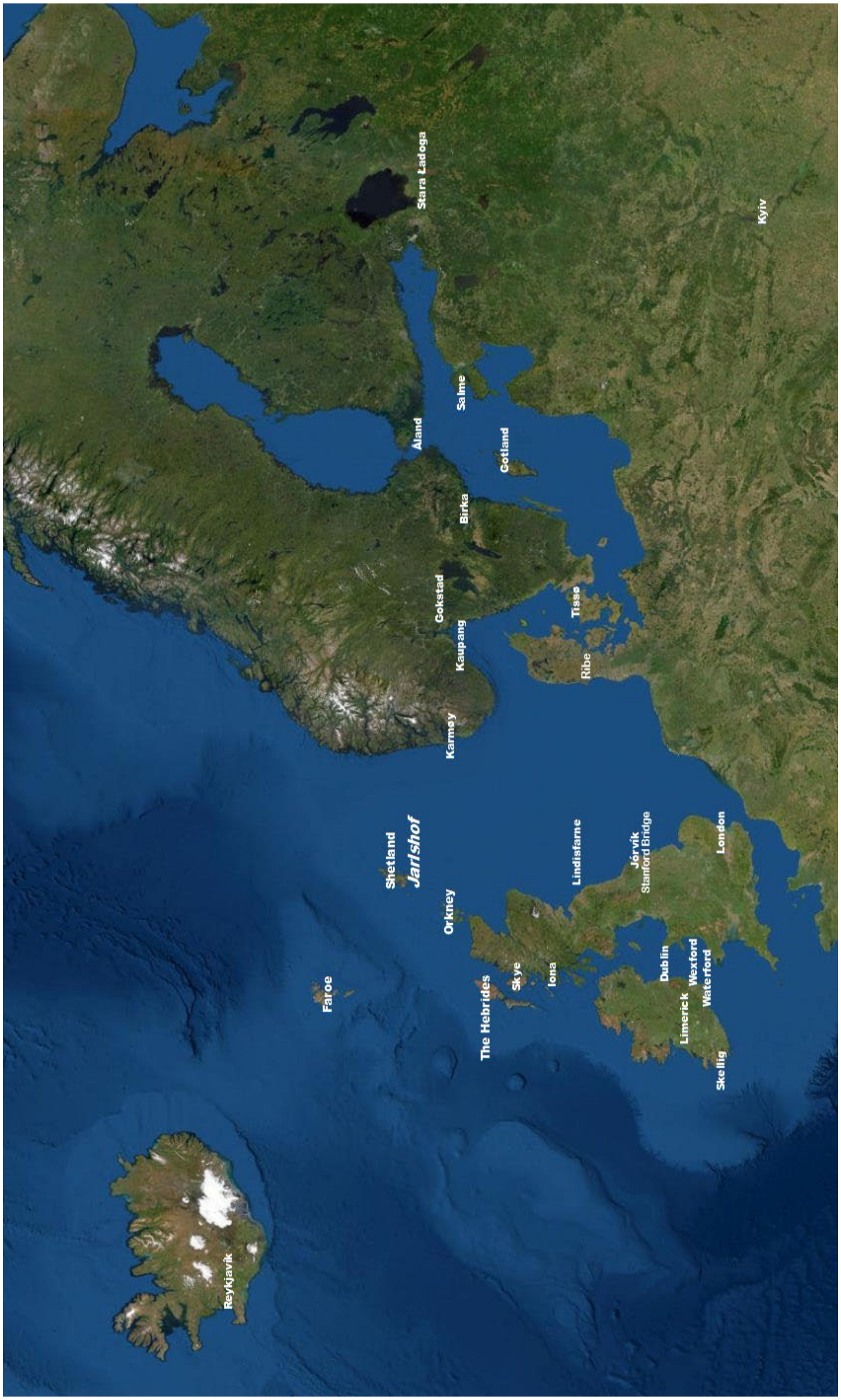
APPENDIX A: MAP OF NORTHERN EUROPE INDICATING LOCATIONS MENTIONED IN TEXT



APPENDIX B: CHAPTER 7 METHODS EXPANDED

Thus far, the physical and socio-cultural connectivity of insular communities throughout the western Viking World has been discussed. This connectivity could be described as past people's engagement and entanglement with their environment, whether terrestrial, maritime, or an amalgam of these variable regions. This amalgam of land and sea can be viewed as a unified cultural 'landscape' composed of both terrestrial and aquatic environments. I would argue that the inextricable nature of these land- and seascapes begs the investigation of their associated cultural 'landscapes'. The following section will discuss the methods used to tailor landscape archaeological techniques to not only insular and coastal sites, but also to the seascapes themselves.

Anna L. Tsing argued that "Landscapes are not backdrops for historical action: they are themselves active," (2015:152). If we acknowledge that landscapes, today as in the past, were active, cognitive aspects of perception that we experience every day need to be considered. The use of models that consider the impacts of visibility or motion have often been used as a means of distancing geo-spatial models from the tradition detached objectivism of the top-down or 'bird's eye' perspective inherent in traditional GIS-based analyses (Llobera, 2001; Lock et al., 2014, Richards-Rissetto, 2017; Sullivan, 2017). The implementation of visibility or mobility analyses has a humanizing effect on GIS-based investigations; therefore, by investigating not only visibility, but also movement, a perception-based model that more accurately depicts the experiential use of the landscape as well as the seascape can be developed.

The case study for the methodology discussed below will be the Norse settlement at Jarlshof at the southern tip of the Mainland Shetland, UK during its occupation from 850 CE-1200 CE. The purpose of the model is to determine whether intervisibility could be possible between a mobile sailing ship and the coastal settlement at Jarlshof and whether that visibility might contribute to the site's interconnectivity overtime. Admittedly, the complexities of the cognitive interplay between motion and the perception of motion are difficult to pin down empirically. Therefore, in order to contribute to the development of knowledge in this area it is necessary to develop a rigorous and explicit methodology by which the investigation of these interrelated concepts can occur. To achieve this, it will be necessary to conduct two distinct forms of visibility analyses as well as a mobility analysis. The steps involved in the development of the methodology employed for the land based Cumulative Viewshed Analysis (CVA) will be discussed first, followed by the Maritime Least Cost Path (MLCP) mobility analysis and the associated Fuzzy Cumulative Visibility Analysis, (FCVA) will be discussed last.

360° Cumulative Viewsheds: The View from the Settlement

The final visual analysis to be discussed is a Cumulative Viewshed Analysis (CVA), which will provide the perspective of an observer from the perspective of the settlement. Cumulative Viewshed Analyses are methodologically robust and are not statistically or computationally complex (Wheatley, 1995). One of the benefits of using CVA is that it allowed for the selection of observation points linked to the structural development of the site. Which in turn allowed for the consideration of architectural changes though time so that changes in overall visibility could be compared across periods of occupation.

Georeferencing and Shapefile Formation:

To ensure that the Cumulative Viewshed Analysis accurately reflected the orientation and scale of the settlement in the past, two site maps –Phase II and another for Phase V- were selected from Hamilton (1956) were georeferenced. These two site maps were selected because they not only depicted the structures within their own occupational phase, but also provided outlines of where the decommissioned structures from the previous period were located in relation to the structures in the phase under scrutiny. This allowed for two rather than five site maps to be georeferenced, which both aided the overall speed and accuracy of the process. This was done by comparing the ArcMap Base map (World Imagery) and the 1m resolution DSM and 1m resolution DTM data files for the southern portion of Mainland Shetland acquired through the remotesensingdata.gov.scot with the georeferenced site maps (SG & JNCC, 2021).

Once these files were brought into ARCGIS their datum and corresponding coordinate systems were transformed from GCS_OSGB_1936 to GSC_WGS_1984 using the transformation OSGB_1936 to WGS_1984_7. This was done because the DTM and DSM raster files were the only layer not employing WGS_1984. For ease of identification, each DTM or DSM raster file retained their original file names which indicate their location within the British National Grid, in which HU stands for a 100km square that surrounds the majority of the Shetland Islands and the associated number denotes easting and northing of the specific 10km grid. For example, Hu_30_DTMPhase2 was the raster file that encompassed the boundaries of the site itself and the surrounding area. The DTM files were bare-earth raster data while DSM raster files still had all historic and modern structures. The variable perspectives of these different views allowed for increased accuracy when placing the ground control points. The points were placed at easily discernable location on both the site maps and the various data layers such as building edges, corners, and doorways.

Shapefiles were then created for each phase of settlement occupation so that the individual polygons represented the floorplan of each structure and were assigned values attribute fields that detailed the structure and the period it was in use. The Feature classes for

Phase V and Phase III were based off the initial floorplan feature class developed for Phase IV due to the reduced number of alterations required to adapt the new features classes and Phase II and Phase I were based off the floorplan for Phase III.

Structure 1D from Phase I at Jarlshof was not included in the analysis for three reasons: first, the degree of dilapidation of the structure at the time of excavation made it difficult to determine the location of the door for the structure, although the possible extent was approximated, and it seems to have been of a size with the smaller outbuilding of the period. Secondly, none of the site maps explicitly document the structure in direct relation to others from any of the periods. Lastly the structure's approximate location on the far northwestern end of structure 1C suggests that its presence or absence is unlikely to have had a significant impact on the scope of the other viewsheds for the same period.

Structure Height Estimation

According to Eriksen (2019) there have been four Iron Age doors recovered from sites across Scandinavia that have provided complete height measurements including sites on the Island of Gotland, at Hedeby in Denmark. Of those doors, two had a height of 180cm, one a height of 165cm dating between the sixth and ninth centuries, while the oldest had a height of 115cm (Eriksen, 2019). Despite the small number of preserved doors, Eriksen (2019) argues that during the Viking Age average door height was equivalent to the average height of a woman of that time, or slightly taller. This assertion is based on the height estimates developed by Sellevold et al. (1984, as cited by Eriksen, 2019) mentioned above (164cm for females and 174cm for males) The total wall height for the structures could therefore be reasonably estimated at 2m.

While little is known archaeologically of what the roofs of the period were constructed of, Eriksen (2019) argues that the most likely method that would have been employed is thatching. Thatching is a roof covering composed of dead plant materials, such as birch bark, straw, or turf (Eriksen, 2019; Hall, 1988). Hamilton, (1956) draws ethnographic comparisons with contemporary rural croft cottages of Shetland and Viking Age vernacular architecture postulating that the Shetland croft was the direct architectural descendant of the Viking Age longhouse in the region. According to Hall, (1988) thatch roofing requires a bare minimum of a 45° pitch, and preferably closer to 50°. This is because the steep pitch of the roof allows the water or snow to run off and if a house were built with a pitch lower than 45°, then the thatch would decay at a rapid pace (Hall, 1988).

A 45° pitch means that the height rises vertically at the same rate the distance is crossed horizontally. So, if we consider House 1 from Jarlshof which has an architectural footprint that is 20ft across and 70ft long, the height of the roof alone would be a minimum of 10ft high, approximately 3m (Hamilton, 1956). Making the overall structure of House 1 approximately 5m tall; this same approximation can be extrapolated for Houses 2 and 3 which had similar dimensions. It is for this reason that the assigned height to the polygon floor plans for each settlement phase was set at 5m for all structures. This was achieved using the Add Z Information tool was used to assign a minimum z value of 0 and a maximum z value of 5 to all polygon feature classes in all phases. The polygon feature classes were then converted into raster data using the maximum z values to assign the structures their maximum height. The Output for this process was Phase_I_Jarlshof_PtoR.

It is acknowledged that this results in a series of unevenly shaped, 5m tall polygons, without considering the actual shape of the roof (a roughly 3m tall 45+° triangle) in the analysis.

This assignment also ignored the potential for variability in roof heights for the smaller structures, or even wider outbuildings. By selecting the minimum possible pitch for these three structures it means that this in turn maximizes the potential visibility around these three structures and provides pitches of closer to the ideal 50°s for the smaller structures.

Merging, Masking, and Preparing Raster Files

Once all five of the newly formed settlement phase raster layers were completed, the Mosaic to New Raster Tool was used to merge the Ordinance Survey DTM raster files Hu30, HU31, HU40, and HU41 into a singular 1m resolution DTM file. That file which covered the extreme southern portion of Mainland, Shetland was named ‘HU_DTM’. The spatial resolution of 1m was maintained for this new raster layer. At this point the Polygon to Raster phase layers (PtoRs) were reclassified using the following Map Algebra equation in the Raster Calculator:

Con(IsNull(“ Phase_I_ Jarlshof_PtoR”),0, “Phase_I_ Jarlshof_PtoR”)

The processing extent of this equation was changed so that it was the ‘same as layer HU_DTM’. The output raster dataset was Phase_I_Data_to_0 and this process was repeated for the other four phases. This effectively changed all empty values to 0 and prepared the settlement footprint raster files, from each phase, to be combined with the HU_DTM raster file. The map algebra for this process was:

“Phase_I_Data_to_0” + “HU_DTM”

This Raster Calculator function created the ‘Phase_I_UrbanDEM’ raster as its output. However, it was determined that the spatial extent of this raster exceeded the necessary size for the study area to the north by several kilometers. Therefore, it was decided to select a subset of this larger raster to run the analysis in order to save on processing time and increase the accuracy and functionality of the analysis results.

A new polygon shape file was created and placed over the top of the Phase_I_UrbanDEM raster layer. These two file types were used as the input values for an Extract by Mask process which created a new spatial extent from the Phase_I_UrbanDEM using the processing extent of the shape file. The output of this process was the 'Extract_Phase_I' raster file which encompassed the whole of the study area without including the extreme northern portion of the Phase_I_UrbanDEM. This new Extract_Phase_I raster could then be used to run the Cumulative Viewshed Analysis. This same process was repeated from the UrbanDEM layer associated with each of the later phases (II-V). The last step before running the analysis was the creation of the points of observation for each phase of occupation. In the case of Cumulative Viewsheds, the observer points selected are not random, but instead are intended to be either a set value or hold some level of cultural significance.

Observer Point Selection

One aspect to consider is the potential for past actors to be at a given location within the settlement at any point in time. Given the multi-phased nature of this research, this is especially true, because the viewsheds that occur in one phase of occupation may become impacted by changes in the orientation or extent of existing structures, the erection of new, or decommission of older architectural features over the course of the five occupation phases examined here. It is for this reason the selection of observer points was based on architectural features. Fisher (2009) discusses physical and social boundaries and their expression in architecture, with a particular focus on the doorway. The lived experiences of past peoples often result in the patterns of movement both within and around habitation centers (Boyd, 2016; Eriksen, 2015; 2019; Fisher, 2009).

We pass through doorways innumerable times over the course of an average day, but it is rare that we take the time to actually consider them as architectural features. Boyd, (2016) and Eriksen, (2015; 2019) discuss the significance of entryways as gateways between private and social life; this perspective enables a more nuanced understanding of human action, interaction, and experience. Marianne Hem Eriksen (2015; 2019) views doorways as symbolic of the processes of transition and transgression because they serve as 'access control points' to structures because they both create and limit access to a given space. Fisher, (2009) and Eriksen, (2019) suggest that it is this physical process of transitioning, which takes place in doorways, -passing from one space into another- that makes doorways an ideal place from which to observe the space differentiated by the presence of the doorway itself.

Taking this into account, it is reasonable to assume that actors in the past crossed through the thresholds of the various structures within the settlement at Jarlshof with some degree of regularity, and certainly at a higher frequency than at a randomly selected point in the settlement. It is for this reason that the space directly outside of the doorways at Jarlshof were selected as the observation points for the 360° Cumulative Viewsheds that were run for each of the five phases considered in this research. Each observation point was assigned an OFFSETA value of 1.7m, this value was selected to represents a height value between the averages from the period for male and female individuals. These calculations are based on the work of Sellevold et al. (1984, as cited by Eriksen, 2019), who documented the average height of male and female Scandinavians during the Viking Age as being 174cm and 164cm tall respectively (on average).

To create the observer points for each phase a new point feature class was created. Each of the point feature classes that were created represent all the observation points in each phase. This feature class was assigned attribute fields to indicate which doorway each point represented as well as the standard OFFSETA (observer height) of 1.7m. Another attribute was added, RADIUS 2, and was set at 4828.03m (3 miles) which is just under maximum extent of human vision when the curvature of the earth is considered for an individual who is 1.7m tall (Young, 2003).

Figure 7.1: Jarlshof Settlement Phase I polygon structures (green) with observer points (7) placed outside all of the doorways to the structures (purple).

Figure 7.2: Phase II polygon structures (purple) with observer points (11) placed outside all of the doorways to the structures (green).

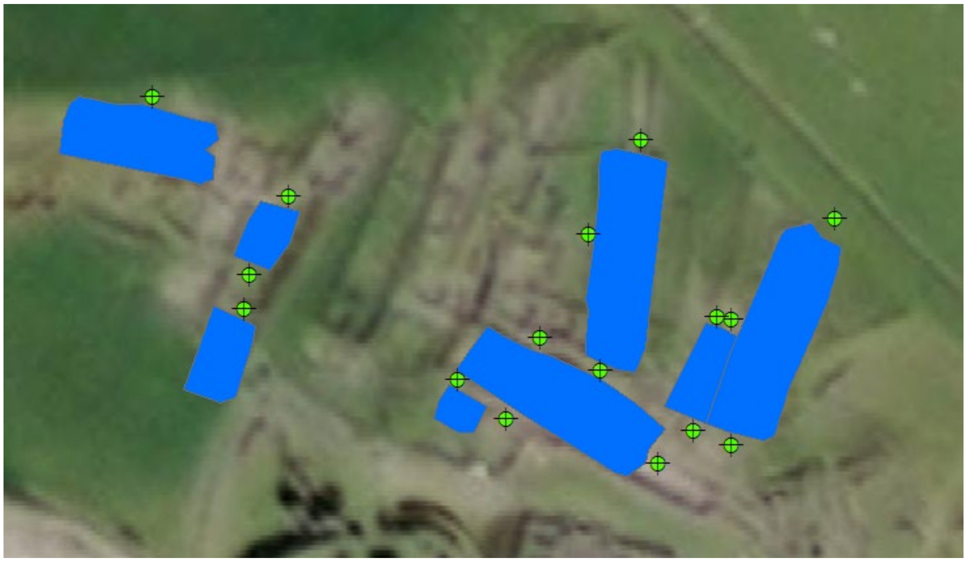


Figure:7.3 Phase III polygon structures (blue) with observer points (16) placed outside all of the doorways to the structures (green).

Figure 7.4: Phase IV polygon structures (yellow) with observer points (18) placed outside all of the doorways to the structures (red).

Figure 7.5: Phase V polygon structures (red) with observer points (14) placed at all doorways to the structures (blue).

Cumulative Viewshed

The Viewshed tool runs a 360-degree horizontal viewshed analysis that continues without end and has a vertical observation range of 180 degrees set at 1 unit above the ground surface. The attribute fields mentioned above alter the parameters of the standard visibility analysis. OFFSETA allows for the height of the observer to be changed, while the RADIUS2 field sets a maximum spatial extent of the analysis. These values were maintained for all five renditions of the analysis allowing for observations to be made regarding how changes in the settlement layout overtime may have had an influence on the overall visibility from the settlement into the surrounding landscape and seascape. It was decided that the modern sea surface data that was captured during initial LiDAR data collection would be left in the settlement CVA analysis, rather than being altered as with the FCVA analysis -see below-, because it provides a sense of how wave motion actively impacts visibility. (Refer to Figures 8.1-8.5 in the results section).

Once each analysis was run successfully, the resulting data fields were reclassified using the 3D Analyst reclassify tool. This converted the output values from the viewshed into a Boolean Raster. This means they were assigned binary values [0,1] in lieu of their previous values which were based on the number of points that could see each pixel. This conversion allows us to visualize what is visible from the settlement observation points and what is not for each of the phases. Following this step, a new field was added to the output raster 'BoolRastCVA_Phase_I.' That field was titled 'Percent_vis' and using field calculator it was assigned the SUM value of the Count field by inputting:

Percent_vis = COUNT / SUM (value within the sum value in the Count field's statistics). With this final step complete, it was then possible to examine each of the cumulative viewsheds for each of the five settlement phases and compare their visibility percentages.

Considerations for a Mobility Analysis

Conducting a mobility analysis is necessary to identify the potential paths that past sailing vessels may have used to reach the settlement at Jarlshof. Various researchers have employed a number of different methods to model maritime travel in the past including Path Distance (Leidwanger, 2013) Least Cost Path (LCP) and Anisotropic Spread Analysis (ASA) models (Inderuzewski & Barton, 2006; 2008) In these models the primary means of propulsion on open bodies of water, such as oceans and seas, was wind direction and strength which all researchers agreed was a crucial aspect of sail-based travel (Leidwanger, 2013; Inderuzewski & Barton, 2006; 2008). However, as discussed above, Gustas and Supernant (2016) found that rather than focusing on converting slope-based land methodologies, inputting cultural values as costs to motion could also be beneficial in modeling potential sea-based coastal travel routes. The dynamic nature of an ocean, due to the impacts that climatology, seasonality, and weather patterns would have had a profound impact on the decisions and actions of the crews of oceangoing vessels anywhere in the North Atlantic region. In this, waters around Jarlshof are no exception, and therefore demand a less simplistic assessment of their potential costs.

Selecting The Ship

As previously discussed, inter-insular connections between diasporic communities throughout the Viking Age have been demonstrated through the distribution of a number of diagnostic artifact and architectural forms which have been identified at various locations throughout the western Viking world. The connections between these far-flung settlements were maintained by the numerous sailing vessels which plied the waters of the Norwegian coast, the Irish Sea, and the North Atlantic at the time. The channel leading to the town of Roskilde in Denmark was determined to contain a series of Viking Age ships of various designs and purposes that were skuttled, or purposefully sank, as a defensive measure sometime around 1070 CE (Crumlin-Pedersen, 2016). Collectively, these clinker-built ships are known as the Skuldelev Ships and represent examples of not only the archetypical Viking Age long ship, but also fishing vessels, cargo ships, and smaller coastal vessels (Cooke et al., 2002; Crumlin-Pedersen, 2016). Crumlin-Pedersen (2016) provided a list of general features associated with the clinker-built ship building tradition between 950 CE and 1150 CE. These include a keel-based double-ended hull, a curved stem for both the fore and aft, the frame is encased by a series of overlapping planks comprising the hull which would be fastened by use of rivets or treenails. The outer hull was supported internally by a series of evenly spaced transverse timber, or thwarts, running from port to starboard; in some instances, these supports could be reinforced with longitudinal stringers.

According to Crumlin-Pedersen (2016), while each of the Skuldelev ships proved to have been of different types, they were a variation on a theme, in that they shared the fundamental basics of clinker construction methods, as discussed above, but differ in the functional aspects of their construction. Skuldelev 1 was selected as the ideal vessel for the purposes of this study; the reasons for this are detailed below. Skuldelev 1 is recognized as the most complete example of a Viking Age ocean-going cargo vessels, or *Knarr* yet recovered (Crumlin-Pedersen, 2016). According to Ossowski and Englert (2009) and Crumlin-Pedersen, (1999), Skuldelev 1 is an example of a sailing vessel designed explicitly for sailing, as evidenced by the inability to lower their masts while at sea, and the limited propulsive abilities of the vessel’s four oars. The location where Skuldelev 1 was constructed is significantly closer to the Shetland Archipelago than its final resting place near Roskilde, Denmark. Skuldelev 1 was built in the area surrounding Sognefjord, on Norway’s western coast around 1030 CE; dendro-analysis indicated the vessel, which was originally crafted of heavy pine, was repaired several times throughout its use-life with oak from the area around Oslo fjord (Crumlin-Pedersen, 2016; Ossowski & Englert, 2009). It was a common practice amongst Scandinavian seafarers to conduct repairs and modifications to ships to extend their use-life (Bruun, 1997).

The rounded bows and sterns of *Knarr* not only increased the vessels' potential for storage but also their seaworthiness, making them capable of handling extended voyages across the open ocean as well as stints in coastal waters (Crumlin-Pedersen, 2016; Ossowski & Englert, 2009). The distinctly rounded shape of the bow and stern of *Knarr* was so recognizable that one Saga writer described two women as being '*Knarrarbrigna*' meaning Knarr-bosomed or Knarr-breasted (Crumlin-Pedersen, 2016). Researchers at the Viking Ship Museum in Roskilde, Denmark estimate that Skuldelev 1 was approximately 15.84m long with a beam of 4.8m, a draft of 1m with a displacement of 20 tons, and a $90m^2$ sail (Viking Ship Museum, 2021). It is estimated to have been able to carry between 20 and 25 metric tons of cargo; its modern replica *Ottar* carried a load of 17 metric tons, worth of stone ballasts, on its voyage from Hedeby (Haithabu) to Gdańsk (Danzig) (Ossowski & Englert, 2009; Viking Ship Museum, 2021).

Crumlin-Pedersen (2016) argues that due to the origin of the repairs conducted on Skuldelev 1 as well as its final resting place, it was likely an *austrfararknörr*, a *Knarr* built for use in the Baltic Sea Trade, making it somewhat smaller than those that would have typically seen use on the North Sea and in the North Atlantic. Larger sailing ships such as the Gokstad ship, at 23m long, were in use a century earlier ca.895-900 CE (Ossowski & Englert, 2009). However, it is worth considering that Skuldelev 3, which was also identified as a Baltic-based cargo ship, seems to have been outfitted and constructed in a manner more suited to shorter voyages and calmer waters of the Danish coast and the Baltic Sea while Skuldelev 1 was clearly more robustly built for use on ocean-bound voyages (Crumlin-Pedersen, 2016; Ossowski & Englert, 2009). This position is supported by The Viking Ship Museum (2021) who note the vessels potential for use in the North Sea and the North Atlantic. Modern reproductions of Skuldelev 1 have been shown to be capable of such extensive and dangerous voyages. One reproduction, the *Saga Siglar* sailed from Norway in 1985 and crossed the North Atlantic via Iceland and Greenland onto L'Anse Aux Meadows in Newfoundland Canada (Crumlin-Pedersen, 2016). In fact, *Saga Siglar* would go on to successfully circumnavigating the globe on that voyage (Crumlin-Pedersen, 2016).

Travel Conditions

Skuldelev 1 is estimated to have held a 6–8-man crew and modern sailing voyages with *Ottar* suggest that in stable weather conditions, a watch of four crew members could readily maintain the vessels course and adjust the sail as needed (Ossowski & Englert, 2009). The average speed anticipated for Skuldelev 1 is estimated to have been between 5 and 7 knots (nautical miles per hour) -between 9 and 13 kph-, and a top speed of 13 knots, or around 24kph (Viking Ship Museum, 2021). This speed would likely have been possible when running before the wind and unburdened by cargo, with ideal sailing conditions in mind. Therefore, it is important to consider what conditions would have impacted sea voyages in the late 9th century in the waters around Scandinavia. First and foremost, Englert (2016) draws attention to the ideal sailing season in Northern Europe, which would have lasted from April until September. Englert (2016) based these assertions on High Medieval textual sources, such as *Konungsskoggsjá*, or King's Mirror. He notes that dangerous winter weather patterns including punishing winter gales, advancing cold, and shortened hours of daylight for sailing operations would not have been conducive to prolonged voyages. Adding that today, even in the summer, winds in the region could be unpredictable, unstable, and inconsistent, thus positing the need to maximize sail use, whenever possible (Englert, 2016). As mentioned above, Skuldelev 1 sported a $90m^2$ sail; given that that sail could not be stowed while at sea, wind was likely the primary nautical factor on extended voyages for such vessels (Englert, 2016, Crumlin-Pedersen, 2016). This supports the modeling of a ship under sailing rather than a ship with sail stowed; has major ramifications for the size of the object under scrutiny.

Information Processing, Cognitive Maps and their Role in Wayfinding

The Shetland Islands, as is the case with the Faroes and Orkney Islands, are land masses which consist solely of islands, bays, islets, and skerries (Gammeltoft, 2010). Gammeltoft (2010) argues that it is these same geographic features that are central to life in island communities, not only for the local inhabitants but also to travelers navigating the waters that surround them. They can be viewed as fixed points within an otherwise unceasingly dynamic aquatic environment. It has been argued that the names of islands, holms and skerries may well represent some of the oldest placenames in the archipelagos (Gammeltoft, 2010). The names of these locations constitute a body of linguistic knowledge which, due to its descriptive and often functional nature, has seen near constant usage and relevance over time (Gammeltoft, 2010). This geographical lexicon, if you will, could then be used to generate, inform, and expand upon an individual's understanding of a region's geographic make up, their 'cognitive map' (Golledge, 1999). This metaphor of a cognitive map is used to describe the internal representation of the environment (Golledge, 1999). Mental maps are directly linked to spatial information processing: the way human actors conceptualize their environments and mentally assemble those embodied experiences over time and space, as well as how memory, and second-hand information can influence the implementation of that knowledge (Bernardini & Peeples, 2015; Golledge, 1999).

For the purposes of this section the way mental maps can inform, and influence wayfinding activities and behaviors is of primary focus. Going forward, the basic premise being laid out is that human locomotion in a given environment is intentional, goal-driven, and adaptive. Wayfinding can broadly be defined as the selection and following of a planned route of travel through a given environment (Golledge, 1999). The ease with which a given route can be followed, when considering general route complexity or environmental factors that could represent time delays or physical danger, is referred to as its *legibility* (Golledge, 1999). In instances in which repeated the use of the same route is necessary, due to cultural factors, or the physical legibility of the route, placenames associated with prominent points on the landscape can help accelerate route-learning processes such as the development of mnemonic markers (Gammeltoft, 2010; Golledge, 1999).

In order to remember the various stages of such a journey, such as the physical layout of the route and the experienced environment, are built upon in an integration process in which new information can be identified, processed, and refined into an individual's cognitive map (Golledge, 1999). Bernardini and Peeples (2015) suggest that familiar locations can act as visual anchors (reference points) in an individual's cognitive map, around which other environmental information is based. According to Bernardini and Peeples, (2015) the location's distinctive features, topographic prominence, or cultural salience can all play a role in their selection as prominent aspects of the landscape. When considering potential sailing routes that may have connect various insular locations across the Irish Sea and North Atlantic, it is likely that reference points for an individual's cognitive map along these routes included geographic features such as islands, holms, bays, to headlands or promontories as well as built features such as coastal settlements or outposts (Thirslund, 1997; Westerdahl, 2006). In terms of navigation this methodology is known as pilotage (Indruszewski et al. 2006).

It has been noted by Indruszewski et al. (2006), Thirslund (1997), and Westerdahl (2006) that both prior to and during the Viking Age, pilotage, that is sailing within sight of land and making use of various points along the landscape, was the primary method employed for navigation. However, with the advent of the Viking Age sailing vessels began crossing not only the North Sea, but the North Atlantic; voyages over such long distances necessitated extended periods of travel out of sight of land. Thirslund (1997) brings attention to the importance of navigational knowledge, sailing directions in particular, to the westward expansion that took place during the Viking Age. Thirslund (1997) discusses a set of sailing directions described in the Icelandic Saga the *Hauksbok,* written between 1302 and 1310 CE, which details the route from Norway to Greenland. The text indicates the distance that a ship sailing directly due west, on route from Hernam, Norway to Hvarf, Greenland, should keep from Shetland, the Faroes and Iceland respectively; in order to maintain their proper course (Thirslund, 1997). This would suggest that the same principles used in coastal navigation and cognitive mapping were still employed, when possible, on longer voyages.

If we look at Gustas and Supernant's (2016) investigation of maritime travel along the Northwest Coast of North America, we are reminded that Least Coast Path Analysis allows for the input of not only environmental and physiological, but also cultural variables, that may have been viewed as a 'cost' to movement. This is important because when we calculate the relative cost imparted on an actor when they move through space it is insufficient to conceive only of those costs as being strictly in the traditional topographical realm. On primary goal of Gustas and Supernant (2016) research was not only to evaluate the least cost path on seascapes, but to do so by considering the cultural agency of maritime movement and its influence on movement costs. If we were to apply such a methodology to the North Atlantic, many points of departure and landfall detailed in the Icelandic Sagas are easily identifiable headlands (Thirslund, 1997). The practice of latitude sailing, referred to by the Thirslund as 'equal altitude sailing', was practiced by Viking Age navigators on east-west and west-east bound voyages (Thirslund, 1997) In such instances, navigation is assumed to have been based on the observation of the celestial bodies, in which the altitude of a given celestial body, would hold true over the course of the whole voyage. The 'Leitharstjaerna', or leading star, which we know today as ‘Polaris,’ the North Star is one well documented example (Thirslund, 1997). Indruszewski et al. (2006) remind us that the process of navigation in the past was not a science, but an art: the application of multifaceted knowledge to a practical task: guiding a sailing vessel safely from its origin to its destination.

It has been argued by both Thirslund (1997) and Indruszewski et al. (2006) among others, that there was no formal process that enabled the Viking navigator to develop the cognitive maps, knowledge, and skills necessary to adequately steer and operate a sailing vessel, outside of a longstanding oral tradition and observational learning. Would-be navigators were taught how to observe and adapt to the dynamic nature and volatile phenomena of the sea, and how to safely reach their desired destination (Indruszewski et al. 2006; Thirslund, 1997). One might argue that the safety of the ship and crew takes precedence on any sailing voyage, be it for trade, resource acquisition, or conflict. It is only reasonable to assume that not all reference points used in the past had inherently positive associations, or even visually identifiable characteristics. According to Golledge (1999) cognitive maps are developed in response to feedback from environmental conditions, as well as from the addition of second-hand information. Based on this, it is likely that a navigator's cognitive map would include not only prominent points, but also any features or phenomena that might prove dangerous along a given route, such as, tidal races, or subsurface obstructions such as rock shelves, rocky pinnacles, or skerries.

If the coastal landscape of the Shetland Islands were to be described in a word, it would be 'rocky'. The coast and its environs consist of stark eroding cliff faces, tidal caves, sea stacks, majestic archways, and submerged inlets, skerries, and outcroppings (Hall et al. 2021). These factors, coupled with the severe local and regional wave and tidal forces, particularly on the Atlantic Coast, make navigation in the isles decidedly difficult (Hall et al., 2021; USHO, 1915). Individuals within a coastal community, where any one of these environmental conditions may represented serious threat likely were taught from a young age how to identify locations that should be avoided within both the surrounding seascape and landscape, because for coastal and insular settlements, these were an ever-present aspect of daily life (Westerdahl, 2019).

The United States Hydrographic Office (USHO) produced a navigational pilot for the waters around Scotland; it provides a detailed accounting of the coastal sailing conditions in and around the Northern Isles (USHO, 1915). As it recounts the conditions around the southern end of Mainland, Shetland it explicitly states that the waters around West Voe -the deep bay between Sumburgh Head and Horse Island- should not be entered by sailing vessels because the Bay is exposed to winds out of the south (USHO, 1915). It goes on to state that, while both West Voe and Grutness Voe are, at times, used by local vessels so long as winds are favorable (that is, that wind blowing from the land out towards sea), neither a safe place to put down anchor (USHO, 1915). Given the light weight of clinker-built vessels these adverse outcomes could be avoided by dry docking, beaching longships rather than having them waiting at anchor in Grutness Voe.

Grutness Voe, was reported to have ‘Pinnacle Rocks’ at the entrance to the bay, at a depth of less two meters below the surface (USHO, 1915). While it is clear that this would prove hazardous for modern ships, the clinker-built vessels of the Viking Age had impressively shallow drafts, that is the portion of the ship that resides below the waterline, with some being a meter or less (Crumlin-Pedersen, 2016; Ossowski and Englert, 2009). It is also worth noting that, since that time, Grutness Voe has served as the primary landing site for in-bound and out-bound ferries to Fair Isle in the south because it is a sheltered bay (Morrison, 1973a).

The pilot notes that in the event that weather condition change, so that the wind blows cold and strongly out of the east, a northbound vessel moving along the eastern side of Sumburgh Head, should change course and round the Atlantic side of Mainland and take shelter in Quendale Bay, which lies on the Atlantic coast of Mainland, just above the archaeological site of Old Scatness, about a mile overland from Jarlshof (Bond & Dockrill, 2016; USHO, 2015). However, grave warnings are given regarding the tidal race that lies offshore of Sumburgh Head and Horse Island (Morrison, 1973a; USHO, 1915). During spring tides, which occur every two weeks with the full and new moon, the tidal stream reaches a speed of 7 knots, and under the right conditions, the roost can cover an area up to three nautical miles wide (USHO, 1915). While during neap tides, which occur once every 14 days, it is often no more than half a nautical mile wide at a speed of 4 knots (USHO, 1915). Instances of ships becoming caught in the ‘roaring roost way’ and losing their way or being scattered by the unpredictable tidal currents Orkineyinga Saga and the navigation pilot (1915) recounts vessels being tossed about for days even in light weather (Morrison, 1973a).

It does not bode well for the navigator of a sailing ship that not only the exact extent, but also the location of the roost itself can change in accordance with the strength of the tidal stream

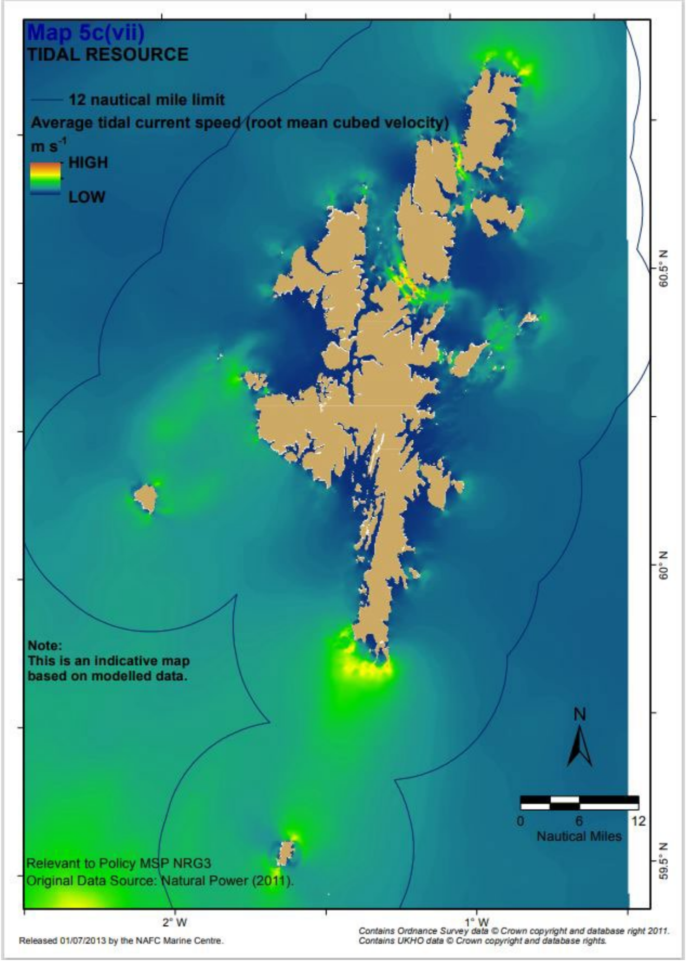


Figure 7.6: A tidal energy map produced by The Shetland Island Council that indicates the location of the Sumburgh Roost directly off the southern tip of Mainland, Shetland (neon yellow-green).

and the opposition of wind and current (USHO, 1915). While it is known to occur often off the shore from Sumburgh Head, conditions can also cause it to occur just to the west side of Horse Island, which lies approximately one nautical mile to the southwest of Sumburgh Head (Morrison, 1973a; USHO, 1915). Taking all this into account, it is reasonable to assume that navigators of Scandinavian vessels in the region would have given the roost a wide berth whenever possible. For this reason, the maritime area encompassing the Sumburgh Roost, was assigned null values during the LCP analysis. With the assumption that sailors would be aware of the dangers of the Roost and typical weather patterns of the area, and justifiably avoid the area. The Shetland Island Council's tidal energy map indicating the location of the Sumburgh Roost directly off the southern tip of Mainland, Shetland can be seen in Figure 43.

Maritime Least-Cost-Path Analysis

The basic steps involved in a GIS based Maritime Least-Cost-Path Analysis, for a sea-based voyage, presented in this research, are a blending of those employed by Indruszewski and Barton (2008) and Gustas and Supernant, (2016). Those steps are as follows:

First, three cost surface raster grids were created, in which the value of each cell represents the relative costs, in this case, resistance to movement, for the area under investigation. For the purposes of this model these values will be based on current velocity and directionality as well as the visual prominence of coastal promontories, this will be discussed further in the section on landmarks, features, and the visual structure of landscapes.

This is followed by the creation of an accumulated cost distance grid, where each cell within the grid represents the total costs incurred by traveling from the designated starting location (origin point) to all the other locations in the study area. Next, a backlink grid (a cost-direction surface) is developed using the accumulated cost surface that indicates the costs incurred by directionality of travel in each grid cell. In a land-based Least Cost Path analysis this would be seen as the greater energy cost associated with traveling upslope versus the reduced cost when traveling downslope. For this aquatic model however, as Gustas and Supernant (2016) note, slope literally does not exist in aquatic environments. Although many researchers have used the concept of slope to model directional movement (Indruszewski and Barton (2006; 2008) and Leidwanger (2013) among others) it was decided that two cost surfaces modeling both current directionality in a singular direction and their speed in m/s in that given direction would be used in place of slope for the purposes of these analyses.

Once this is complete, the desired sailing route is calculated by determining which path minimized the friction on the vessel as it traveled across the accumulated cost surface from the point of origin to the desired end location. The path of least resistance is the modeled sailing route. To ensure that the ship's desired sailing route did not cross any land area, these locations were treated as null areas throughout the course of the analysis.

Visual Recognition of Coastal Landmarks as Weighted Movement Costs

In their discussion on the social significance of visually prominent landmarks, Bernardini and Peeples (2015) suggest prominent, familiar locations have the potential to skew a viewer's perception of distance or time to the surrounding area by taking on 'visual gravity' and acting as visual anchors (reference points). According to Bernardini and Peeples, (2015) the location's distinctive features, topographic prominence, and perceptual or cultural salience can all play a role in their selection as visually prominent aspects of the landscape. To put it another way, they influence the development of an individual or group's similarly oriented mental maps. Therefore, certain 'visual anchors' may be identified that have the potential to impact the distance the intended sailing route comes to the associated section of the coast. For the purposes of the prescribed sailing route, the headland of Sumburgh Head is taken to have been a visual anchor given that it is not only a prominent headland, but also the southernmost tip of Mainland Shetland.

Adjusting the Sea Surface Data

In order to create a sea surface model, I acquired data from a sea surface model available from the Copernicus Marine Services website (https://resources.marine.copernicus.eu/products). The files I selected were a subset of the Atlantic-European Northwest Shelf- Ocean Physics Reanalysis model. This ocean simulation model included data of horizontal ocean currents as well as sea level from 1993 to the present day. For the purposes of this research, I selected two datasets from this: Eastward Sea Surface Velocity (uo_EastwardCV1ms) and Northward Sea Surface Velocity (vo_NorthwardCV1ms) both were measured in m/s set to a depth of 0 to 15m. I selected these two data sets and specified that they only include data that spanned a 20-year period from December 31th 2000 to December 31th of 2020. This was done so that the data could be more readily extrapolated in order to cover broader temporal spans of 100 years and avoid the possibility of annual inconsistencies. In addition to this, the geographic extent of these files was reduced to enhance processing speeds and better conform to the study area. Both files consist of bands spanning from 61.0°N to 58.5°S and from –3.7°W to –0.3°E. This allowed for the inclusion of the Shetland and Orkney Islands within the scope of the analysis. These NetCDF files were brought into ArcMaps using the Make NetCDF Raster Layer (Multidimensional) tool. As the files were already originally georeferenced using GCS_WGS_1984, their coordinate system was not altered. This tool converted these data sets into two raster layers, one representing Northward flowing current velocities (vo_NCurrents) and another representing Eastward flowing currents (uo_ECurrents measured at 1 m/s, (see figures 7.7 and 7.8).

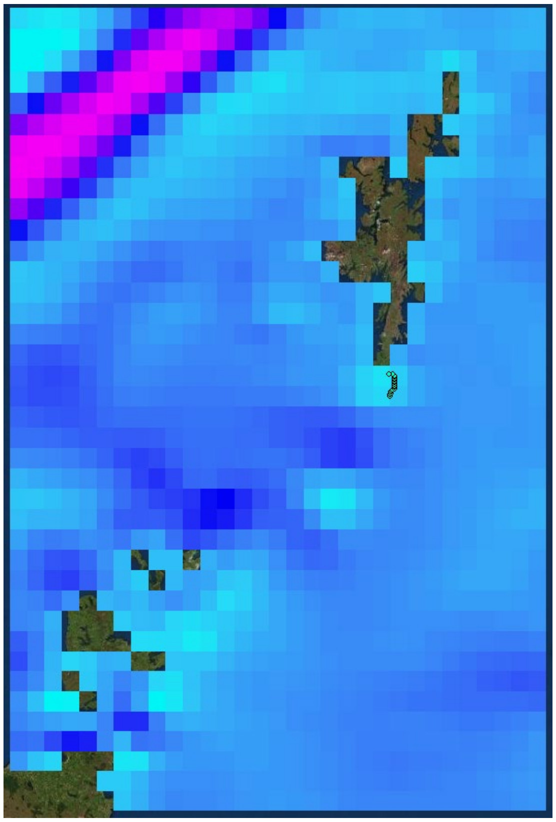


Figure 7.7: Original extent and resolution for the Copernicus Marine Data uo_ECurrents

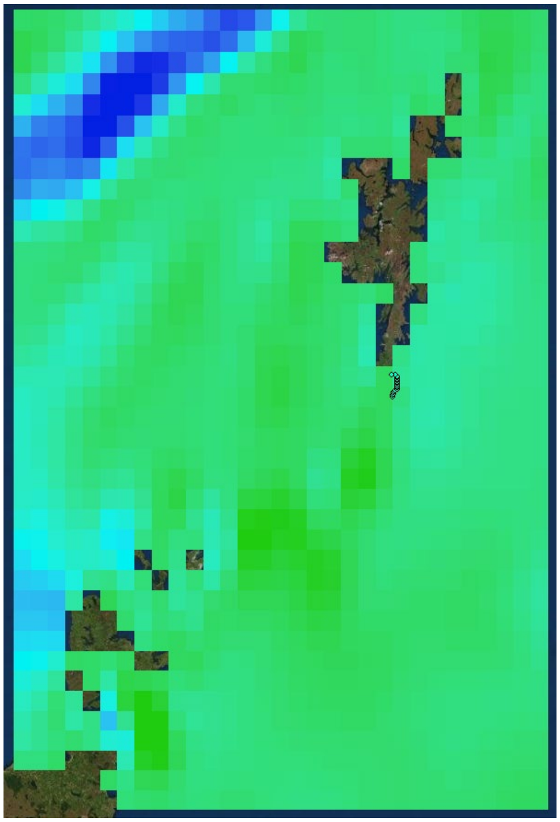
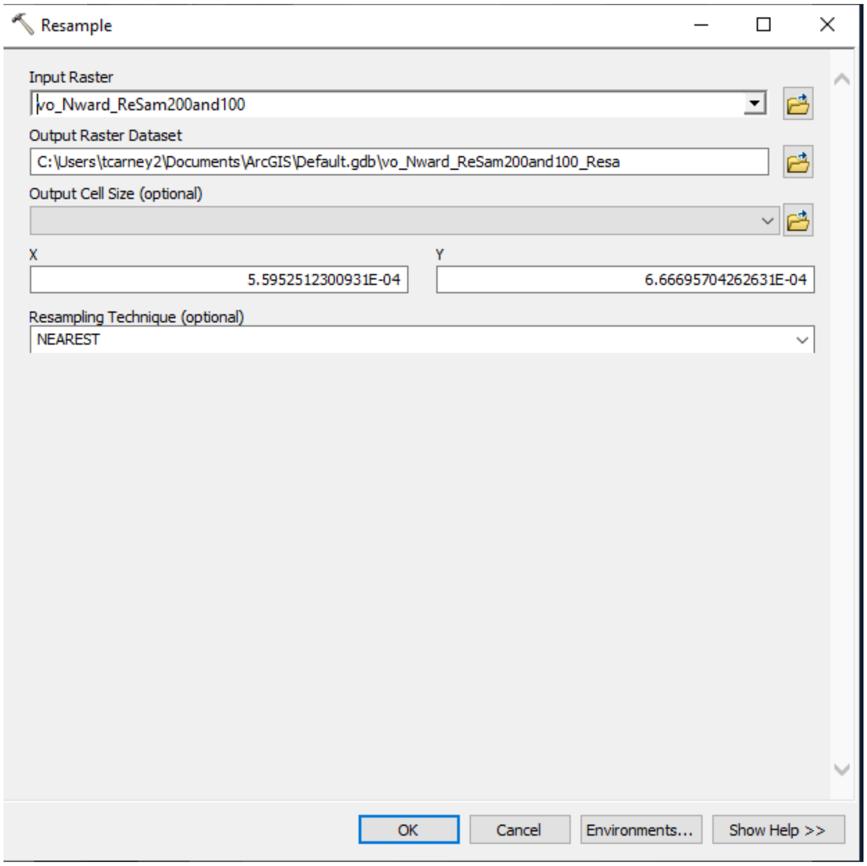


Figure 7.8: Original extent and resolution for the Copernicus Marine Data vo_NCurrents



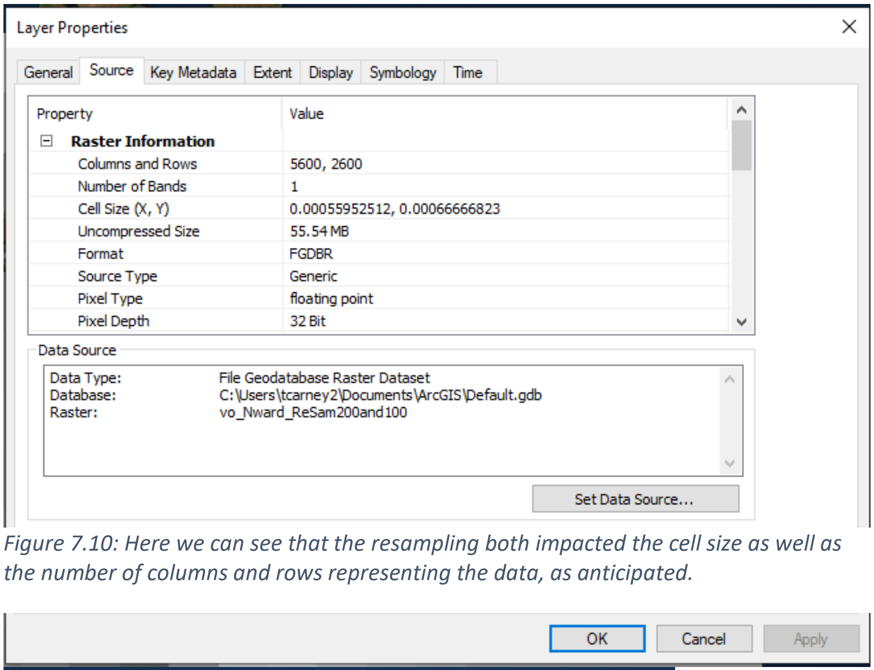
Input Raster: vo_Nward_ReSam200and100
Output Raster Dataset: C:\Users\tcarney2\Documents\ArcGIS\Default.gdb\vo_Nward_ReSam200and100_Resa
Output Cell Size (optional):
X: 5.5952512300931E-04
Y: 6.66695704262631E-04
Resampling Technique (optional): NEAREST

Figure 7.9: The Z Values were adjusted using the Resample tool to reduce their resolution without impacting their values.

The Copernicus current velocity dataset resolutions were in decimal degrees (0.111° × 0.067°). These values were multiplied by 111139 in order to provide the linear meters, (12,336.429m x 7,446.313m). It was quickly noted that there was a discrepancy between the values calculated when using the measuring tape tool, and their Y value resolution in their properties table. The properties table stated the pixel size for the Y values were 0.067°, or 7,446.313m, while the raster pixel size calculated by the measuring tape tool indicated this value was doubled: 14,892.626m. This was due to the number of columns generated for the data, rather than the actual pixel size, as the pixel size clearly states half that of the value displayed visually. Once these values were identified and understood, it was decided that, in order to better model cultural choices associated with proximity to coastal areas, the spatial resolution of the cells would be reduced while preserving their associated values.

The approximately 12kmx7km bands were divided into smaller units while maintaining the original resolution of the data using the Resample Tool in the Data Management Toolbox.

(See Figures 7.9 and 7.10). The cell size for the X values were divided by 200 and the Y values by 100. Resulting in 62.84mx74.09m cells. The new files created were ‘uo_ECurrents_ReSam’ and ‘vo_NCurrents_ReSam’. While these sizes are not ideal, given that they are not neatly divisible or of equal values, they were reduced to this scale in order to allow for the removal of current data overlap with landmasses. As a result, with this reduced spatial resolution of the cells, the ship will not travel overland, which would have occurred previously with the original roughly 12 km x 7km wide bands.



Property	Value
Raster Information	
Columns and Rows	5600, 2600
Number of Bands	1
Cell Size (X, Y)	0.00055952512, 0.00066666823
Uncompressed Size	55.54 MB
Format	FGDBR
Source Type	Generic
Pixel Type	floating point
Pixel Depth	32 Bit

Data Source

Data Type:	File Geodatabase Raster Dataset
Database:	C:\Users\tcarney2\Documents\ArcGIS\Default.gdb
Raster:	vo_Nward_ReSam200and100

Figure 7.10: Here we can see that the resampling both impacted the cell size as well as the number of columns and rows representing the data, as anticipated.

Figure 7.11: Polygon feature classes created to overlay the Shetland and Orkney Islands.

Selecting a Sailing Route

A number of archaeological sites throughout the western Viking world have been discussed thus far. However, by considering archaeological sites in the Orkney Islands allows for the investigation of a historically and archaeologically supported southern sailing route, without the need to place too much analytical stress on the current velocity data. As a longer sea voyage would likely increase the risk of inaccuracies associated with the resulting sailing route. As such, three archaeological sites that were mentioned above in the discussion on the artifactual links between Jarlshof and other localities in the North Atlantic and the British Isles were selected as source locations for the Maritime Least Cost Path Analysis. The locations that were selected as sources for the analysis included the Norse settlement at Quoygrew on Westray, the Pictish and Norse settlement on the Brough of Birsay, off the northwestern coast of Mainland, Orkney, as well as the large Norse Hall discovered under the 19th century farmstead at Skaill, on Rousay (UHIAI, 2019).

Extracting Land Areas and the Tidal Race

Once the raster files were resized, polygon feature classes of the Shetland Islands, Fair Isle, and the Orkney Islands were created titled 'LandArea' (See Figure 48). Many of the major islands were assigned specific names in an addition field added to the shape file to distinguish them from one another. A second polygon feature class 'LandAreaReverseMask' was then created. All the polygon features were clipped out of this overlaying layer so that the outline of the islands could be more easily distinguishable now that the cell size of the original current rasters had been reduced. Unfortunately, the course size of the original current raster files left some areas with NoData values. Fortunately, this was not the case for the Source or Destination locations, but they were,

Figure 7.12: The 'LandAreaReverseMask' polygon feature class was used to remove the current data that covered the land surfaces to increase the overall accuracy of the analysis. This also allowed for the newly adjusted pixel size to become readily visible.

nevertheless covered in raster data. The Extract by Mask tool was used on the 'LandAreaReverseMask' and each of the resized current rasters, 'uo_ECurrents_ReSam' and 'vo_NCurrents_ReSam', to remove the excessive raster pixels from within the boundaries of the islands. This also allowed the new raster pixel size of 'uo_ECurrents_ReSam' and 'vo_NCurrents_ReSam' to become readily observable. (see Figure 7.12).

After this, Shetland Island Council's tidal energy raster file was added to the map in order to identify the location of the Sumburgh Roost. Due to the dangerous conditions this tidal race presents it was elected to exclude it from the analysis, by assigning it NoData value. The same method employed above to extract pixels from the landscape was again used to extract raster values from the uo_ECurrent_ReSam and vo_NCurrents_ReSam. The Output for these raster's became: 'NoDataAreaSet_NCurrents' and 'NoDataAreaSet_ECurrents.'

Reclassifying Currents:

It was decided that an Eastward flowing current would be beneficial until passing 9 original pixels (12,336.429m wide each), or 111.027.861km, from the eastern edge of the boundary of the analysis. This distance would place a vessel to the eastward side of Mainland Shetland; therefore, any movement farther east would increase energy expenditure for a sailing party. The values for the Eastern and Western sections of the 'NoDataAreaSet_ECurrent' raster data were extracted and then their values were reclassified to a common scale, that was later shared with the 'NoDataAreaSet_NCurrent' raster.

When reclassifying these data sets, it was decided to convert the original values, current speed in m/s, into values between 1 and 10. With the slowest currents being valued at 10 and fast a value of 1 for the 'NoDataAreaSet_NCurrent' and 'Extract_Western_ECurrents'. This scale was selected so that the scales across all three friction surfaces would be consistent (see discussion below regarding Euclidean Distance). Whereas the Extract_Eastern_ECurrents received the opposite treatment with slow current speeds being replaced with a 1 and fast currents receiving a 10. Mosaic to New Raster was then used to recombine the Eastern and Western parts of the east flowing currents; this was renamed 'Reclass_ECurrents_Combined.' (see Figures 7.13).

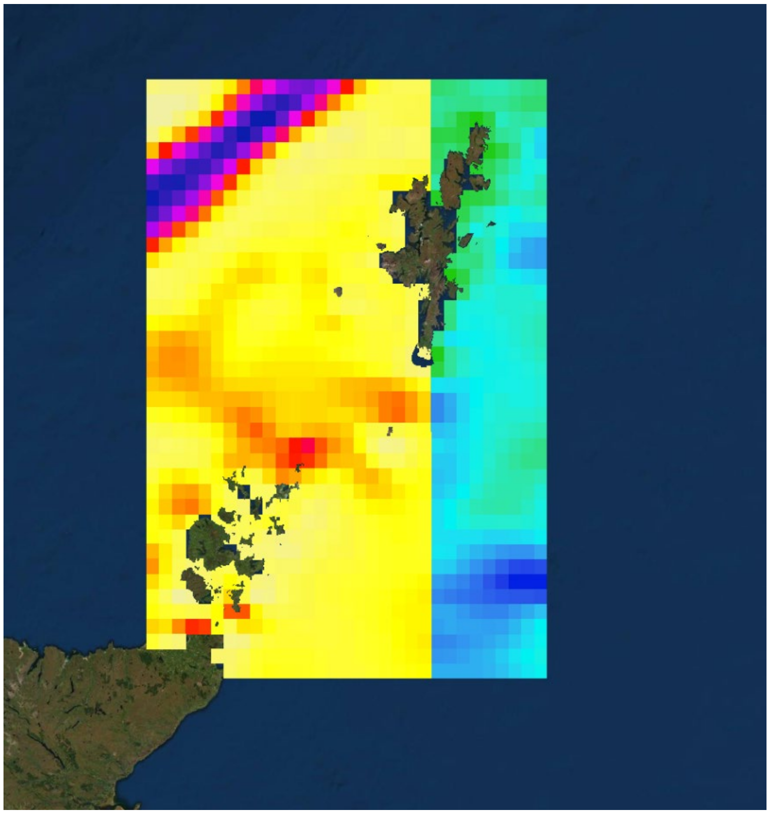


Figure 7.13: Eastward flowing currents after they were separated from one another, and prior to reclassification and recombining them.

Euclidean Distance Coastal Corridor

The Euclidean Distance tool was used to create a raster that expressed the distance from the 'LandArea' polygon with 50m cell size, a value that is relatively in line with the current velocity raster cell sizes. The land area was then extracted from the output raster and titled: 'Extract_Land_Euc_Coastal_Dist'. This new raster file was then reclassified into 10 classes and the breaks were added at 5km intervals up to 45km and everything past that being rated as a 10 (see Figure 7.14).

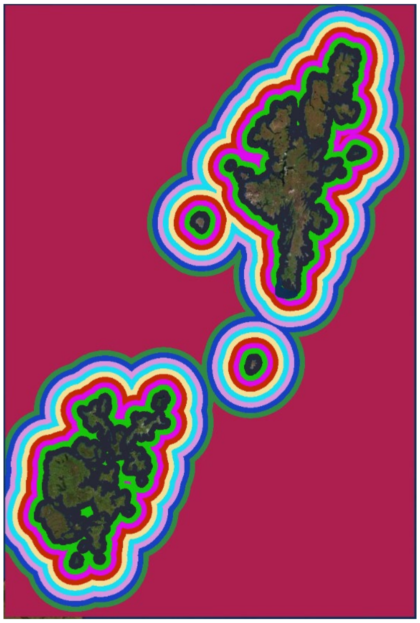


Figure 7.14: Euclidean Distance Surface detailing distance from the coast at 5km intervals up to 45km distant.

To account for the visual and physical proximity necessary to navigate using pilotage techniques, (i.e. sailing in sight of land,) these sailing corridors were assigned greater values as they radiate out from the land, with 5km being a 1, 10km being a 2 and so on. The processing extent was set to be the same as the 'Reclass_ECurrents_Combined' raster. Once this was run, the LandandTidesReverseMap was used to extract the Sumburgh Roost tidal race from the Euclidean Distance Raster. This was done in order to account for the importance of viewing the headlands at Sumburgh Head, while also accounting for the dangers represented by the Sumburgh Roost (USHO, 1915), (See Figure 7.15).

Figure 7.15: Portion of data extracted from all cost surfaces to represent the strongest portion of the Sumburgh Roost.

Weighing Surface Costs

Raster Calculator was used to combine the various surface layers into three weighted combined surface layers. The first Math Algebra equation is detailed here:

Euclidean Distance_reclass * .3333 + ECurrentsReclass * .3333 + NCurrentsReclass * .3333

The output file for that equation was named ‘AllThingsEqual_Weighted_Surface’. This weighting provided a baseline in which the factors considered were not assigned varying levels of importance. This general process was repeated for two other weighted calculations. The second process run was the ‘CultKnowledge50_Weighted_Surface’ calculation in which distance from the coast was weighted at .50 while both current directional speed layers were assigned .25, respectively. This was done to account for the navigational aspects of coastal sailing (i.e., the use of waypoints or prominent coastal features along a route to maintain a proper course). This put greater weight on the cost distance away from land than to the velocity and directionality of the currents. The final calculation considered the current directionality and velocity to be of greater importance, placing .40 on the eastward and northward current surfaces and only .20 on the Euclidean Distance surface. This was done to model a greater reliance on ocean current speed and directionality, while still considering the navigational benefits of sailing within sight of land. The output for that final calculation was ‘Seamanship4040_Weighted_Surface.’ (See Figures 7.16 and 7.17 below)

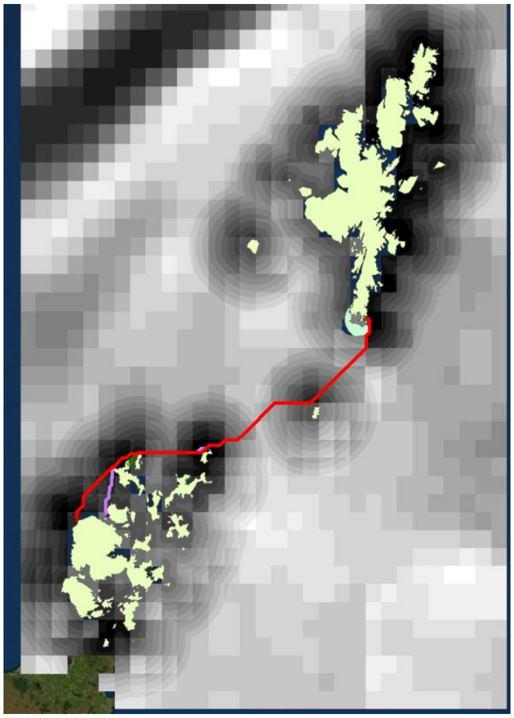


Figure 7.16: All Things Equal weighted cost surface. All friction surfaces were assigned 33.33% influence on the model.

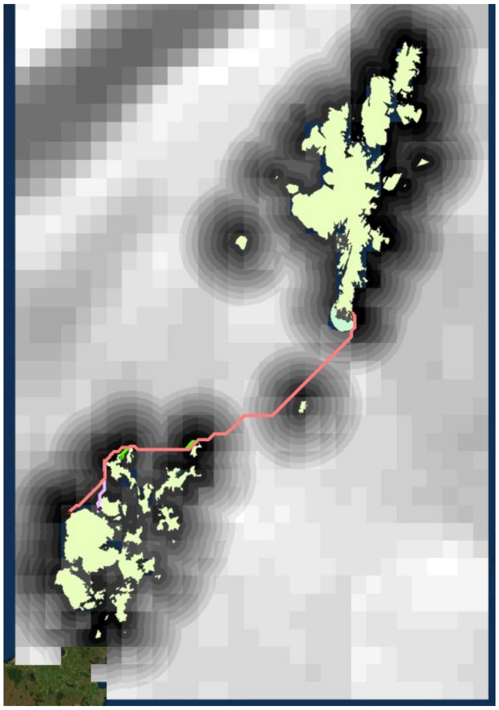


Figure 7.17: Cultural Knowledge weighted cost surface. Euclidian Distance friction surface was assigned 50% and the Eastward Northward Current Velocity friction surfaces were assigned 25% respectively.

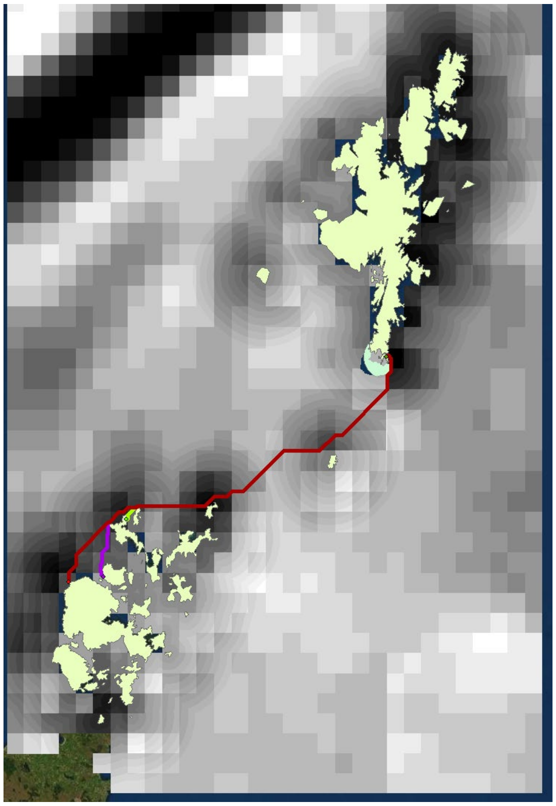


Figure 7.18: Seamanship weighted cost surface, the Eastward Northward Current Velocity friction surfaces were each assigned 40% while Euclidean Distance was assigned 20%.

Cost Distance, Cost Direction. And Cost Path

These weighted raster surfaces were then used as inputs for the Cost Distance tool alongside the selected source data, which was the point feature classes created to represent three Viking Age settlements in the Orkney islands. As mentioned above, the origin points for the sailing routes included the Brough of Brisay, which could also conceivably serve as a shared point for the nearby archaeological site of Buckquoy on Mainland, the Quoygrew settlement on Westray, and the Viking Age Hall recently discovered at the Skaill Farmstead on the Isle of Rousay (UHIAI, 2019). Each of these points were to the Cost Distance tool inputs along with the 'AllThingsEqual' weighted cost surface raster; a backlink raster was generated indicating the directions available to the ship from its source location. The accumulated travel costs for each cell back to the source are also calculated. This process was repeated for each weighted surface at each of the source locations for a total of 18 outputs. These outputs included: nine weighted cost distance raster files, and nine associated back linked weighted direction raster files.

Once the cost distance and cost direction backlink raster files were created, they could be used as inputs in the next step of the analysis as well as the 'Destination' point feature class, which was placed at the head of Grutness Voe. With these inputs the Least Cost Path for each of the nine routes could be run. An additional step was taken to rerun the final Maritime Least Cost Path analyses using the Cost Path as Polyline tool. This allowed the output to be a polyline rather than a raster which allowed for better legibility when it came time to visualize all nine potential routes over such a large distance. (Compare Figure 7.19 with Figure 7.20).

Figure 7.19: Raster Maritime Least Cost Path route outputs from the Brough of Birsay to Jarlshof. Note the lack of clarity in the displayed path.

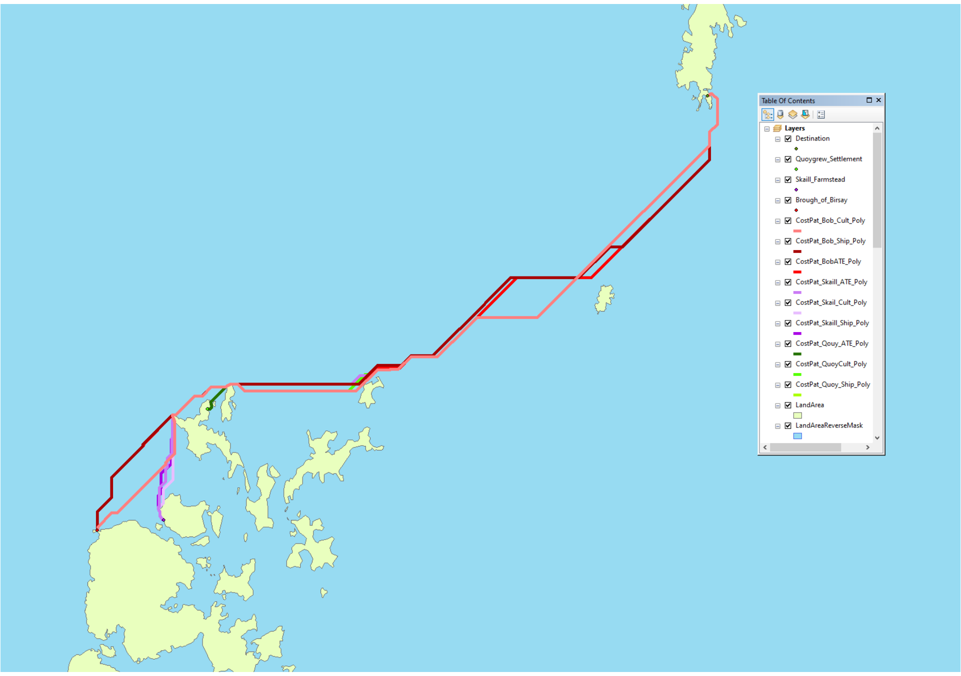


Figure 7.20: Polyline Maritime Least Cost Path route outputs for all weightings and all source locations.

Fuzzy Cumulative Viewshed Analysis

Sea Surface Height Adjustment: The estimation of past sea height was possible with the help of Marisa Borreggine, Evelyn Powell and their colleagues in the Mitrovica Group, Department of Earth and Planetary Sciences at Harvard University who provided local sea height estimation data for the period under investigation. Unlike typical paleoenvironmental models, designed to estimate past sea height in which sea levels in the past are assumed to have varied overtime in accordance with a “eustatic” value, that was averaged on a global scale. Borreggine et al. (2022), challenge this traditional methodology, arguing that significant changes in past sea height have, and continue to take place regionally due to isostatic rebound. It is for this reason that their help was enlisted to establish a specific local sea height estimate for the area around Shetland.

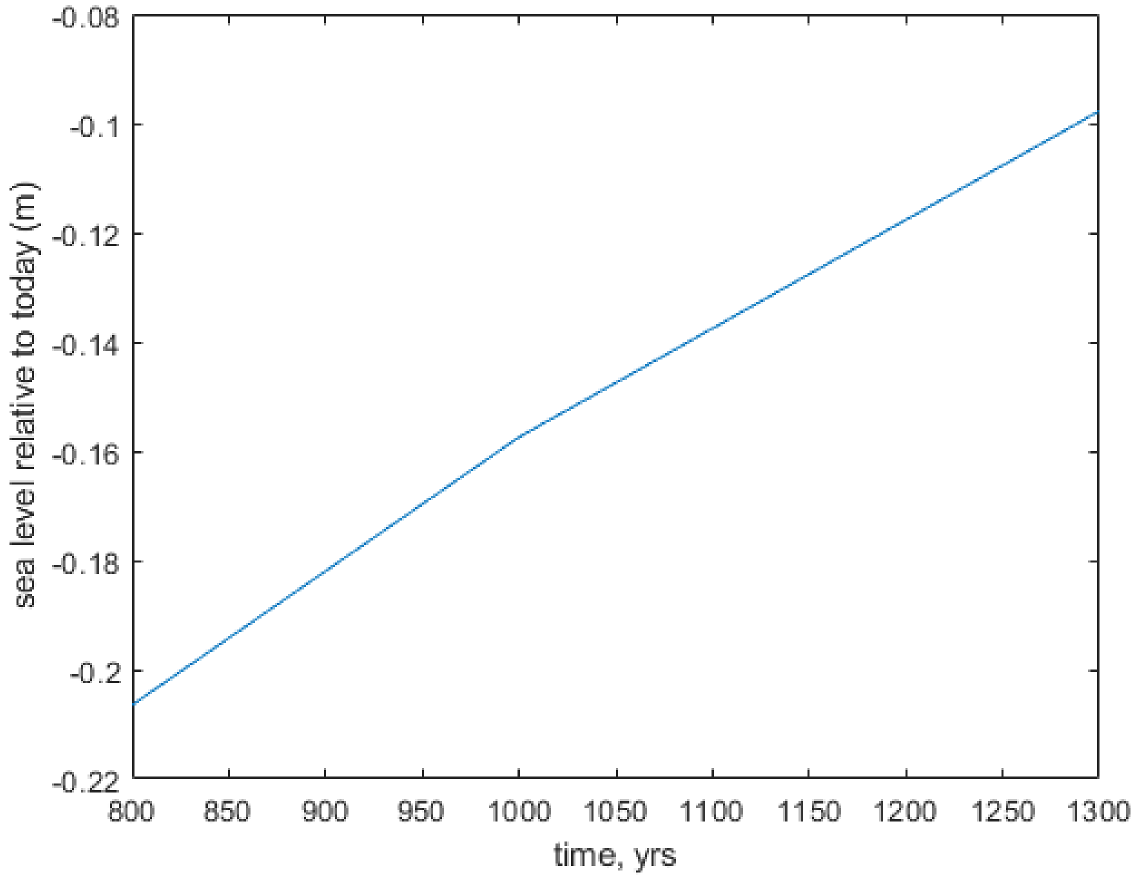


Table 7.2: Graph of past sea level changes from 800-1300 CE in meters as they relate to modern sea surface height for the area around south Mainland Shetland.

Based on the sea surface model developed by Berregione (2022) the difference in sea level height from around 800 CE when compared with modern day levels was 0.20646m (just over 8in) below the current sea level. The sea surface height rose consistently over the period of interest so that by 1300 CE the sea surface height was 0.09775m below the present-day surface height (just under 4 inches). The total change over this period was 0.10871m (≈ 4.28 in). These changes can be seen in the Tables 7.1 and 7.2. The relative change in sea height is not significant when we consider not only the dynamic the nature of the ocean surface, which can be variably above or below relative sea surface height as surface conditions are impacted by ocean currents, tides, and weather conditions, but also natural variability in the height of a potential observer. It was decided that the past sea height would not be adjusted per period, but instead be set at 0.1524m (6 inches) under the current sea height for all periods under investigation.

Sea Surface Height Change Over Time Relative to Modern Sea Surface Height

time (CE)	time (kyr)	RSL (past sea level - present sea level)
800	-1.2	-0.20646
900	-1.1	-0.18194
1000	-1	-0.15743
1100	-0.9	-0.13754
1200	-0.8	-0.11764
1300	-0.7	-0.09775

Table 7.2: Tabulated representation of past sea level changes from 800-1300 CE as they relate to modern sea surface height for the area around south Mainland Shetland.

This was done by importing a number of files from the previous analyses: the 'LandArea" and 'LandAreaReverseMask' polygon feature classes that were created during the MLCPA and the Extracted UrbanDEM raster files for each settlement phase (I-V) that were developed during the land-based Settlement CVA analysis. Extract by Mask was used to extract the extent of the LandArea polygon from the UrbanDEMs for each phase of occupation.

The non-land values depicted in the UrbanDEM files can be seen as snap shots of the modern sea surface height. These values were extracted using the same masking method to determine the mean surface value. These 1m raster values ranged from 7.12m to –1.691m. The Spatial Analyst Zonal Statistics tool was used to find the mean of the raster height values within the LandAreaReverseMask polygon. The mean value of the sea surface captured in the LiDAR

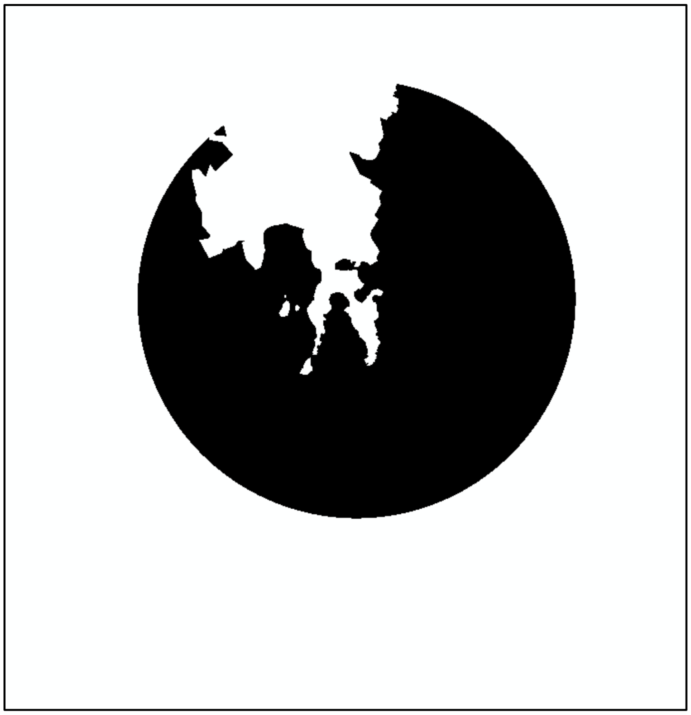


Figure 7.21: 32km diameter DEM of the calculated past sea height for the area around south Mainland Shetland. The scale of this was cropped prior to running the Diachronistic Fuzzy Cumulative Viewshed Analyses.

data from the Scottish Remote Sensing Portal (https://remotesensingdata.gov.scot/) was determined to be –0.573457 and the output was renamed 'ModernSeaSurfaceHeight; Raster Calculator was used to subtract 0.1524m (6 inches) from that value (SG & JNCC, 2021). This places the sea height at just above the anticipated sea height for 1000 CE, however this method creates a singular flat surface, a method that does not reflect the dynamic variation in oceanic conditions which in turn constantly impact sea height. Due to this, and the natural variability in individual observer height, this averaging of sea heights was seen as an acceptable compromise for the purposes of this analysis. The past sea surface height was estimated to be –0.725857m for the purposes of the analysis. (See Figure 7.21). This height of -0.725857m was established relative to the DEM data and its association to the sea surface levels as they were recorded in that data prior to adjustment.

Analysis Extent

A new Z enabled polygon feature class was created 'FCVA_Extent,' this circle was assigned the radius (r=16000m), to encompass the horizon point at which a ship with a 10m tall sail would, under ideal conditions would be visible from an observer on coast who was 1.7m tall. The equation used for this according to Young, (2003) is:

$$D_{BL} < 3.57\left(\sqrt{h_B} + \sqrt{h_L}\right)$$

Young (2003) states the radius of the Earth to be 6378 km and observer (h) in measured in meters, then the distance to the horizon is 3.57 km times the square root of the height of the eye, which for our purposes is 1.7m. However, if generalized refraction is accounted for, the distance to the horizon is about 3.86 km times the square root of the height in meters. The Z information from 'PastSeaHeight' (-0.725857m) was assigned as the maximum height of the 'FCVA_Extent' layer. This was then converted into a raster using the Polygon to Raster Tool, for use with the FCVA analysis; the Shetland Islands were then removed from the raster data using Extract by Mask tool and the Mosaic to New Raster tool was used to merge the 'LandArea UrbanDEMs' (I-V) with the 'FCVA_Extent' Raster. Creating the raster layer for the maximum possible extent for the Fuzzy Cumulative Viewshed Analysis.

Euclidean Distance Path

It was determined that all the potential Least Cost Paths regardless of weighting conformed to the same route within the extent of the FCVA analysis (see Figure 7.22). The next step was to import one of the cost path polylines (CostPat_Bob_Cult_Poly) so that it could provide the route the ship would travel on the final leg of its journey towards the settlement. 'CostPat_Bob_Cult_Poly' was renamed 'FCVA_Sailing_Route' and was then

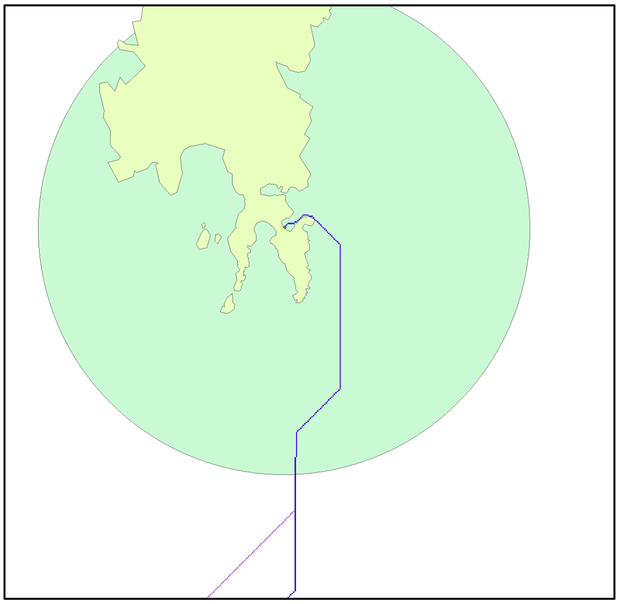


Figure 7.22: 32km area where past sea height DEM was created is visible in pale green. The Maritime Least Cost Path routes all converge on a singular path within the boundaries of that area.

clipped to the extent of the FCVA analysis. From there, a Euclidean Distance tool was used on a shape file (KnarrFCVA) placed on the sailing route where it enters the edge of the analysis. The processing extent for the Euclidean Distance tool was set to be the same as the 'FCVA_RouteEuc_Extent' polygon. The Knarr_FCVA provided the origin point to use when calculating distances out from the ship in the direction of the settlement. Once the Euclidean Distance tool was run, the results were reclassified to reflect distance bands along the sailing route spaced at 1km intervals, where observer points would later be placed. The edges of the distance bands serve place markers for observer points as if the ship were moving through space along its selected route (See figure 7.23).

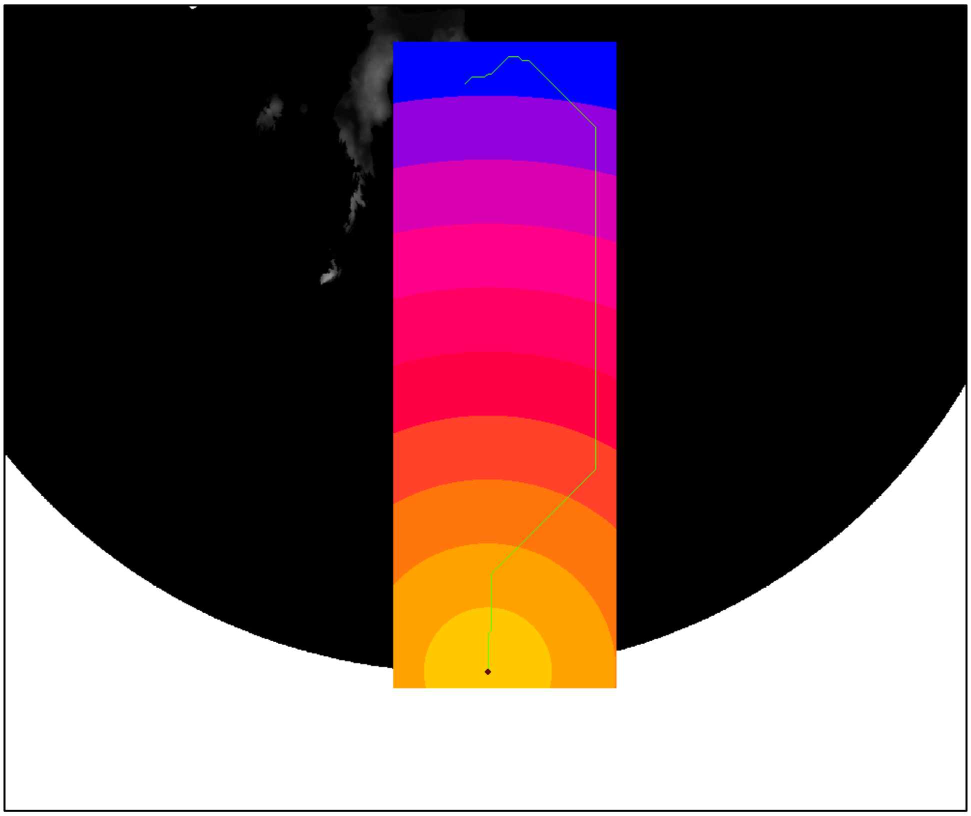


Figure 7.23: Reclassified Euclidean Distance Raster in which each band represents the movement of the Knarr 1km northward, towards the destination -the Norse settlement at Jarlshof. The outer edge of each band was used to place each observer point 1km apart along the sailing route with the exception of the origin and the destination points.

View From the Ship

Once the ideal sailing route is established to represent the perspective of the sailing vessel as it moves towards Jarlshof along the coastline. A Fuzzy Cumulative Visibility Analysis, (FCVA) was implemented. FCVA was developed by (Lock et al. 2014) in order to model pedestrian motion through the landscape under study by treating the analysis as if the actor was moving from cell to cell; calculating visibility in all directions as they went. As mentioned earlier in the section on wayfaring and cognitive mapping, the underlying assumption being made here is that seafarers would have intentionality behind their selected path of movement, as well as, the decisions that were used to justify, or were related to, those movements. If the number of Old Norse place names in the Shetland Islands is any indication, it is logical to assume that seafarers would identify potential way points or prominent landscape features along the prescribed sailing route and use them as mnemonic markers for return journeys (Fellows-Jensen, 2012; Gammeltoft, 2010).

The idea of topographic prominence, put forward by Llobera's (2001), suggests that as an actor moves past prominent points on the landscape, and their perspective changes, those prominent points are more likely to be seen for extended periods, while less prominent points become obscured or are lost from view (Higuchi, 1983). It is intended that this process will be modeled using the FCVA, so that the gradual change in visibility will be accounted for by the advancement of the observer points northward along the sailing route.

As with the settlement based CVA, the observer points were created using new point feature classes for each of the 17 bands and an additional two were also created to mark the source and destination points of the route for a total of 19 observer points. This feature class was assigned an additional attributes field to indicate which band, or specific location it belonged to.

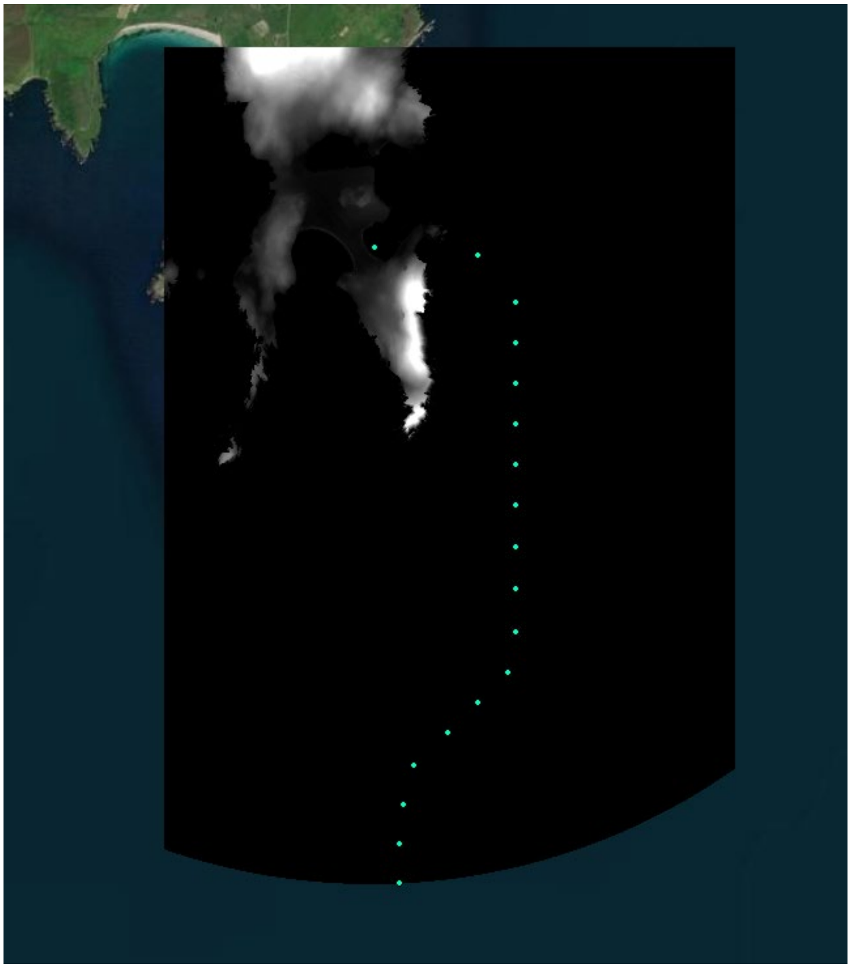
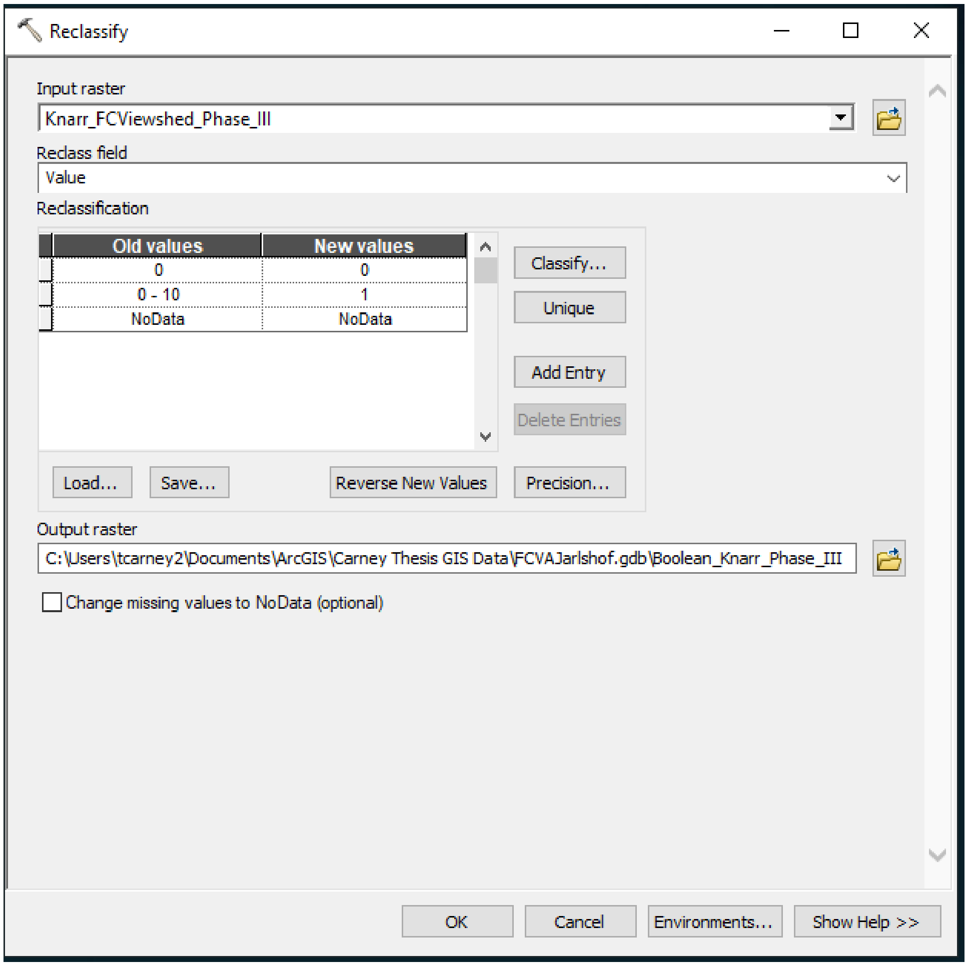


Figure 7.24: The final extent of the merged land and sea DEMs used for the five FCVAs. The Observer Points can be seen in light blue leading from the edge of the study area up to the settlement.

Another field was created: OFFSETA (observer height), which was kept consistent with the settlement observer height of 1.7m. Another field was added to the observer points attribute table: RADIUS 2, which was also kept consistent with the range used in the settlement based CVA analysis (4828.03m -3 miles-). The same observer points were used for each of the four subsequent analyses to determine whether the visibility of the settlement from the water changed over the course of the settlement's occupation. To save on processing time the original 32km diameter study area for this analysis was reduced to an area that more closely bounded the viewshed extents, (compare Figure 7.22 with Figure 7.24). The viewshed was then run using these observation points and the ‘Extract_SpecFCVA_Phase_I’ raster. The output for each of the five renditions of this analysis were named: ‘Knarr_FCVA_Phase_I’ and so on for the other four phases (II-V).

As with the Cumulative Viewshed Analysis conducted on the settlement, once the analyses were complete, their data fields were reclassified using the Reclassify too in order to convert them into Boolean Rasters. By assigning the viewsheds binary values [0,1] what is and is not visible along the route traveled by the ship can be evaluated for each phase. As with the other Viewshed analyses a 'Percent_vis' field was added to the output raster using field calculator to assign the field the SUM value of the Count field as discussed above (see Figure 7.25). With this done, each of the five Fuzzy Cumulative Viewsheds, representing travel during each phase of occupation examined in this research, could have their percent visibility compared with one another.



Input raster
Knarr_FCViewshed_Phase_III

Reclass field
Value

Reclassification

Old values	New values
0	0
0 - 10	1
NoData	NoData

Output raster
C:\Users\tcarney2\Documents\ArcGIS\Carney Thesis GIS Data\FCVAJarlshof.gdb\Boolean_Knarr_Phase_III

☐ Change missing values to NoData (optional)

Figure 7.25 Reclassifying the Phase III FCVA viewshed into a Boolean Raster.