

City University of New York (CUNY)

CUNY Academic Works

Publications and Research

Hunter College

2017

Zooarchaeology of the Scandinavian settlements in Iceland and Greenland: diverging pathways

Thomas McGovern
CUNY Hunter College

Konrad Smairowski
CUNY Graduate Center

George Hambrecht
University of Maryland

Seth Brewington
CUNY Hunter College

Ramona Harrison
University of Bergen

See next page for additional authors

[How does access to this work benefit you? Let us know!](#)

More information about this work at: https://academicworks.cuny.edu/hc_pubs/638

Discover additional works at: <https://academicworks.cuny.edu>

This work is made publicly available by the City University of New York (CUNY).
Contact: AcademicWorks@cuny.edu

Authors

Thomas McGovern, Konrad Smairowski, George Hambrecht, Seth Brewington, Ramona Harrison, Megan Hicks, Frank J. Feeley, Brenda Prehal, and James Woollett

Oxford Handbooks Online

Zooarchaeology of the Scandinavian settlements in Iceland and Greenland: diverging pathways

Thomas H. McGovern, Konrad Smiarowski, George Hambrecht, Seth Brewington, Ramona Harrison, Megan Hicks, Frank J. Feeley, Céline Dupont-Hébert, Brenda Prehal, and James Woollett

The Oxford Handbook of Zooarchaeology

Edited by Umberto Albarella, Hannah Russ, Kim Vickers, and Sarah Viner-Daniels

Print Publication Date: Mar 2017

Subject: Archaeology, Scientific Archaeology, Environmental Archaeology, Archaeology of Europe

Online Publication Date: Apr 2017 DOI: 10.1093/oxfordhb/9780199686476.013.9

Abstract and Keywords

The Scandinavian Viking Age and Medieval settlements of Iceland and Greenland have been subject to zooarchaeological research for over a century, and have come to represent two classic cases of survival and collapse in the literature of long-term human ecodynamics. The work of the past two decades by multiple projects coordinated through the North Atlantic Biocultural Organization (NABO) cooperative and by collaborating scholars has dramatically increased the available zooarchaeological evidence for economic organization of these two communities, their initial adaptation to different natural and social contexts, and their reaction to Late Medieval economic and climate change. This summary paper provides an overview of ongoing comparative research as well as references for data sets and more detailed discussion of archaeofauna from these two island communities.

Keywords: North Atlantic, zooarchaeology, Greenland, Iceland, climate change, human ecodynamics

Common Origins, Different Ends

BOTH Iceland and Greenland were settled in the wave of sea-borne colonization that took European agricultural settlements to far offshore North Atlantic islands, reaching Iceland *c.* AD 875, Greenland *c.* AD 985, and briefly to Newfoundland by AD 1000 (Fig. 10.1). Both modern and ancient DNA analyses (Helgason et al., 2000a; 2000b; 2001) confirm the strong British Isles genetic component of Icelanders, and recent aDNA from Greenlandic

cemeteries (Lynnerup and Nørby, 2004) provide confirmation of the traditional accounts of Greenlandic settlement from Iceland. The long-term fate of these communities presents a stark contrast: despite challenges of climate cooling, soil erosion, volcanic eruption, famine, smallpox, and plague, the Icelanders survived to become a fully developed twenty-first-century Scandinavian society. The Greenlanders were not as successful, and while the end of their community around AD 1450 has become a classic case of ‘collapse’ (Diamond, 2005), their dramatic fate remains an active subject for international, interdisciplinary research (Dugmore et al., 2012; 2013). (p. 148)



[Click to view larger](#)

Figure 10.1 Map of the North Atlantic with regions and sites mentioned in the text.

Authors' own image.

Zooarchaeology came early to Iceland and Greenland. The Danish Captain Daniel Bruun regularly collected unmodified animal bone remains from his very professionally conducted excavations in both islands just over a century ago (Bruun, 1895; 1896; 1899; 1903; 1917; Bruun and Jónsson, 1911), with pioneering zooarchaeological reports

produced by Herluf Winge of the University of Copenhagen Zoological Museum (Winge in Bruun, 1895; 1917). Magnus Degerbøl and Ulrik Møhl continued the Zoological Museum tradition with a series of now-classic reports based on major Danish projects in Greenland and Iceland (Degerbøl, 1929; 1934; 1936; 1939). Post-World War II zooarchaeology in Greenland added radiocarbon-dated, stratified collections and sieved recovery (McGovern, 1985a; Buckland et al., 1996; McGovern et al., 1996; Enghoff, 2003). Since 1975 there has been an explosion of new zooarchaeological work in both Iceland and Greenland, as in the rest of the North Atlantic, much of which is now available through the North Atlantic Biocultural Organization (NABO) website (www.nabohome.org). During the 2007–11 International Polar Year and under the 2012–15 Comparative Island Ecodynamics Project, NABO research has focused on the diverging pathways and differing outcomes of ‘long-term human ecodynamics’ in Iceland and Greenland. This paper draws both upon this new work and upon a zooarchaeological research tradition extending over a century. The pace of research and large new archaeofauna still under analysis from both Iceland and Greenland will inevitably make this overview something of

an interim report of work in progress, but the rich zooarchaeological record now in hand allows for some productive broad scale comparison.

(p. 149) Diverging Pathways at Landnám

The initial settlement (*Landnám*) of Iceland and Greenland was also a moment for initial branching of economic pathways. In Iceland, Norse settlement became widespread around the time of the volcanic ash fall datable to 871±2 AD with full-scale settlement spreading surprisingly rapidly to inland areas such as the well-studied Lake Mývatn basin up to 70 km from the coast (McGovern et al., 2007; Vésteinsson and McGovern, 2012). While the traditional written accounts (composed centuries after the event) emphasize chiefly land-taking in agricultural regions, there is both place name and zooarchaeological evidence for the major role of wild species in the Viking Age economy (McGovern et al., 2006; 2009). Since 1944, investigations in the Aðalstraeti area under modern downtown Reykjavik have produced walrus (*Odobenus rosmarus*) bone and substantial amounts of sea-bird including great auk (*Pinguinus impennis*) and marine fish bone datable to first settlement (summary in Harrison et al., in press). Walrus fragments include both tusks and post-cranial bone (some from very young individuals), suggesting nearby kill sites and local breeding populations. A segment of walrus vertebra and a scapula embedded in the exterior turf wall of the early long hall at Aðalstraeti, as apparent trophies, and walrus place names down the nearby Reykjanes peninsula suggest walrus hunting may have been an initial motive for the Icelandic *Landnám* (Pierce, 2009; McGovern, 2011). As in Faroese Viking Age archaeofauna (Brewington, 2006; 2010b; 2011; 2014; Brewington and McGovern, 2008; Church et al., 2005), sea-bird bones initially outnumber those of imported sheep (*Ovis aries*), goat (*Capra hircus*), pig (*Sus domesticus*), cattle (*Bos taurus*), and horse (*Equus caballus*) in the early southern Icelandic archaeofauna, indicating that both sea mammals and bird colonies provided a source of natural capital that was drawn down to support the early phases of colonization in southern Iceland.

In the north of Iceland multiple projects have demonstrated early use of marine fish and marine mammals, especially from the cod family (Gadidae) on both coastal and inland sites (McGovern et al., 2006; Gísladóttir et al., 2013). Volcanic tephra horizons have allowed secure dating of multiple contemporary sites in the inland Lake Mývatn basin prior to 940 AD that are rich in headless gadid fish, with post-cranial element distributions suggesting large scale consumption both as flat-dried and round-dried ('stockfish') products, along with smaller numbers of marine mammal, bird, and molluscan remains. These well-dated inland Mývatn archaeofauna provided critical evidence that the

widespread 'Fish Event Horizon' observed in British and Continental archaeofauna (Barrett et al., 2004) has a Scandinavian origin, and may well represent one of the most lasting heritages of the Viking Age in Europe (Perdikaris and McGovern, 2008a; 2008b). Recent work at the eroding coastal site of Siglunes, an early chieftain's farm at the mouth of Siglufjord in northern Iceland, has provided radiocarbon and tephra dates extending well into the Viking Age (Harrison, 2014b). It has produced large, stratified archaeofauna dominated by cod-family fish and demonstrating the relative surplus of cranial vs post-cranial bones characterizing later 'producer sites' (Krivogorskaya et al., 2005). (p. 150)

Domestic mammals in the Icelandic Viking Age archaeofauna are dominated by cattle and caprines (in most cases mainly sheep but with a significant proportion of goats), with substantial numbers of pigs in some collections. Ancient DNA analysis of house mice (*Mus musculus*) accidentally imported to Iceland show connections to populations in both Continental Europe and Norse Greenland (Jones et al., 2012).

Horse bones are comparatively rare in all archaeofauna, but in pre-Christian contexts it is clear that they were occasionally butchered and consumed on most sites. Both horses and dogs were regularly included in pagan burials, and the horse bones (unaffected by partly marine or freshwater fish diet, Ascough et al., 2010) are now regularly used for radiocarbon dating of the rapidly growing corpus of pre-Christian Icelandic graves (Friðriksson, 2013). Stable nitrogen (N), carbon (C), and strontium (Sr) isotope analyses in the Mývatn area have all documented a significant freshwater reservoir effect (FRE) in local arctic char (*Salvelinus alpinus*) and trout (*Salmo trutta*), and allowed for the identification of a special freshwater-fish consumption signature in a few of the Viking Age pigs (Ascough et al., 2007; Sayle et al., 2013).

Recent work on pre-Christian cemetery complexes in northern Iceland (Roberts and Hreiðarsdóttir, 2012) and at the temple farm complex at Hofstaðir, near Mývatn (Lucas, 2009), suggests that cats (*Felis domesticus*) as well as dogs (*Canis familiaris*) and horses (*Equus caballus*) may have played a role in rituals (Maher, 2009; Prehal, 2011). Cats are found in rare and unusual circumstances, such as at the pre-Christian grave field at Ingiríðarstaðir, where one was found in a pit amongst human skull fragments (Brewington, 2010a). The modern large-scale excavations at Hofstaðir conducted by the Archaeological Institute of Iceland and NABO, followed the initial work by Daniel Bruun in 1908 (Bruun and Jónsson, 1911). The project produced both a substantial archaeofauna, dated c.940–1000 AD and evidence for skinning cats for fur as well as a recurring ritual beheading of bulls, with their skulls displayed along the exterior of the great hall (Lucas and McGovern, 2008; Lucas, 2009; McGovern et al., 2009).

The Mývatn archaeofauna also document a millennial-scale case of successful, community-level management of migratory waterfowl, beginning at Landnám and

continuing down to the present (McGovern et al., 2006; Hicks et al., 2013; 2015). The Mývatn lake basin annually hosts up to 30,000 pairs of migratory waterfowl coming from both sides of the Atlantic, and modern lakeside farmers regularly collect 10,000 eggs annually without adversely impacting these species (Guðmundsson, 1979). Modern farmers carefully monitor nesting birds, take only a few eggs per nest, and only rarely consume the adults, while protecting the nesting grounds against predators (Beck-Guðmundsdóttir, 2013). This pattern can be documented back to the mid-nineteenth century AD, and current archaeological excavations around Mývatn have generated archaeofauna rich in eggshells but with only a small number of waterfowl bones (McGovern et al., 2006). Ongoing collaborative work making use of modern comparative specimens and SEM imagery is combining wildlife management, ethnography, and zooarchaeology to both document this case of long-term traditional ecological knowledge and apply lessons learned to future management for long-term sustainability (Hicks et al., 2015). (p. 151)

The zooarchaeology of Viking Age Iceland is thus producing an increasingly rich record of a North Atlantic community similar in many respects to contemporary communities in northwestern Europe. Wild species supplemented domestic stock (and initially widespread barley cultivation; Trigg et al., 2008), animals played varied roles in pre-Christian rituals, and cases of both rapid draw-down and long term sustainable management of animals as natural capital can be documented dating back to the first years of settlement. By the time Iceland was Christianized, in c.1000 AD, it had become a well-populated island community integrating farming with hunting and fishing, and producing modest surpluses of wool and dried fish mainly for internal exchange. By the end of the eleventh century AD, Iceland's population had probably neared its pre-modern maximum of 50,000–60,000 and supported two bishoprics and many large estates.

Greenland was always different. When Icelandic settlers crossed the Denmark Strait around AD 985–1000 to found two communities on the western coast (Eastern Settlement in modern Kujalleq district; Western Settlement further north in Sermersooq district, near Nuuk) they crossed significant climatic and biological frontiers, though these may not have all been immediately apparent (Dugmore et al., 2013). In Greenland they encountered caribou (*Rangifer tarandus*), polar bear (*Ursus maritimus*), and huge populations of walrus as well as both familiar North Atlantic and unfamiliar Arctic seals and whales. Greenland was probably always beyond the reach of cereal agriculture, and the two pockets of farmland in the inner fjords of the southwest were isolated by thousands of kilometres of barren coast and the interior ice sheet.

Strontium (Sr) isotope calibration samples unexpectedly identified two early cattle in Greenland who had been born in Iceland (Price, in press). Initially, the full Icelandic

range of cattle, sheep, goats, dogs, horses, and pigs appear in early Greenlandic collections (Smiarowski, 2012; 2013; 2014).

Recent comparative research has increasingly underlined the character of the Greenlandic settlements as always something of a specialized arctic resource extraction community, with export-orientated hunting for ivory and furs being supported by subsistence hunting and farming, rather than a farming community supplementing agriculture with subsistence hunting and fishing as in Iceland (Dugmore et al., 2007b; Keller, 2010). The historic concentration of walrus and walrus hunting has centred on Disko Bay on the central western coast, in an area the Norse called the 'Norðursetur' or northern hunting grounds (Gad, 1970; McGovern, 1985b). Written sources indicate that annual hunting trips were launched from both settlement areas to the Norðursetur, up to 800 km one way from the farming districts. The zooarchaeological evidence for this remarkable long-range hunt has been found in virtually every archaeofauna from the home farms in the form of fragments of walrus maxilla from around the tusk root, left behind by careful extraction of the ivory from the maxilla. These walrus maxillary fragments are found on inland as well as coastal farms in both settlement areas and throughout the stratigraphic sequences, indicating the active participation of most of the community in the Norðursetur hunt and ivory preparation (McGovern et al., 1996). Tusk ivory or finished ivory pieces are rare on the home farms (though walrus (p. 152) penis-bone trophies and post-canines used for craftwork are not unusual). There are no concentrations of walrus post-cranial elements as found in the Aðalstraeti deposits in Iceland, as the Greenlandic walrus kill sites were regularly hundreds of kilometres from the home farm processing area. This long-range Norðursetur walrus hunt thus seems to have been of a very different character and intensity from the sort of exploitation of nearby local walrus pods that we can now document from early Iceland. Processing of the furs and hides mentioned in written sources is harder to document through zooarchaeology, but new collections from the Greenlandic Bishop's manor at Gardar/Igaliku in the Eastern Settlement have produced multiple polar bear third phalanges with cut marks suggesting on-site final finishing of bear skins (Smiarowski, 2013; Frei et al., 2016).

On the Greenlandic home farms, shorter growing seasons and lower overall pasture productivity levels constrained stock production. Dairy cattle probably spent nearly nine months a year indoors being hand-fed fodder harvested in autumn (McGovern, 1992), and evidence of preserved dung concentrations suggests that at least some goats and sheep were also regularly stabled indoors in winter (Enghoff, 2003). The spectre of late winter shortfall in stored fodder and human provisions was a recurring threat to North Atlantic farmers (McGovern et al., 1988; Amorosi et al., 1998). Nevertheless, cattle were still maintained on all farms and there are no archaeofaunas indicating specialized caprine herding, even on the smallest farms with poor pastures. Among the caprines, goats were

often more numerous than sheep in the Greenlandic archaeofauna from first settlement onwards (McGovern et al., 2014; Smiarowski, 2014).

Greenlandic settlers' encounter with the immense populations of migratory harp (*Pagophilus groenlandicus*) and hooded seals (*Cystophora cristata*) (rare or absent in Iceland and the eastern North Atlantic) had immediate and lasting impact on their subsistence economy. Current zooarchaeological evidence from both the Western Settlement (McGovern, 1985a) and the Eastern Settlement (Smiarowski et al., 2007; Smiarowski, 2012; 2013; 2014) dating to the early settlement period, indicates a rapid and radical shift in use of wild species by the original colonists. Marine fishing and dried fish production seems to have been immediately supplanted by large scale (probably communal) hunting of the newly encountered migratory seals, supplemented by sea-bird and caribou hunting. Seals were regularly taken throughout the North Atlantic from prehistoric times, but the harbour (*Phoca vitulina*) and grey seals (*Halichoerus grypus*) found in most of the eastern North Atlantic form comparatively small non-migratory pods and are very vulnerable to over-hunting. In Iceland, law codes regulated sealing beaches and harbour and grey seal populations seem to have generally been harvested sustainably at a fairly low level, with seal bones appearing as trace species in most archaeofauna in the Viking and early Middle Ages. In Greenland, harbour seal colonies were present, and the bones of this species appear regularly in Greenlandic archaeofauna (McGovern, 1985a; Ogilvie et al., 2009; Smiarowski, 2013), but they are greatly outnumbered by the bones of migratory harp seals (both settlements) and hooded seal (Eastern Settlement only). The bones of non-migratory arctic ringed (*Phoca hispida*) and bearded seals (*Erignathus barbatus*), which make breathing holes in winter ice but are not so readily taken with boat drives and other communal hunting strategies, are (p. 153) rare in Norse collections from Greenland. The Norse Greenlanders apparently adapted communal seal hunting techniques to the newly encountered migratory species and did not make extensive use of the sea ice sealing practices of either the Dorset or Thule peoples or of the Nordic ringed-seal hunters of the contemporary northern Baltic (Storå and Löugas, 2005).

Seal bones vary from about 25% of major identified taxa to nearly 80% on small farms with limited pasture, and are common on far inland Greenlandic farms. While a few marine and freshwater fish bones have now been identified in Greenlandic archaeofauna, they represent a trace element (less than 1%, Smiarowski, 2013; 2014), far less than the staple represented by marine fish (25 to over 80%) in Viking and Early Medieval Icelandic archaeofauna. Seals appear to have replaced marine fish almost entirely in the Greenlandic subsistence strategy, and this seems to have happened in the very first years of settlement. There has been extensive debate about the cause of this clear pattern, which seems strongly counter-intuitive given both the role of marine fisheries in modern Greenland and the now well-documented late ninth-century AD Icelandic fishing record.

Scheduling issues, rather than ritual prohibitions (Diamond, 2005), are likely at the core of this unexpected divergence. In Iceland, marine fishing was regularly practised in winter, and the air drying of stockfish requires prolonged temperatures hovering around the freezing point for curing. Winter was also the agricultural slack season, and in later time periods Icelandic farm hands were regularly put to sea in winter as fishermen. In Greenland, winter sea conditions, even during a warmer climate, are far more affected by sea ice, and winter temperature ranges, for most of even the southwest, tend to be too cold for effective stockfish curing. Greenlandic seagoing boats and labour were needed for most of the summer for the weeks-long voyages to the Norðursetur and the walrus hunt, which thus would compete directly with a summer fishing effort.

The migratory seals would arrive in the outer fjords of the two Greenlandic settlements in late May and early June; before the probable start of the Norðursetur voyages and during the worst of any recurring late-winter household provisioning gap. Despite centuries of hunting, harp seals still number in the millions, and unlike the non-migratory harbour seals they could support a large-scale harvest sustainably. The Greenlandic choice of intensifying migratory seal hunting and de-emphasizing marine fishing thus appears rational, given the environmental conditions and the scheduling limitations imposed by the long-range Norðursetur hunt. As in more recent cases, the demands of production for export may have limited the options for viable local subsistence strategies.

The Gardar bishopric was established in AD 1126, and current evidence suggests that this became by far the largest manor and elite centre in Greenland, with cattle byres capable of housing nearly a hundred cattle (in contrast to the 3–5 stalls usually encountered on smaller farms). This site also contains the largest concentration of caribou bone in the Eastern Settlement (Smiarowski, 2013), adding to the pattern of elite caribou consumption suggested for the Western Settlement (McGovern et al., 1996).

Comparative investigations of church and settlement patterns between Iceland and Greenland during the period c. AD 1000–1200 suggest a pattern of consolidation (p. 154) by higher-ranking elites who in both communities seem to have gathered power at the expense of middle-ranking chieftains and farmers (Arneborg et al., 2008). The Greenlandic settlements remained much smaller than the Icelandic, with maximum population probably well under 4,000 at peak.

By the thirteenth century AD both Greenland and Iceland were well-established Medieval communities, with ecclesiastical and secular hierarchies in place. Though by AD 1264 both were part of a trans-Atlantic Norwegian realm, they had become very different places, with a similar mix of imported northwestern European domestic livestock masking major contrasts in the use of wild species and the role of surplus extraction. While Icelandic fisheries and marine-mammal hunting seem to have been initially focused on supplying

local subsistence demand and could be readily integrated into an annual agricultural cycle, the Greenlandic Norðursetur hunt generated inedible trans-Atlantic trade goods while creating significant conflict with the subsistence round (McGovern, 1985b).

High Medieval Course Changes

In the mid-thirteenth to early fourteenth century AD a conjuncture of local, regional, and extra-regional social, economic, and environmental changes placed both stresses and opportunities before these two westernmost Scandinavian communities. Growing links between East Asia, the Mediterranean, and northern Europe during the *Pax Mongolica* of the mid-thirteenth to the mid-fourteenth century AD developed into a Medieval proto-world-system, with distant echoes in the Scandinavian North Atlantic (Abu-Lughod, 1981). In Iceland, this period saw the establishment of a number of seasonal trading centres distributed around the coastal fjords, with Gásir in Eyjafjord currently the best archaeologically documented (Hermannsdóttir, 1987; Roberts, 2002; Roberts et al., 2009; 2010; Harrison et al., 2004; 2008; Harrison, 2005; 2006; 2009; Pálsdóttir and Roberts, 2006; 2007; Vésteinsson et al., 2008; 2011 Vésteinsson, 2009; 2011). The investigations at Gásir have developed into a multi-site investigation of the impact of this seasonal trading centre on a broader hinterland (Harrison, 2009; 2010a; 2010b; 2010c; 2011a; 2011b; 2013; 2014a). Among the findings of this ongoing research is that farms in this hinterland altered the traditional dairying economy in order to provision Gásir with prime-beef aged cattle. In return, some of these farms were consuming imported barley, and even had access to fashionable continental lap dogs; this area of rural Iceland was clearly connected to the larger world on multiple levels. While the Gásir excavations have confirmed documentary references to Medieval trade in Icelandic falcons and sulfur, the major exports seem to have been woolen cloth and dried fish (Harrison et al., 2008; Harrison, 2014a, 2014b).

Coastal fishing sites increase in numbers and distribution in northern Iceland and the West Fjords after c. AD 1250, with the small seasonal site of Akurvík producing two large, fish-dominated archaeofauna, the first datable to the thirteenth century AD and (p. 155) the second to the fifteenth (Amundsen et al., 2005). These both show a clear 'producer signature' of surplus fish heads, as well as indications of the production of both flat-dried and round-dried cod and haddock in the thirteenth century AD, switching in the fifteenth century AD to a concentration on round-dried 'stockfish' cod. The nearby farm at Gjögur shows a dramatic increase in fish bone after c. AD 1250 and in later times was known as a major fishing farm (Krivogorskaya et al., 2005). By the late thirteenth century AD Icelandic magnate families were switching their core holdings from the main agricultural areas to

the prime fishing regions, and it seems clear that the local-level artisanal subsistence fisheries of Viking Age Iceland were undergoing intensification for wider export (Vésteinsson, 2016).

In the thirteenth century AD some Icelandic archaeofaunas show a dramatic change in cattle to caprine bone ratios, shifting from the 1: 3 to 1: 5 ratios common in the Viking Age and Early Medieval periods to the 1: 20 ratios characteristic of eighteenth-century AD stock records. Goats become very rare, and the zooarchaeological data suggest higher proportions of older (and larger) sheep likely representing wethers or older ewes maintained for wool production (McGovern et al., 2007; Harrison, 2013). In Eyjafjord, the Gásir hinterlands were spatially re-organized, with small subsistence farms like Skuggi replaced by specialized sheep-herding structures on valley floors (Harrison, 2010a; 2013). Woolen cloth fragments show standardization into the legally defined *vaðmal*, suitable for exchange and valuation as a commodity (Hayeur-Smith, 2011). In Iceland by the mid-thirteenth century AD it appears that wool production and marine fishing were both being intensified, and that both woolen goods and dried-fish products were undergoing standardization and commoditization for a new export market as well as domestic consumption.

In Greenland, there is no indication of similar alterations in the relation of subsistence and surplus production for trade. The amount of walrus maxillary bone tusk-extraction debris remains constant or increases in the stratified Western and Eastern Settlement archaeofauna (McGovern et al., 1996; Smiarowski, 2013; 2014). Documentary records indicate that while hundreds of kilos of Greenlandic walrus ivory were still being collected by church factors in the mid-fourteenth century AD, this product was increasingly difficult to market profitably (Keller, 2010). Cattle-to-caprine ratios remain fairly stable on larger manor farms, and where caprine bones increase on smaller farms many of these are goats rather than sheep (Smiarowski 2014; McGovern et al., 2014). No evidence for standardization of woolen cloth production has yet been identified in the Greenlandic collections (Hayeur-Smith, 2014). While initially probably far more engaged in cash hunting for low-bulk, high-value exchange products in the Viking Age, the Greenlandic community proved less able than the Icelanders to shift to high-bulk, low-value commoditized trade in the thirteenth century AD.

Climate change as well as early globalization impacted both Medieval Iceland and Greenland. In AD 1257–1258 a massive volcanic eruption on Lombok (Indonesia) triggered an immediate cooling across the North Atlantic, and between 1275–1300 AD a threshold-crossing increase in summer sea ice impacted both northern Iceland and southwest Greenland (Miller et al., 2012). Pasture productivity in both communities (p. 156) was adversely affected, and the summer drift ice impacted trans-Atlantic voyages to Greenland, local travel, and the viability of harbour seal colonies in the Eastern

Settlement area (Ogilvie et al., 2009). In Iceland, a *c.* AD 1300 archaeofauna from Hofstaðir exhibits both intensive bone processing for collagen extraction and the sudden appearance of substantial numbers of harp seal bones on this inland farm; both patterns indicating not only 'hard times' but also the resilient use of a newly available wild resource (McGovern et al., 2014). In Greenland, later archaeofauna show a marked intensification of the existing harp seal hunt, a pattern mirrored by the human stable isotope data that indicate Norse Greenlanders moving decisively into the marine food web after *c.* AD 1250 (Arneborg et al., 2012). The combined zooarchaeological and bioarchaeological record indicates that the Norse Greenlanders successfully survived the climate shocks of AD 1275–1300 by intensifying their existing communal seal hunting strategies to compensate for stress on the farming economy. Around AD 1425, a second climate shock impacted the whole region, with a dramatic increase in storminess (Dugmore et al., 2007a). The successful Greenlandic response to the initial climate impact may have rendered this small community tragically vulnerable to loss of life at sea in a radically stormier North Atlantic, and by around AD 1450 Norse Greenland was extinct.

While the Icelanders were impacted by both increased storminess and the appearance of the Black Death in AD 1402, their larger population and more effective combination of subsistence and exchange economies may have provided critical buffering (Streeter et al., 2012). European demand for stockfish continued to expand. Recent work on the Snæfellsnes peninsula has revealed nearly a kilometre of exposed dense fishbone midden 50–75 cm thick with radiocarbon dates indicating an accumulation within a few decades in the mid- to late fifteenth century AD (Pálsdóttir, 2011; 2013). While field and laboratory work at Gufuskálar continues, mammal bones suggest a pattern of provisioning with cuts of high quality lamb and beef more similar to the consumption patterns at the earlier Gásir trading site than the contemporary but much smaller Akurvík fishing station (Feeley, 2012; 2013). Finds of amber and pewter rosary beads, a bronze finger ring, fragments of chain mail armour, and a concentration of imported glazed red wares within a substantial stone structure suggests that this 'near industrial scale' fishing station may have been occupied and run by English or other Europeans as well as Icelanders. While Norse Greenland was slipping into final obscurity by the mid-fifteenth century AD, Iceland remained vital, with an economy that now appears more complex and diverse than previously thought (Boulhosa, 2010).

References

Abu-Lughod, J. (1981) *Before European Hegemony: The World System AD 1250–1350*, New York: Oxford University Press.

Amorosi, T., Buckland, P. C., Edwards, K., Mainland, I., McGovern, T. H., Sadler J., and Skidmore, P. (1998) 'They did not live by grass alone: the politics and paleoecology of animal fodder in the North Atlantic region', *Environmental Archaeology*, 1, 41-55.

(p. 157) Amundsen, C., Perdikaris, S., McGovern, T. H., Krivogorskaya, Y., Brown, M., Smiarowski, K., Storm, S., Modugno, S., Frik, M., and Koczela, M. (2005) 'Fishing booths and fishing strategies in Medieval Iceland: an archaeofauna from the site of Akurvík, north-west Iceland', *Environmental Archaeology*, 10(2), 141-98.

Arneborg, J., Heinemeier, J., and Lynnerup, N. (eds) (2012) 'Greenland isotope project: diet in Norse Greenland AD 1000-AD 1450'. *Journal of the North Atlantic*, Special Volume 3.

Arneborg, J., Nyegaard, G., and Vésteinsson, O. (eds) (2008) 'Selected papers from the Hvalsey Conference 2008'. *Journal of the North Atlantic*, Special Volume 2.

Ascough, P. L., Cook, G. T., Church, A., Dugmore, A., McGovern, T. H., Dunbar, E., Einarsson, A., Friðriksson, A., and Gestsdóttir, H. (2007) 'Reservoirs and radiocarbon: 14C dating problems in Mývatnssveit, northern Iceland', *Radiocarbon*, 49(2), 1-15.

Ascough, P. L., Cook, G. T., Church, M. J., Dunbar, E., Einarsson, Á., McGovern, T. H., Dugmore, A. J., Perdikaris, S., Hastie, H., Friðriksson, A., and Gestsdóttir, H. (2010) 'Temporal and spatial variations in freshwater 14C reservoir effects: Lake Myvatn, northern Iceland', *Radiocarbon*, 86(3), 211-15.

Barrett, J., Locker, A. M., and Roberts, C. M. (2004) 'Dark Age economics revisited: the English fish bone evidence AD 600-1600', *Antiquity*, 78(301), 618-36.

Beck-Guðmundsdóttir, S. (2013) 'Exploitation of wild birds in Iceland from the Settlement period to the 19th century and its reflection in archaeology', *Archaeologia Islandica*, 10, 28-52.

Boulhosa, P. P. (2010) 'Of fish and ships in Medieval Iceland', in Imsen, S. (ed.) *The Norwegian Domination and the Norse World c.1100-c.1400*. Trondheim Studies in History 3, pp. 175-94. Trondheim: Tapir Academic Press.

Brewington, S. D. (2006) 'Interim Report on Archaeofauna from Undir Junkarinsflótti, Sandoy, Faroe Islands'. NORSEC Zooarchaeology Laboratory Report No. 32.

Brewington, S. D. (2010a) 'Report: Analysis of Animal Bones Recovered during 2010 Excavations at Ingiríðarstaðir (ING), N Iceland'. NORSEC Zooarchaeology Laboratory Report No. 51.

- Brewington, S. D. (2010b) 'Third Interim Report on Analysis of Archaeofauna from Undir Junkarinsfløtti, Sandoy, Faroe Islands'. NORSEC Zooarchaeology Laboratory Report No. 46.
- Brewington, S. D. (2011) 'Fourth Interim Report on Analysis of Archaeofauna from Undir Junkarinsfløtti, Sandoy, Faroe Islands'. NORSEC Zooarchaeology Laboratory Report No. 56.
- Brewington, S. D. (2014) 'The key role of wild resources in the Viking-Age to Late-Norse palaeoeconomy of the Faroe Islands: the zooarchaeological evidence from Undir Junkarinsfløtti, Sandoy', in Kulyk, S., Tremain, C. G., and Sawyer, M. (eds) *Climates of Change: The Shifting Environments of Archaeology. Proceedings of the 44th Annual Chacmool Conference*, pp. 297–306. Calgary: Department of Archaeology, The University of Calgary.
- Brewington, S. D. and McGovern, T. H. (2008) 'Plentiful puffins: zooarchaeological evidence for early seabird exploitation in the Faroe Islands', in Michelsen, H. and Paulsen, C. (eds) *Símunarbók: Heiðursrit til Símun V. Arge á 60 ára Degnum*, pp. 23–30. Torshavn: Faroe University Press.
- Bruun, D. (1895) 'Arkæologiske Undersøgelser i Julianehaabs Distrikt', *Meddelelser om Grønland*, 16, 171–462.
- Bruun, D. (1896) 'Arkæologisk Undersøgelsesrejse til Færøerne og Island 1896', *Geografisk Tidsskrift*, 13, 175–7.
- Bruun, D. (1899) 'Arkæologiske Undersøgelser paa Island', *Geografiske Tidsskrift*, 15, 71–87.
- Bruun, D. (1903) 'Arkæologiske Undersøgelser i Godthaabs og Frederikshaabs Distrikter i Grønland foretagne i Aaret 1903', *Geografisk Tidsskrift*, 17, 187–206.
- (p. 158)** Bruun, D. (1917) 'Oversigt over Nordboruniner i Godthaabs og Frederikshaabs Distrikter', *Meddelelser om Grønland*, 56, 55–148.
- Bruun, D. and Jónsson, F. (1911) 'Finds and excavations of Heathen Temples in Iceland', *Saga Book of the Viking Club*, 7VII, 25–37.
- Buckland, P. C., Amorosi, T., Barlow, L. K., Dugmore, A. J., Mayewski, P. A., McGovern, T. H., Ogilvie, A. E. J., Sadler, J. P., and Skidmore, P. (1996) 'Bioarchaeological and climatological evidence for the fate of the Norse farmers in Medieval Greenland', *Antiquity*, 70(1), 88–96.

Church, M., Arge, S., Brewington, S., McGovern, T. H., Woollett, J., Perdikaris, S., Lawson, I. T., Cook, G. C., Amundsen, C., Harrison, R., and Krivogorskaya, Y. (2005) 'Puffins, pigs, cod and barley: paleoeconomy at Undir Junkarinsflótti, Sandoy, Faroe Islands', *Environmental Archaeology*, 10(2), 198-221.

Degerbøl, M. (1929) 'Animal bones from the Norse ruins at Gardar, Greenland', *Meddelelser om Grønland*, 76, 183-92.

Degerbøl, M. (1934) 'Animal bones from the Norse ruins at Brattahlið', *Meddelelser om Grønland*, 88, 149-55.

Degerbøl, M. (1936) 'Animal remains from the West Settlement in Greenland with special reference to livestock', *Meddelelser om Grønland*, 88(3), 1-54.

Degerbøl, M. (1939) 'Nogle bemærkninger om husdyrene på Island i Middelalderen', in Stenberger, M. K. H. and Roussell, A. (eds) *Forntida Gårdar i Island: Meddelanden från den Nordiska Arkeologiska Undersökningen i Island Sommaren 1939*, pp. 261-8. Copenhagen: E. Munksgaard.

Diamond, J. (2005) *Collapse: How Societies Choose to Fail or Survive*, London: Allen Lane.

Dugmore, A. J., Borthwick, D. M., Church, M. J., Dawson, A., Edwards, K., Keller, C., Mayewski, P., McGovern, T. H., Mairs, K., and Sveinbjarnardóttir, G. (2007a) 'The role of climate in settlement and landscape change in the North Atlantic islands: an assessment of cumulative deviations in high-resolution proxy climate records', *Human Ecology*, 35, 169-78.

Dugmore, A. J., Keller, C., and McGovern, T. H. (2007b) 'Reflections on climate change, trade, and the contrasting fates of human settlements in the North Atlantic islands', *Arctic Anthropology*, 44(1), 12-37.

Dugmore, A. J., McGovern, T. H., Streeter, R., Madsen, C. K., Smiarowski, K., and Keller, C. (2013) '“Clumsy solutions” and “elegant failures”: lessons on climate change adaptation from the settlement of the North Atlantic islands, chapter 38', in Sygna, L., O'Brien, K., and Wolf, J. (eds) *A Changing Environment for Human Security: Transformative Approaches to Research, Policy and Action*, pp. 435-50. London: Routledge.

Dugmore, A. J., McGovern, T. H., Vésteinsson, O., Arneborg, J., Streeter, R., and Keller, C. (2012) 'Cultural adaptation, compounding vulnerabilities, and conjunctures in Norse Greenland', *Proceedings of the National Academy of Sciences of the United States of America*, 109(10), 3011-16.

Enghoff, I. B. (2003) 'Hunting, Fishing, and Animal Husbandry at the Farm Beneath the Sand, Western Greenland: An Archaeozoological Analysis of a Norse Farm in the Western Settlement'. *Meddelelser om Grønland/Man and Society* 28. Copenhagen: Danish Polar Center.

Feeley, F. J. (2012) 'Mammal Consumption at the Medieval Fishing Station at Gufuskálar'. NORSEC Zooarchaeology Laboratory Report No. 62.

Feeley, F. J. (2013) 'Medieval commercial fishing at Gufuskálar, Snæfellsnes, Western Iceland', Paper presented at the 2013 NABO Stefansson Arctic Institute Conference, Akureyri, Iceland, 12 July 2013.

(p. 159) Frei, Karin M., Coutu, Ashley N., Smiarowski, Konrad, Harrison, Ramona, Madsen, Christian K., Arneborg, Jette, Frei, Robert, Guðmundsson, Gardar, Sindbæk, Søren, M., Woollett, James, Hartman, Steven, Hicks, Megan, and McGovern, Thomas, H. (2015). 'Was it for walrus? Viking Age settlement and medieval walrus ivory trade in Iceland and Greenland', *World Archaeology*, DOI: 10.1080/00438243.2015.1025912.

Friðriksson, A. (2013) 'La place du mort: les tombes Vikings dans le Paysage Culturel Islandais'. Unpublished PhD dissertation, University of Paris-Sorbonne (Paris).

Gad, F. (1970) *The History of Greenland: Earliest Times to 1700*, Vol. 1, London: Hurst and Co.

Gísladóttir, G. A., Woollett, J. M., Ævarsson, U., Dupont-Hébert, C., Newton, A., and Vésteinsson, O. (2013) 'The Svalbard project', *Archaeologia Islandica*, 10, 69–103.

Guðmundsson, F. (1979) 'The past status and exploitation of the Mývatn waterfowl populations', *Oikos*, 32, 232.

Harrison, R. (2005) 'Faunal analysis results from the 2004 excavations at Gásir, Eyjafjörður, N Iceland', in Roberts, H. (ed.) *Excavations at Gásir 2004: An Interim Report*. CUNY Northern Science and Education Center; FSÍ (Fornleifastofnun Íslands/Icelandic Archaeological Institute), FS280-01076, June 2005, Reykjavík, Iceland.

Harrison, R. (2006) 'Faunal analysis results from the 2005 excavations at Gásir, Eyjafjörður, N Iceland', in Pálsdóttir, L. B. and Roberts, H. (eds) *Excavations at Gásir 2005: An Interim Report*. CUNY Northern Science and Education Center; FSÍ (Fornleifastofnun Íslands/Icelandic Archaeological Institute), FS312-01078, May 2006, Reykjavík, Iceland.

Harrison, R. (2009) 'The Gásir Area A Archaeofauna: An Update of the Results from the Faunal Analysis of the High Medieval Trading Site in Eyjafjörður, N Iceland'. NORSEC Zooarchaeology Laboratory Report No. 44.

Harrison, R. (2010a) 'Small holder farming in Early Medieval Iceland: Skuggi in Hörgárdalur', *Archaeologia Islandica*, 8, 51-76.

Harrison, R. (2010b) 'Skuggi in Hörgárdalur, N Iceland: Preliminary Report of the 2008/2009 Archaeofauna'. NORSEC Zooarchaeology Laboratory Report No. 50.

Harrison, R. (2010c) 'Gásir Hinterlands Project 2009: Midden Prospection and Excavation'. FSÍ (Fornleifastofnun Íslands/Icelandic Archaeological Institute), Reykjavík and NORSEC, New York, FS440-06384, February 2010.

Harrison, R. (2011a) 'Myrkárdalur in Hörgárdalur, N Iceland: Brief Summary of the 2008/2009 Archaeofauna'. NORSEC/HERC Zooarchaeology Laboratory Report No. 57.

Harrison, R. (2011b) 'Möðruvellir in Hörgárdalur, N Iceland: General Overview of the Faunal Remains Analyzed from the 2006-08 Midden Mound Excavations'. NORSEC/HERC Zooarchaeology Laboratory Report No. 59.

Harrison, R. (2013) 'World Systems and Human Ecodynamics in Medieval Eyjafjörður, North Iceland: Gásir and Its Hinterlands'. Unpublished PhD dissertation, City University of New York (New York).

Harrison, R. (2014a) 'Connecting the land to the sea at Gásir: international exchange and long-term Eyjafjörður ecodynamics in Medieval Iceland', in Harrison, R. and Maher, R. (eds) *Human Ecodynamics in the North Atlantic: A Collaborative Model of Humans and Nature through Space and Time*, pp. 117-36. Lanham: Lexington Publishers.

Harrison, R. (2014b). 'The Siglunes 2011/12 Archaeofauna. Interim Report on the Fishing Station's Sampled Faunal Remains'. NORSEC/HERC Zooarchaeology Laboratory Report No. 62.

Harrison, R., Brewington, S., Woollett, J., and McGovern, T. H. (2004) 'Interim Report of Animal Bones from the 2003 Excavations at Gásir, Eyjafjörður, N Iceland'. NORSEC Zooarchaeology Laboratory Report No. 16.

(p. 160) Harrison, R., Roberts, H. M., and Adderley, W. P. (2008) 'Gásir in Eyjafjörður: international exchange and local economy in Medieval Iceland', *Journal of the North Atlantic*, 1(1), 99-119.

Harrison, R., McGovern, T. H., and Tinsley, C. (in press) 'The Zooarchaeology of Aðalstræti 14-18: Revised Report on the Aðalstræti Viking Age Archaeofauna', in Vésteinsson, O. (ed.) *Excavations at Aðalstræti Reykjavik Iceland*. Reykjavik: City Museum of Reykjavik.

Hayeur Smith, M. (2011) 'Preliminary Textile Report: Möðruvellir, Iceland, 2011'. Research Report of the Circumpolar Laboratory No. 3, Haffenreffer Museum of Anthropology, Brown University.

Hayeur Smith, M. (2014) 'Dress, cloth, and the farmer's wife: textiles from Ø 172 Tatsipataa, Greenland, with comparative data from Iceland', in Arneborg, J., McGovern, T. H., and Nyegaard, G. (eds) *In the Footsteps of Vebæk: Vatnahverfi Studies 2005-2011*, pp. 64-81. *Journal of the North Atlantic*, Special Volume 6.

Helgason, A., Hickey, E., Goodacre, S., Bosnes, V., Stefansson, K., Ward, R., and Sykes, B. (2001) 'mtDNA and the islands of the North Atlantic: estimating the proportions of Norse and Gaelic ancestry', *American Journal of Human Genetics*, 68, 723-37.

Helgason, A., Siguroardottir, S., Gulcher, J. R., Ward, R., and Stefansson, K. (2000a) 'mtDNA and the origin of the Icelanders: deciphering signals of recent population history', *American Journal of Human Genetics*, 66, 999-1016.

Helgason, A., Siguroardottir, S., Nicholson, J., Sykes, B., Hill, E. W., Bradley, D. G., Bosnes, V., Gulcher, J. R., Ward, R., and Stefansson, K. (2000b) 'Estimating Scandinavian and Gaelic ancestry in the male settlers of Iceland', *American Journal of Human Genetics*, 67, 697-717.

Hermannsdóttir, M. (1987) 'Fornleifarannsóknir að Gásam og víðar í Eyjafirði árið 1986', *Tímaritið Súlur*, 1987, 3-39.

Hicks, M., Edwald, A., Einarsson, A., Anamthatwat Jónsson, K., Þór Þórsson, Æ., Friðriksson, A., Hambrecht, G. and McGovern, T. H. (2015) 'Local sustainable management on the millennial scale', in Isendahl, C., and Stump, D. (eds) *Oxford Handbook of Historical Ecology and Applied Archaeology*. Oxford: Oxford University Press.

Hicks, M., Einarsson, A., Anamthatwat Jónsson, K., and Þór Þórsson, Æ. (2013) 'A Preliminary Report of the Mývatn Bird Egg Archaeofaunal Identification Project'. NORSEC/HERC Zooarchaeology Laboratory Report No. 65.

Jones, E. P., Skinisson, K., McGovern, T. H., Gilbert, M. Y. P., Willerslev, E., and Searle, J. B. (2012) 'Fellow travelers: a concordance of colonization patterns between mice and men in the North Atlantic region', *BMC Evolutionary Biology*, 12, 35-43.

Keller, C. (2010) 'Furs, fish, and ivory: Medieval Norsemen at the Arctic fringe', *Journal of the North Atlantic*, 3, 1-23.

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

Lucas, G. (ed.) (2009) *Hofstaðir: Excavations of a Viking Age Feasting Hall in North Eastern Iceland*, Reykjavik: Institute of Archaeology.

Lucas, G. and McGovern, T. H. (2008) 'Bloody slaughter: ritual decapitation and display at Viking age Hofstaðir N Iceland', *Journal of European Archaeology*, 10(1), 7–30.

Lynnerup, N. and Nørby, S. (2004) 'The Greenland Norse: bones, graves, computers, and DNA', *Polar Record*, 40(2), 107–11.

Maher, R. A. (2009) 'Landscapes of Life and Death: Social Dimensions of a Perceived Landscape in Viking Age Iceland'. Unpublished PhD dissertation, City University of New York (New York).

(p. 161) McGovern, T. H. (1985a) 'Contributions to the paleoeconomy of Norse Greenland', *Acta Archaeologica*, 54, 73–122.

McGovern, T. H. (1985b) 'The arctic frontier of Norse Greenland', in Green, S. and Perlman, S. (eds) *The Archaeology of Frontiers and Boundaries*, pp. 275–323. New York: Academic Press.

McGovern, T. H. (1992) 'Bones, buildings, and boundaries: palaeoeconomic approaches to Norse Greenland', in Morris, C. D. and Rackham, D. J. (eds) *Norse and Later Settlement and Subsistence in the North Atlantic*, pp. 193–230. Glasgow: Department of Archaeology, University of Glasgow.

McGovern, T. H. (2011) 'Walrus Tusks and Bone from Aðalstræti 14–18, Reykjavík, Iceland'. NORSEC Zooarchaeology Laboratory Report No. 55.

McGovern, T. H., Amorosi, T., Perdikaris, S., and Woollett, J. W. (1996) 'Zooarchaeology of Sandnes V51: economic change at a chieftain's farm in West Greenland', *Arctic Anthropology*, 33(2), 94–122.

McGovern, T. H., Bigelow, G. F., Amorosi, T., and Russell, D. (1988) 'Northern islands, human error, and environmental degradation: a preliminary model for social and ecological change in the Medieval North Atlantic', *Human Ecology*, 16(3), 45–105.

McGovern, T. H., Gestsdóttir, H., Brewington, S., Harrison, R., Hicks, M., Smiarowski, K., and Woollett, J. (in press) 'Medieval climate impact and human response: an archaeofauna circa 1300 AD from Hofstaðir in Mývatnssveit, N Iceland', *Journal of the North Atlantic*.

McGovern, T. H., Harrison, R., and Smiarowski, K. (2014) 'Sorting sheep and goats in Medieval Iceland and Greenland: local subsistence, climate change, or world system impacts?', in Harrison, R. and Maher, R. (eds) *Human Ecodynamics in the North Atlantic*:

A Collaborative Model of Humans and Nature through Space and Time, pp. 153–76.
Lanham: Lexington Publishers.

McGovern, T. H., Perdikaris, S., Einarsson, A., and Sidell, J. (2006) 'Coastal connections, local fishing, and sustainable egg harvesting: patterns of Viking age inland wild resource use in Mývatn District, northern Iceland', *Environmental Archaeology*, 11(1), 102–28.

McGovern, T. H., Perdikaris, S., Mainland, I., Ascough, P., Ewens, V., Einarsson, A., Sidell, J., Hambrecht, G., and Harrison, R. (2009) 'Chapter 4: the archaeofauna', in Lucas, G. (ed.) *Hofstaðir: Excavations of a Viking Age Feasting Hall in North-Eastern Iceland*. Institute of Archaeology Monograph Series 1, pp. 168–252. Reykjavik: Institute of Archaeology.

McGovern, T. H., Vésteinsson, O., Friðriksson, A., Church, M. J., Lawson, I. T., Simpson, I. A., Einarsson, A., Dugmore, I. A., Cook, A. J., Perdikaris, S., Edwards, K., Thomson, A. M., Adderley, P. W., Newton, A. J., Lucas, G., Edvardsson, R., Aldred, O., and Dunbar, E. (2007) 'Landscapes of settlement in northern Iceland: historical ecology of human impact and climate fluctuation on the millennial scale', *American Anthropologist*, 109(1), 27–51.

Miller, G. H., Geirsdóttir, Á., Zhong, Y., Larsen, D. J., Otto-Bliesner, B. L., Holland, M. M., Bailey, D. A., Refsnider, K. A., Lehman, S. J., Southon, J. R., Anderson, C., Björnsson, H., and Thordarson, T. (2012) 'Abrupt onset of the Little Ice Age triggered by volcanism and sustained by sea-ice/ocean feedbacks', *Geophysical Research Letters*, 39, DOI: 10.1029/2011GL050168.

Ogilvie, A. E. J., Woollett, J. M., Smiarowski, K., Arneborg, J., Troelstra, S., Kuijpers, A., Pálsdóttir, A., and McGovern, T. H. (2009) 'Seals and sea ice in Medieval Greenland', *Journal of the North Atlantic*, 2, 60–80.

Pálsdóttir, L. B. (2011) 'Archaeological Investigations on the Fishing Station at Gufuskálar, Snæfellsnes: Preliminary Report'. FSÍ (Fornleifastofnun Íslands/Icelandic Archaeological Institute), FS407-08232.

(p. 162) Pálsdóttir, L. B. (2013) 'Archaeological Investigations on the Fishing Station at Gufuskálar, Snæfellsnes: Preliminary Report'. FSÍ (Fornleifastofnun Íslands/Icelandic Archaeological Institute), FS407-08233.

Pálsdóttir, L. B. and Roberts, H. M. (eds) (2006) 'Excavations at Gásir 2005 An Interim Report/Framvinduskýrsla. Fornleifastofnun Íslands FS312-01078'. Reykjavík: Fornleifastofnun Íslands.

Pálsdóttir, L. B. and Roberts, H. M. (eds) (2007) 'Excavations at Gásir 2006: an Interim Report/Framvinduskýrsla. Fornleifastofnun Íslands FS355-010710'. Reykjavík: Fornleifastofnun Íslands.

Perdikaris, S. and McGovern, T. H. (2008a) 'Codfish and kings, seals and subsistence: Norse marine resource use in the North Atlantic', in Rick, T. and Erlandson, J. (eds) *Human Impacts on Ancient Marine Ecosystems: A Global Perspective*, pp. 157–90. Berkeley: University of California Press.

Perdikaris, S. and McGovern, T. H. (2008b) 'Viking Age economics and the origins of commercial cod fisheries in the North Atlantic', in Sickling, L. and Abreu-Ferreira, D. (eds) *The North Atlantic Fisheries in the Middle Ages and Early Modern Period: Interdisciplinary Approaches in History, Archaeology, and Biology*, pp. 61–90. Leiden: Brill Publishers.

Pierce, E. (2009) 'Walrus hunting and the ivory trade in early Iceland', *Archaeologia Islandica*, 7, 55–63.

Prehal, B. (2011) 'Freyja's Cats: Perspectives on Recent Viking Age Finds in Thegjadadalur, North Iceland'. Unpublished MA dissertation, Hunter College of the City University of New York (New York).

Price, T. D. (in press) 'Viking settlers of the North Atlantic: an isotopic approach', *Journal of the North Atlantic*.

Roberts, H. M. (2002) 'Archaeological Investigations at Gásir 2002: A Preliminary Report. Fornleifastofnun Norðurlands, FS180-01072'. Reykjavík: Fornleifastofnun Íslands.

Roberts, H. M. and Hreiðarsdóttir, E. O. (2012) 'The Litlu-Núpar burials', *Archaeologia Islandica*, 10, 1–40.

Roberts, H. M., Vésteinsson, O., Brorsson, T., Konráðsdóttir, H., Harrison, R., Ólafsson, S., Gílsadóttir, G. A., and Snæsdóttir, M. (2009) 'Gásir Post Excavation Reports: Volume 1. 2009, FS423-010712'. Reykjavík: Fornleifastofnun Íslands.

Roberts, H. M., Vésteinsson, O., Guðmundsdóttir Beck, S., Mould, Q., Konráðsdóttir, H., and Hansen, S. C. J. (2010) 'Gasir Post Excavation Reports: Volume 2. 2010, FS450-010713'. Reykjavík: Fornleifastofnun Íslands.

Sayle, K. L., Cook, G. T., Ascough, P. L., McGovern, T. H., and Hicks, M. (2013) 'Application of ³⁴S analysis for elucidating terrestrial, marine and freshwater ecosystems: evidence of animal movement/husbandry practices in an early Viking community around Lake Mývatn, Iceland', *Geochimica et Cosmochimica Acta*, 120, 531–44.

Smiarowski, K. (2012) 'E172 Tatsip Ataa Midden Excavation: 2009 & 2010 Preliminary Excavation Report'. NABO Field Report Series.

Smiarowski, K. (2013) 'Preliminary Report on the 2012 Archaeofauna from E47 Gardar in the Eastern Settlement, Greenland'. HERC-NORSEC Zooarchaeology Laboratory Report No. 61.

Smiarowski, K. (2014) 'Climate related farm-to-shieling transition at E74 Qorlortorsuaq in Norse Greenland', in Harrison, R. and Maher, R. (eds) *Human Ecodynamics in the North Atlantic: A Collaborative Model of Humans and Nature through Space and Time*, pp. 177–94. Lanham: Lexington Publishers.

(p. 163) Smiarowski, K., Pálsdóttir, A., and McGovern, T. H. (2007) 'Preliminary Assessment Report of the Archaeofauna from KNK 203 (E 74), a Norse Farm in the Eastern Settlement, Greenland'. NORSEC Zooarchaeology Laboratory Report No. 39.

Storå, J. and Lőugas, L. (2005) 'Human exploitation and history of seals in the Baltic during the Late Holocene', in Monks, G. G. (ed.) *The Exploitation and Cultural Importance of Sea Mammals*, pp. 95–106. Oxford: Oxbow Books.

Streeter, R. T., Dugmore, A. J., and Vésteinsson, O. (2012) 'Plague and landscape resilience in premodern Iceland', *Proceedings of the National Academy of Sciences of the United States of America*, 109(10), 3664–9.

Trigg, H. B., Bolender, D. J., Johnson, K. M., Patalano, M. D., and Steinberg, J. M. (2008) 'Note on barley found in dung in the lowest levels of the farm mound midden at Reynistaður, Skagafjörður, Iceland', *Archaeologia Islandica*, 7, 64–72.

Vésteinsson, O. (2009) 'A Medieval merchants' church in Gásir, North Iceland', *Hikuin*, 36, 159–70.

Vésteinsson, O. (ed.) (2011) 'Gásir Post Excavation Reports—Volume 3'. FSÍ (Fornleifastofnun Íslands/Icelandic Archaeological Institute), FS466-010714.

Vésteinsson, O. (2016) 'Commercial fishing and the political economy of Medieval Iceland', in Barrett, H. H. and Ortion, D. C. (eds.) *Cod and Herring: The Archaeology and History of Medieval Sea Fishing*, pp. 71–80. Oxford: Oxbow Books.

Vésteinsson, O., Gísladóttir, G. A., and Harrison, R. (2008) 'The Church in Gásir: Interim Report on Excavations in 2004 and 2006. Fornleifastofnun Íslands, FS385-010711'. Reykjavík: Fornleifastofnun Íslands.

Vésteinsson, O. and McGovern, T. H. (2012) 'The peopling of Iceland', *Norwegian Archaeological Review*, 45(2), 206–18.

Vésteinsson, O., Þorgeirsdóttir, S., and Roberts, H. M. (2011) 'Efniviður Íslandssögunnar: vitnisburður fornleifa um einokun og neyslu', in Vésteinsson, O., Lucas, G., Þórsdóttir, K.,

and Gylfadóttir, R. G. (eds) *Upp á Ýfirbórðið: Nýjar Rannsóknir í Íslenskri Fornleifafræði*, pp. 71–93. Reykjavik: Fornleifastofnun Islands.

Thomas H. McGovern

Thomas H. McGovern (Ph.D. Columbia University 1979) is professor in Anthropology at City University of New York, serving both at Hunter College's Zooarchaeology Laboratory and the CUNY Doctoral Center Human Ecodynamics Research Center. He has done archaeological fieldwork in UK, France, US, Norway, and Caribbean, but his major research focus has been on the islands of the North Atlantic (Greenland, Iceland, Faroes, Shetland). Since 1992 he has served as coordinator for NABO (North Atlantic Biocultural Organization; www.nabohome.org) and is active in promoting archaeological contributions to global environmental change research through GHEA (the Global Human Ecodynamics Alliance; www.gheahome.org) and IHOPE (Integrated History and Future of People on Earth; ihopenet.org).

Konrad Smiarowski

CUNY Graduate Center

George Hambrecht

University of Maryland, Anthropology

Seth Brewington

Hunter College

Ramona Harrison

University of Bergen

Megan Hicks

Megan Hicks (Ph.D. candidate, Anthropology, Archaeology CUNY Graduate Center, MA Hunter College, 2009) is a zooarchaeologist with an interest in the socio-ecological aspects of past animal economies. She presently works in collaboration on several projects in the Mývatn Region, Northern Iceland, as the NABO NORSEC Laboratory supervisor in the CUNY Hunter College Anthropology Department, and recently as an instructor of undergraduate courses. Recent publications include: Hicks, M. (2014). Losing sleep counting sheep: early modern dynamics of hazardous husbandry in Mývatn, Iceland. In R. Harrison and R. A. Maher (eds), *Human Ecodynamics in the North Atlantic: A Collaborative Model of Human and Nature through Space and Time*. Lanham, MD: Lexington Publishers.

Frank J. Feeley

CUNY Graduate Center

Céline Dupont-Hébert

Université Laval

Brenda Prehal

CUNY Graduate Center

James Woollett

Universite Laval

