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## Cod Fish, Walrus, and Chieftains: Economic Intensification in the Norse North Atlantic

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## Cod Fish, Walrus, and Chieftains: Economic Intensification in the Norse North Atlantic Sophia Perdikaris and Thomas H. McGovern

### Introduction

Just over a thousand years ago, Scandinavian voyagers crossed the grey waters of the North Atlantic to briefly explore the coast of North America. These now well publicized transatlantic trips were part of larger economic, environmental, and social developments of the Viking Age, and were the product of an Iron Age chiefly society with a complex economy incorporating both classic “prestige goods” and “staple goods” components. The Viking Age expansion was the result of linked factors of economic intensification, military and technological advances, climate change, and intense competition among chiefly elites and between elites and commoners. The period saw escalating Nordic impact upon north-west Europe and a dramatic expansion of European settlement into the offshore islands of the North Atlantic. This paper will focus upon the economic development of two of the most western of the Norse Atlantic settlements, Iceland and Greenland, and seeks to bring fresh data to bear on the knotty problem of pre-state economics. In both examples, complex political and economic structures were supported through intensification in both domestic consumption and export to European markets. The particular resources, terrestrial and marine, domestic and wild, that were the subject of intensified economic effort differed in Iceland and Greenland. We examine the production and utilization of these resources and effects that changing demand for these products entailed for the fortunes of the Norse settlements of Iceland and Greenland, and for their would-be magnates. We are fortunate to be able to draw

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upon new work by many scholars in several disciplines through the research cooperative of the North Atlantic Biocultural Organization (NABO), as well as new zooarchaeological and locational evidence.

### **Background: The Viking Age**

The Viking Age traditionally begins with the well documented raids on monastic centers of early medieval literacy in the late 8th century AD, but Scandinavian merchants, mercenaries, and pirates had long been active in the North Sea, Baltic, and the river routes to the steppe khanates of central Asia (Jones 1985). For at least a century before the first recorded attacks on the monasteries of Northumbria and Ireland, wealth had flowed into South Scandinavia. Massive amounts of silver were being deposited in graves and hoards all over Scandinavia which lacks any local sources. Trading emporia in what is now South Norway, Denmark, and South Sweden attracted literate visitors from Latin, Byzantine, and Muslim worlds, and rich burials in the lake Malaren area (south-central Sweden) provide archaeological confirmation of the written accounts picture of prosperous, turbulent, and adventurous, if uncouth and heathen, entrepreneurial society awash in imported goods (Sawyer 1982). Central Asian silver, Baltic amber, Mediterranean glass ware, Irish bronze and gold as well as a small bronze Buddha probably from North-West India, all appear as grave goods in burials of well-traveled elites in these pre-Viking entrepôts (Hedeager 2000). As several art historians have noted, Viking age jewelry and ornamental metal work is both more widespread and often also less technically precise in its craftsmanship than the limited distribution high quality work of the earlier Vendel age (Graham-Campbell 1996). Some commonly occurring ornaments like brooches and belt hardware were clearly mass produced from common molds – lower priced knock offs of the designer interlace decorating royal objects. A wider range of consumers were able to afford items of decorative metalwork and were bold enough to flaunt these highly visible marks of wealth and status. Late Iron Age Scandinavia was enjoying an economic boom, probably further enhanced by a period of relatively warm and stable climate punctuated however by some colder episodes (Hughes and Diaz 1994, Ogilvie, Barlow and Jennings 2000, Ogilvie and McGovern 2000, Ogilvie and Jonsson 2001, and McGovern 1991). Settlements appear to have expanded in many areas, moving up mountain valleys and into former woodlands, and surplus labor was clearly available for the construction of massive earthworks, roads, bridges, and causeways across marshes (Randsborg 1981). At the same time, steady improvements in ship building produced the wide range of elegantly designed sea going ships now well documented by maritime archaeology (Christensen 2000). Less well understood advances in Scandinavian navigational skills allowing for long voyages out of sight of land had probably an even greater impact, a breakthrough in seamanship with both peaceful and warlike applications (Vihjalmsson 2001).

In Arctic Norway, powerful chieftainships grew up on the Lofoten and Vesterålen islands during the late Iron Age, creating a power center that was to long contest primacy with the expanding petty kingdoms of western and southern Norway. These northern

islands held huge boat houses, extensive farms, and at least one huge feasting hall at Borg equipped with imported gold and glass that must have rivaled any similar structure below the Arctic Circle (Munch and Johansen 1987). While the warm currents of the north Atlantic drift allow some barley growing in these offshore Arctic islands, most barley production was probably reserved for beer rather than porridge and the majority of the diet was supplied by meat and milk of domestic stock, birds and bird eggs, sea mammals, and especially the abundant stocks of marine fish, whose spawning grounds surround Lofoten and Vesterålen. These rich fishing grounds but rather marginal grain growing potentials apparently gave rise to an intensive winter fishery for cod, haddock, and other cod-family (*gadid*) species. Gutted and beheaded, these gadids could be preserved for over five years without salt by a process of air-drying on racks set up on windy points. While fish size (ca 65–110 cm length) and narrow temperature range during curing (+/- 1 °C) had to be carefully controlled, the resulting *stockfish* provided a high-protein storable staple product that could be consumed locally, employed in redistributive strategies, transferred as tribute or debt payment, and used in inter-regional trade. Stockfish production seems to have been well underway in Arctic Norway by at least the later Iron Age (Perdikaris 1999). This early fishing economy was to have a major role in the North Atlantic islands during the Viking expansion.

However, dried fish was far from the only product handled by Nordic entrepreneurs. A frequently cited account by a North Norwegian chieftain, Ottar, was recorded in the court of King Alfred of Wessex in the 10th century and provides a description of chiefly economics, mentioning income from “tribute” collected regularly from the Saami, reindeer farming, whaling and walrus hunting (Lund 1984). A wondering Anglo-Saxon scribe noted that this North Norwegian chieftain owned far fewer cattle than any respectable thane of Wessex, but was “accounted wealthy in his own country.” As King Alfred knew all too well, Nordic seafaring skills allowed for the acquisition of wealth from raiding, protection racketeering (Danegeld collection), and large scale slaving as well as fishing and maritime trade. In the three centuries between AD 800 and 1100, Iron Age Scandinavians became major players in the royal politics of north-west Europe, and for a brief period in the early 11th century a single Scandinavian dynasty controlled most of England, Denmark, and Norway. Several scholars have argued that the escalating raids and massive wealth generated by Viking activity contributed greatly to social changes that eventually promoted stable monarchies in Scandinavia and thus contributed to the demise of chiefly Viking-age politics in Denmark, Norway, and Sweden by AD 1100 (Randsborg 1981).

During the same period, Scandinavian settlers also colonized the islands of the North Atlantic. The islands of the eastern North Atlantic (Faeroes, Shetland, Orkney, Hebrides, Man, and Ireland) probably saw substantial Norse settlement soon after AD 800. Further west, Iceland was traditionally settled ca. AD 874, Greenland ca. 985, and the short-lived Vinland colony survived a few years around AD 1000 in Newfoundland/Gulf of St. Lawrence region. Around AD 1000 a common language and culture stretched from Bergen to the St. Lawrence, and colonists drawn from both Scandinavia and the British Isles were attempting the dangerous business of Landnám (land-taking, first settlement) over a

diverse range of island ecosystems. Some of these Landnám attempts were to fail rapidly (like the ill-fated Vínland colony), some (like the Earldom of Orkney) were to prosper greatly in the Middle Ages, and others (like Norse Greenland) were to become extinct after hundreds of years of apparently successful economic and social adaptation (for reviews see McGovern 1990, 2001, Bigelow 1991, and Morris and Rackham 1992). Iceland endured profound environmental degradation, climate change, epidemic disease, and foreign rule and survived while producing the impressive written vernacular corpus of law codes, histories, hagiographies, and sagas that provide such unique participant's view of north Atlantic chiefly society and its transformations (for discussion of these sources see Vesteinsson 1998, 2000). This rich literature is an invaluable resource, but it has some flaws from the economic perspective. None of the sources are contemporary with the Viking Age, and most report events occurring 200-300 years before their date of composition (Vésteinsson 2000a, b). More seriously, the focus of these works was upon the doings and sayings of important men and women. The details of everyday life and much we would like to know now were then deemed too commonplace to record. Fortunately, the impressive expansion of archaeology and environmental science in the region over the past two decades has provided much of the basic economic information only indirectly hinted at in the saga literature.

### **Viking Age Political Economy**

The economic basis of the Viking expansion has attracted a growing body of scholarship, increasingly based upon a rich archaeological record (Durrenberger 1989, 1992, Hastrup 1985, McGovern 1985b, 1992, Perdikaris 1990, 1996, 1998, Vesteinsson et al. 2002, Barrett 1995, Barrett et al. 1997, 2000, Amorosi et al. 1996, Bigelow 1984). As Thurston's work (this volume, Thurston 1999) illustrates, economic power, military power, religious authority, and competitive display were interlocking elements in elite strategies for aggrandizement—and key points of friction with the long-established leveling mechanisms of Iron Age Germanic society. A widespread heroic ethic stressed the importance of competition for glory, search for personal and family honor, sanctity of vengeance, and the ability to provide for clients and kin. An ideal Iron Age/Viking chieftain had sharp elbows and a quick temper, expanded his holdings opportunistically, defended his own aggressively, and was always ready to reward loyalty with silver and treachery with iron. While ancient aristocratic lineage was an important element of chiefly power, newly acquired wealth and fame could also easily promote or topple individuals and families. Combined with leveling mechanisms that tended to make paramount kingship a dangerous and short career path (Thurston 1999), this ancient North-West European social structure generated a great many ambitious but unfulfilled actors at many social levels looking for an angle and leverage. These are the characters we probably meet in the Arabic accounts of Scandinavian (Rus) slave traders on the mid-Volga, and most certainly meet in the adventurous drengs (variously translatable as “stout lads” or “good old boys”) pulling the oars in the early 30-40-man raids on vulnerable monastic centers in Atlantic Europe. They were not all aristocratic, but all aimed to become rich enough to marry, obtain some flashy jewelry for the girls at home, start a lineage, and (fates willing) plot to replace

the local chieftain or set up on their own someplace new. While their allegiance would be valued by any rising chieftain, such individualistic actors were hardly a stabilizing influence in a context of rising opportunity and improving access to power for the bold and ruthless.

As more wealth (from whatever sources) flowed into this competitive and decentralized society, it was as likely to provoke more intense jockeying for power, resources, and followers by a wider range of potential chieftains as to promote the creation of a successful state administered by a few hereditary lords. As shipbuilding and seamanship improved, initially small-scale trading and raiding ventures (in multiple directions) provided wealth not directly tied to long standing patterns of land holding, and not always easily captured and channeled by traditional elites. The new lands in the islands to the west likewise provided an expanded range of options for aristocratic ambition, refuges for losers in chiefly competition, and a fresh start for people of all ranks. This open frontier to the west may have absorbed many troublesome characters impeding royal ambitions, but it also provided alternative power bases potentially dangerous to mainland Scandinavian authorities. While the eventual outcome of the Viking Age may have been centrally administered, literate, Christianized states, the early Viking Age was certainly a much more turbulent and dynamic period, destabilized rather than ordered by new wealth and improved technology.

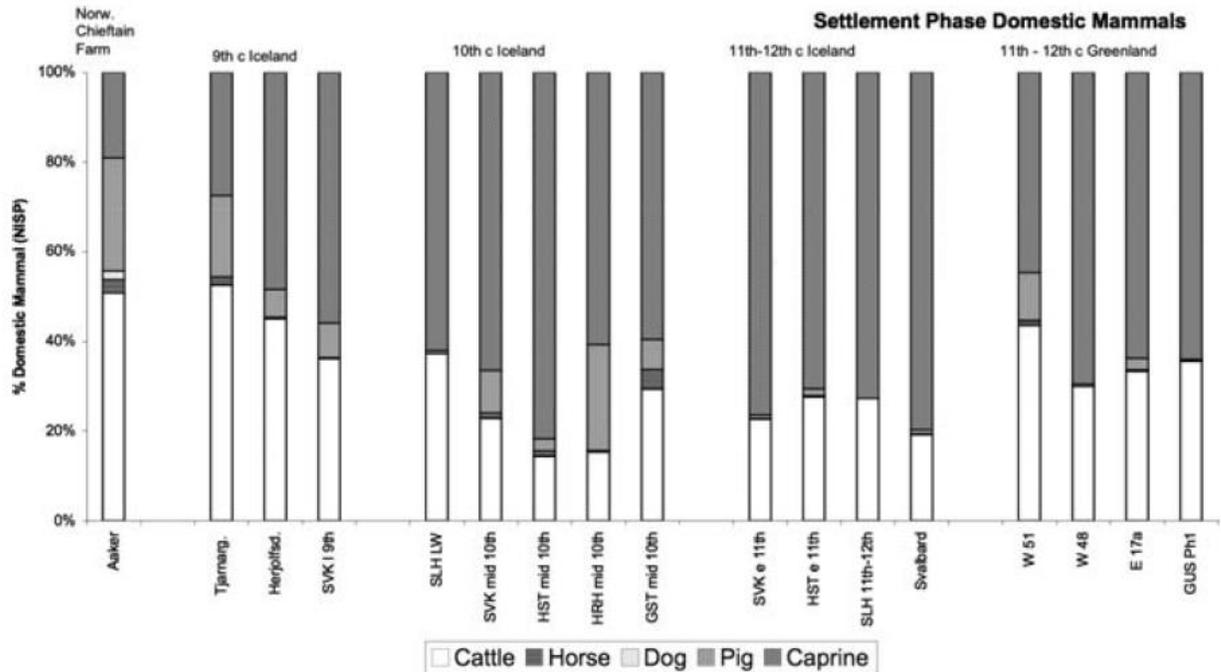
#### *Prestige Goods Economy*

As Gelsinger (1981) noted, Viking age chiefly economics was ultimately not about money, but about honor and power. Wealth generated from successful farming, intensified fishing, loot, trade, or protection-selling was not an end in itself, but a means to acquire the key elements of chieftainship - well armed retainers, loyal clients, fine clothing, jewelry, weapons, exotic objects for display and award, spectacular architectural settings for glorious feasts and impressive ritual moments. Wealth without chiefly power was a dangerous possession, and several Icelandic sagas recount how commoners or minor chieftains who acquired wealth and the trappings of elite status (but neglected to collect enough well-armed drengs in the process) were rapidly relieved of these inappropriate burdens by more powerful men better able to make use of them. Evil dragons and short-lived misers hoarded riches, but successful chieftains were founts of generosity bestowing carefully graded jewelry, clothing, and fine weapons on supporters ("ring-giver" and "hoard foe" are repeating positive epithets in surviving skaldic elegiac poetry). This skaldic vision of the ideal chieftain thus has stood as an icon of the pre-state "prestige goods" economy based on the acquisition, display, and exchange of rare, rich, and expensive items (Carneiro 1981, Earle 1987, 1991, Feinman and Neitzel 1984). While there is no question that the prestige goods which figure so strongly in the saga accounts played a critical role in the new chiefly societies of the North Atlantic, current archaeological evidence indicates a more complex interaction between subsistence production, prestige goods, and exchange.

*Economy of Landnám*

The work of the past two decades by many scholars has generated a substantial and growing number of fully quantifiable animal bone collections (archaeofauna) from sites across the North Atlantic (McGovern et al. 2001). Figure 1 presents a selection of these data, arranged in approximate chronological and geographical order from earliest (Åker, Norway) to latest (GUS, Garden under Sand) in Greenland. The site of Åker near Hammar in Eastern Norway is an extremely rich magnate farm, and its archaeofauna arguably represents the socially and economically ideal stock mix for chieftains of the Viking Age: many cattle, many pigs, some sheep and goats (together termed “caprines”). In South Iceland, the ideal mix was relatively smoothly transplanted, with the early (probably elite) collection from Tjarnargata 4 under modern Reykjavik showing close similarities to the Norwegian magnate farm collection. In more Arctic North Iceland, conditions were far less like South Norway, but the probably mid-ranking farmer at Sveigakot (SVK) managed a respectable proportion of both cattle and pigs in the late 9th century. At Sveigakot, the early layers show substantial proportions of goats as well as sheep in the “caprine” category. A growing number of large (1,000 – 15,000 NISP) archaeofauna from nearby 10th century sites in North Iceland show a range of strategies, and considerable fluctuation in the mix of domestic animals between sites and between phases of the same site. By the 11th-12th centuries, comparative stability returns, pigs have become rare in the collections, cattle are generally reduced in relative proportion, and the caprine category is dominated by sheep. This pattern was to continue into late medieval modern Iceland, with a tendency for cattle to further decline relative to sheep on most sites (McGovern et al 2001). Thus, by the time Greenland was settled from Iceland ca AD 985 (just over 100 years after the Icelandic Landnám) the most common mix of domestic mammals had changed considerably from the cattle and pig-rich ideal farmyard of Åker. However, the Greenlandic settlers did not import their contemporary Icelandic farmyards to the new (even more Arctic) home, but again attempted a mix of domestic species strongly reminiscent of the old country ideal (especially at the elite site of W51 Sandnes). Unsurprisingly, pigs rapidly became extremely rare in Norse Greenland, and early and on most sites cattle decline relative to sheep and goats in later layers (McGovern 1994, 1985, Enghoff 2003). Clearly social rather than purely biological factors are behind the patterns in the domestic mammal bone collections in this period.

While domestic mammals imported from Europe formed a core of the Landnám economy in the North Atlantic, local wild species provided a vital supplement to subsistence economy and a source of trade goods. As Figure 2 illustrates, if we expand our view of the same Settlement Age archaeofauna compared in Figure 1, we gain a better appreciation of the comparative role of domestic mammals, wild birds, mammals, molluscs, and fish. The developed chieftain’s farm at Åker in East Norway made some use of birds and fish (both freshwater and marine), but the vast majority of the archaeofauna is composed of domestic mammal bone. This was not the case in the two 9th century south Icelandic sites Tjarnargata 4 and Herjolfsdalur, where birds make up 60–75% of these archaeofauna. This pattern probably reflects initial human impact upon nesting seabird easily killed” as later sagas recalled (see Vesteinsson et al. 2002). In north Iceland, fresh



**Figure 1.** Domestic mammals in Norse settlement phases.

water fish and birds are the only major supplements, though as we will see their species and element distributions raise some important economic questions. A few walrus bones (ribs and long bones) were recovered in the Tjarnargata 4 excavations in downtown Reykjavik, including a few from newborn walrus too small to swim far. The discovery of three complete walrus tusks in the very early long hall at Aðalstraedi a block away in 2001, and the documentation of a number of walrus-element place names along the Reykjanes peninsula further contribute to the impression that there was a resident walrus colony in South-West Iceland at Landnám. The tusks show marks of their extraction from the dense maxillary bone, but all three were successfully removed without major damage (McGovern in Roberts and Snaesdóttir in press). In the 10th-11th century archaeofauna (all inland sites from North Iceland), freshwater and marine fish, birds and small amounts of marine mammal bone (seal and porpoise) make up a highly variable portion of the existing archaeofauna. By the 12th-13th centuries, both inland and coastal Icelandic archaeofauna are increasingly dominated by marine (especially cod-family) fish, which often make up 70-80% of late medieval and early modern archaeofauna (Amorosi 1996, Amundsen 1999, 2004, Amundsen, Perdikaris et al. 2004). Locally available wild species of animals and plants thus provided an initial “natural capital” (in the sense of Cronon 1997) that could potentially underwrite economic and social agendas based upon control and expansion of the imported domesticate economy. This natural capital like any bank account could be left untouched, totally expended in a short period, gradually expended over a long period, retained for emergencies, or managed for a sustainable long-term yield.

### Icelandic Fishing: Subsistence, Local Exchange, Commoditization

In Iceland, while grazing land was finite and subject to reduction through erosion or climate change, marine fisheries provided far greater scope for intensification. The increasing focus on marine fishing evident in the later archaeofauna was to produce a complex pattern of economic intensification and social reaction. In early medieval times, fisheries were apparently managed both locally and regionally, with great magnates and churches owning fishing rights in distant parts of the country (Edvardsson 1996; Vésteinsson 2000). In later medieval and early modern times, agrarian elites became increasingly concerned about the social effects of semipermanent fishing stations and proto-villages developing independent of the cattle rich landed aristocracy, and efforts were made to curb these unruly settlements and closely regulate access to imported goods, effectively reining in further intensification of fisheries until the 19th-20th centuries. It appears that social stratification, intensification of fishing, and control of overseas trade were closely interacting variables, and all were tied to changing relations between humans and fish. It may be useful to consider more broadly how the intensification of fishing and the economic and social role of fish and stockfish changed through time.

The transformation of gadid fish in the depths of the sea into a processed product that could be stored for later consumption was the result prehistoric technology and skills probably long pre-dating the Iron Age. This reflects a simple dietary use described by Cronon (1997) as a product of “first nature”—direct interaction between product and producer. The assignment of value to this ancient preserved product and its assimilation

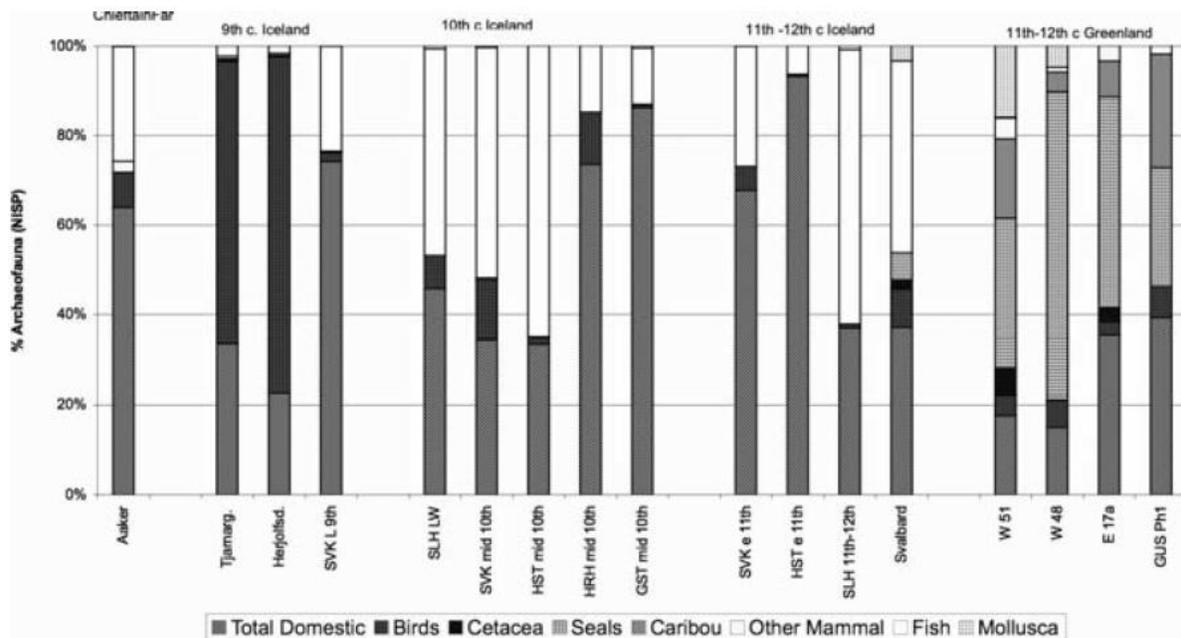
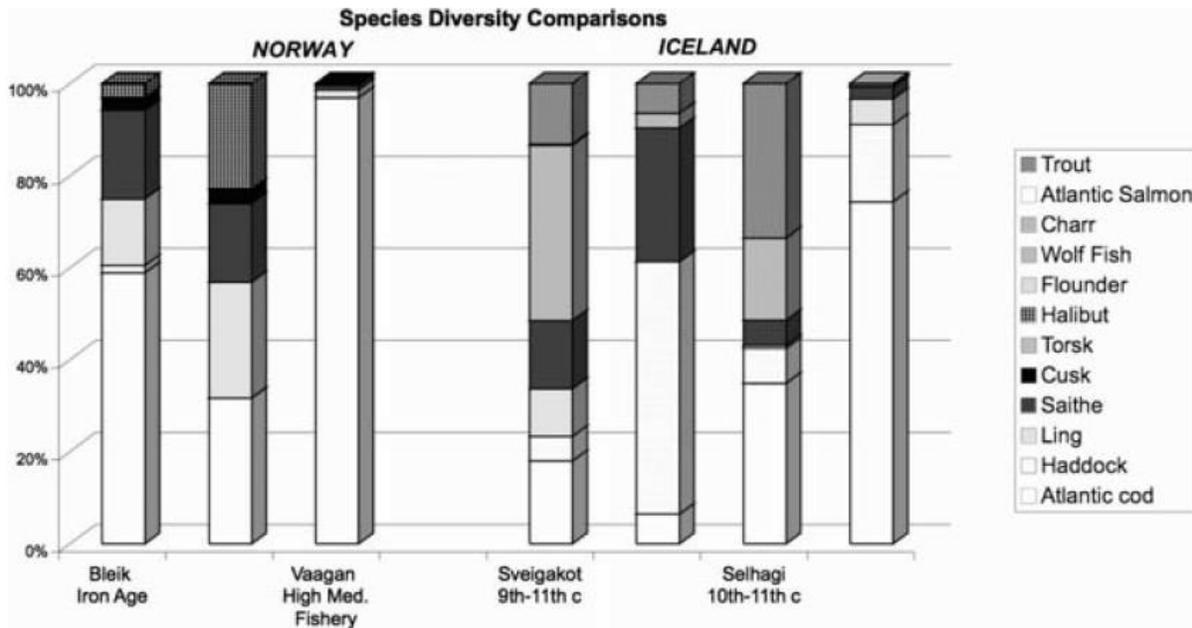


Figure 2. Wild and domestic animals in Norse settlement phases.

into local level redistribution and exchange was probably an Iron Age development (Perdikaris 1998). In the Middle Ages (after ca AD 1100) this local product became far more widely traded and acquired considerable value in an emerging international system of banking and credit. The difference between the Iron Age and the medieval times lies in the focus and scope of the processing and exchange activity as well as the nature of the controlling elements. In both eras, elites were changing fish into objects of abstract value (Cronon's "second nature"). In the Iron Age fish was transformed into chiefly prestige by facilitating the purchase of barley for beer making, exchanged for getting furs that were then traded for luxury items in distant ports, and was of course used for feeding people both at home and during voyages (Perdikaris 2000). All these transactions had the ultimate product of "honor," prestige and lineage power. In medieval times the transformation was of a different nature. It was no longer aimed mainly at acquisition of prestige useful for local and regional competition with other chieftains, but rather aimed at acquiring coined fully monetized cash that could be spent anywhere by anyone. A fish thus did not just change from an individual item of food into an object of value (first to second nature), but was further altered to become an abstract and standardized commodity (a third order abstraction). Its value as a commodity went beyond the local/regional level to truly international scale by the high Middle Ages.

The medieval transformation of fish is a more profound transition than the one observed in the Iron Age. During the commercialization era, 12th–13th century AD, local power was not autonomous any more in North Norway. The king and church were now the ultimate power foci. Taxation and tithes were to be collected by the state for the state. Profits driven through intense fishing became a domain of the new centralized government. The growth of trading places and towns during this period expanded the physical settings for impersonal proto-capitalist exchange, and the spread of coinage and monetization broadened familiarization with ideas of abstract value and impersonal transfer (Randsborg 1981; Hodges 1982, 1983). Medieval kingdoms were usually small, courts and wars were expensive, and agricultural tribute income was often hard to predict, collect, and convert to cash. A product that could be directly and reliably converted to cash, and which could be further pledged as security for loans against expected future production, was thus immediately attractive. Management of surplus and extraction of natural capital moved from the hands of local lords to the hands of the state. During the high Middle Ages, the Nordic states rapidly converted gadid fish into armies, art, architecture, and a persistent pattern of indebtedness to German bankers ready to lend money in exchange for fish not yet caught.

This transformation of fish to a monetary commodity requires imposing standardization on an inherently variable product. Neither fishermen nor fish are in fact totally interchangeable units and the loss of identity and the social links of honor, family, land, place, genealogy, and personal skills, that were so critical to economic transactions in the Viking Age required some profound conceptual reordering of first and second nature. Today we are used to standardized products such as wood, bread, cheese (all often now packaged in shrink-wrapped plastic). By the use of these words we think of interchangeable standardized items and can buy, sell, and borrow against them as abstract and stan-



**Figure 3.** Comparisons of species diversity.

standard units without ever touching tree, wheat, or milk. Even though standardized, they are still affected by the first nature of the raw material and the individual skill and ability of the person who transformed them from tree, grain, milk, to salable product. This transformation of variable, individual fish to a standard product of specific weight, length and standard processing, was not only one of the first such transformations that are part of everyday modern life, but one of the most significant ones, as it provided a model for many subsequent transformations in the AD 17th-19th centuries. The connection of commoditization to standardization of a variable natural product makes it possible for us to create a set of archaeologically visible indicators that enable us to use zooarchaeology to track some of these changes through time.

*Signatures of Commoditization: Species Diversity, Body Size, Element Distribution*

Species diversity of fish landed depends upon many factors besides the natural patterns in the sea: different bait, gear, boat type, and seasonality of fishing effort will all affect the species and age-classes taken, but in most cases fishing effort aimed at one species usually catches a wider range ("by-catch" is a major modern issue in fisheries conservation). It is thus not easy to take only one or two species of fish in a given catch, and a "natural" landing pattern will show fairly high species diversity. Where archaeological deposits show a reduction in fish species diversity to focus upon one or two target species we are thus seeing human economic selection more often than environmental change. In north Norway gadid species diversity in excavated archaeofauna drops dramatically

with the full commercialization of the high Middle Ages as preserved fish products shift from an artisanal product exchanged locally as an element of natural capital in socially embedded trade and tribute relationships (a product of "first nature" in Cronon's terms) to becoming a standardized commodity of known size, weight, and ranked quality that could be bought and sold in counting houses distant from the actual process of fishing, butchery, and curing (a product of "second nature"). Figure 3 compares the fish species diversity at two Iron Age sites in North Norway (Bleik and Toften) with an archaeofauna from the high medieval fishing center at Vågan in Lofoten, and also compares the fish species diversity at the Landnám period phase at the North Icelandic sites of Sveigakot and Selhagi near Lake Mývatn with a large (NISP 60,000+) 18th-19th century deposit from Tjarnargata 3c in downtown Reykjavik. In the Norwegian case, the transition to a simplified, cod-dominated bone collection is clear and dramatic. In Iceland, the early settlement period sites mirror Iron Age patterns in the Norwegian homeland, with the addition of substantial amounts of locally available freshwater salmon-family fish (brown trout and charr). The early modern urban collection from Reykjavik seems to be a mix of cod and haddock, both commercial species during the early modern period, though the haddock also seems to have been locally consumed as fresh fish (Perdikaris et al. 2001).

While gadid fish grow throughout their lives and form age/size classes with different niche requirements, only a restricted size range of fish is useful for making dried fish. The "stockfish window" is between ca 60 cm and 110 cm live length: smaller fish desiccate and larger ones tend to rot. Where measurable elements are present in sufficient quantity, regressions allow reconstructed live length to be compared. Figure 4 compares the distribution of measurable cod mouth parts at the small island farm of Miðbaer on Flatey with the distribution of the early modern collection from Reykjavik. While the Reykjavik cod appear to be solidly within the stockfish window, the distribution of reconstructed length of the cod from Miðbaer suggests subsistence consumption of smaller individuals as well (Perdikaris et al. 2001, Amundsen).

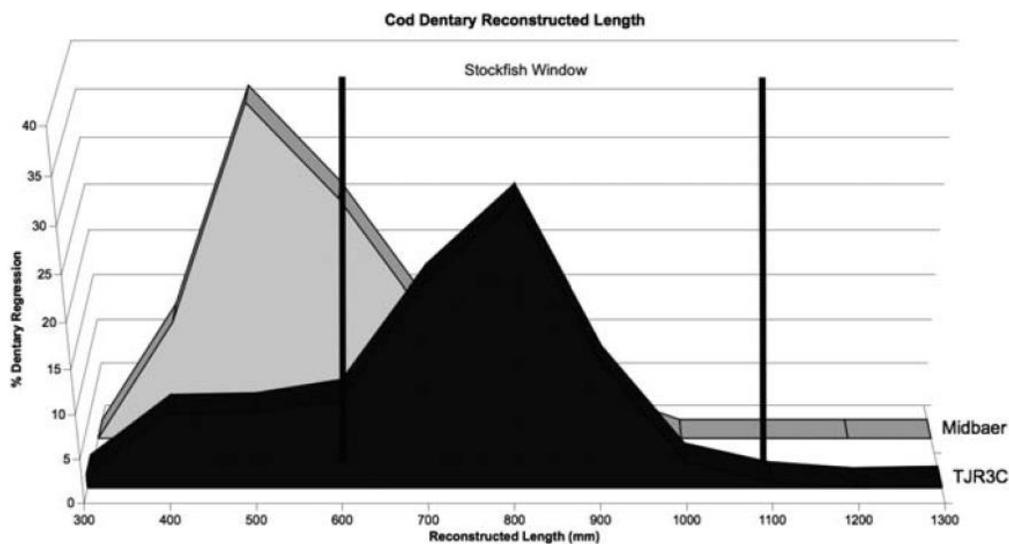
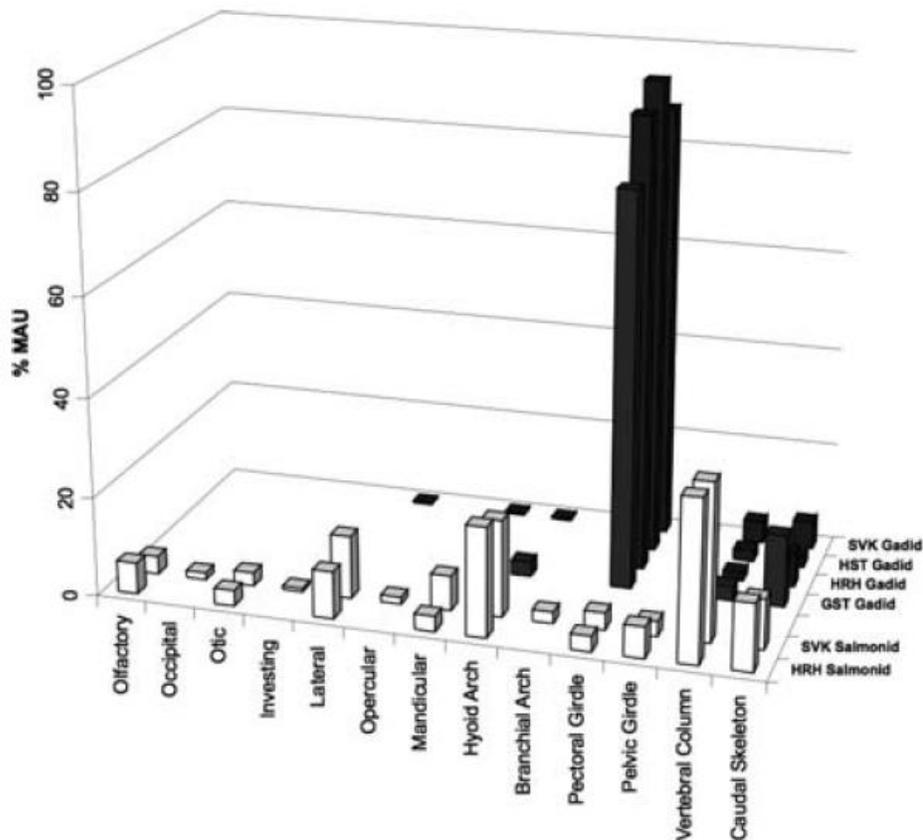
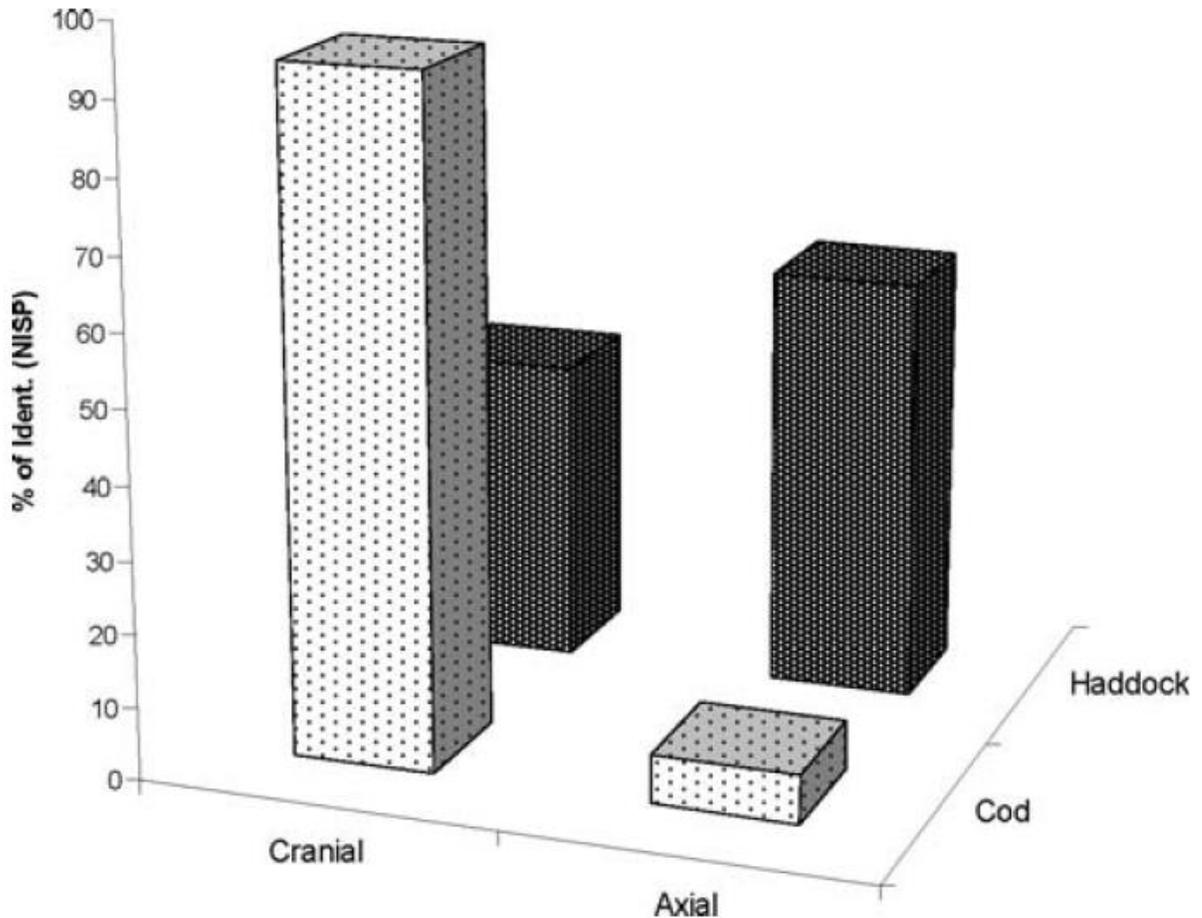


Figure 4. Cod dentary reconstructed length.



**Figure 5.** Element distribution.

Element distribution analysis has become increasingly feasible as reliable characters for species level identification of both cranial and axial fish skeletal become available. Figure 5 illustrates one such comparison between the distribution of gadid (cod-family) with salmonid (trout and char) at four settlement period inland Viking Age Icelandic sites near Mývatn. In each case there is a consistent pattern—the salmonids are represented by virtually all skeletal elements, but the gadids are mainly represented by bones from the pectoral girdle (especially the cleithrum) and the lower (caudal) vertebrae. Gadid cranial skeletons produce a set of dense mouth parts that generally preserve well and are immediately identifiable, but these are completely absent in these early inland sites. This element distribution is consistent with a fish preparation strategy that removes and discards the head at the processing point but leaves the cleithrum attached to the exported body to help keep the fish carcass together and to aid in spreading the body cavity for drying. This retention of the cleithrum with the exported body is seen in ancient as well as modern Norwegian stockfish production. A marked difference is in the distribution of the upper (thoracic) vertebrae. In stockfish these elements are left in the exported fish body, as stockfish is left in the round and virtually the whole vertebral column travels as a unit.



**Figure 6.** Tjarnargata 3 C.

Figure 6 contrasts the distribution of cranial and axial bones of cod (bodies exported, heads retained) and haddock (both heads and bodies deposited locally) at the early modern site of Tjarnargata 3c, illustrating the contrasting commercial and subsistence patterning in these elements expected from the residue of stockfish production and export.

In Viking Age Northern Iceland however, the fish were processed differently than they were to be in later times. They were beheaded, gutted and then the thoracic and precaudal vertebrae were removed, apparently during splitting and opening of the body into a flattened form. Ethnohistoric evidence suggests that in South-East Norway where the climate is warmer and wetter than Northern Norway and stockfish cannot be reliably produced, a flattened dried fish was produced. However, the closest zooarchaeological parallel to the pattern of gadid distribution in Viking Age Mývatn is in the Northern and Western Isles of Britain where solid evidence for intensified Viking period fishing and at least local level exchange is becoming increasingly well documented (Barrett et al. 2000, 1997, Barrett 1995, Bigelow 1984). Since we know that many early Icelandic settlers were from the British Isles (both slaves and aristocrats), this similarity may warrant more extensive investigation.

In any case, the Viking Age fish bone collections from sites up to 70 km from the sea indicate that some sort of regular mechanism existed to bring fish (and marine birds and a few sea mammal bones) far inland to consumers (McGovern, Perdikaris, Einarsson, and Sidell). The combined signatures of high species diversity and specialized element distribution indicate the robust existence of a regional premodern, not yet fully commoditized staple goods economy involving fish and possibly other wild products. The early establishment of this network underlines both the importance of wild species in supporting subsistence and the importance of such mundane bulky items alongside the more sagaworthy fine cloaks and decorated weapons in Viking Age Iceland.

### **Economic Patterns in Norse Greenland**

In Greenland, a very different mix of wild species greeted the first settlers. Caribou were present in both the settlement areas colonized (Eastern Settlement in the far South-West, Western Settlement in modern Nuuk district further North). Caribou were hunted in a variety of ways by the Norse, as upland drive systems, caches, crossbow bolt holes in caribou crania, and the widespread presence of large long-limbed dogs (most similar to the modern Norwegian Elk hound) suggest (McGovern and Jordan 1982, McGovern 1985). Caribou bones are found in all archaeofauna, with the greatest concentration on high status sites and on inland sites near modern caribou hunting areas (McGovern 1994, Enghoff 2003). Analysis of element distribution suggests that meat rich upper limb bones were differentially transported from upland kill sites to the chieftain's farm at W 51 Sandnes (McGovern et al. 1996). Though caribou were rapidly hunted out in the Eastern Settlement area by Inuit hunter-gatherers after the introduction of firearms in the 19th century, caribou were not driven to local extinction in either settlement area in the Middle Ages despite the much greater density of permanent settlement in the core grazing areas and the competition of domestic sheep and goats. Some social factors prevented this particular tragedy of the commons, and allowed a sustainable use of the caribou population of South-West Greenland by the Norse colonists for over 400 years.

In medieval Iceland, access to communal resources like upland pastures and in some cases access to seal colonies and stranded whales were regulated by the local community (*hreppur*) of ca 15-30 neighboring farms in an often-successful bottom-up attempt to regulate the commons (Simpson et al. 2001). In high medieval Europe, wild animal resources tended to be the property of secular or ecclesiastical aristocracy and their exploitation was strictly regulated by ferociously enforced top-down "forest laws". We do not know what mix of management strategies was employed in Norse Greenland, nor if the balance shifted through time towards top-down strategies (as it generally did in continental Europe), but the zooarchaeological record from later sites clearly indicates that there were plenty of large caribou being taken down to the end of the colony.

Seals appear to have played an even more important role in the subsistence economy, and their bones regularly make up 40 % to over 70% of the later archaeofauna (McGovern 1994). Stratified collections from the small low status farm W48 in the Western Settlement indicate that seal bones increased steadily from 11th to 14th century layers (McGovern 1994, McGovern et al 1983, 1996, 1988). Isotopic evidence of increasing participation in

marine food webs by later Norse Greenlanders (Arneborg et al. 1999) suggests that the expanding use of seals to supplement domestic mammal products was a widespread strategy. The 13th century source *Kings' Mirror* (Translation, Larsen 1917) accurately describes all five species of seals in Greenlandic waters (migratory harp and hooded seals, harbor seals, ringed seals, and bearded seal), but the zooarchaeological record indicates that only harp seal, hooded seal, and harbor seal were regularly taken by Norse hunters. In both settlement areas, the migratory harp seal makes up the majority of the bones identifiable to species. Tooth annuli indicate that the great majority of these seals were killed in early spring, mainly during the annual migration northwards from their pupping grounds off Newfoundland. Seasonal round reconstruction (McGovern 1981, Barlow et al. 1997) indicates that early spring would have regularly seen provisioning shortages, as stored food ran short on many farms, and domestic stock were not yet eating enough to produce milk. The spring harp seal migration (still numbered in the millions of individuals) seems to have filled this critical seasonal gap from first settlement times down to the end of the colony. Traditional Norse/Scottish sealing with nets and clubs was clearly effective against masses of harp seals and harbor seal colonies, but seems to have been less effective in taking the more solitary (but widespread) ringed seal. The bones of this species are extremely rare in all Norse archaeofauna, though modern catch records indicate that they are common in the Norse Settlement areas. Ringed seals (present in the Arctic year-round) are a staple of Inuit sealing, and are the main target of the elaborate complex of ice edge and breathing hole hunting technology well documented by excavation in Alaska, Canada, and Greenland. No toggling harpoons or even barbed spears have ever been recovered from any Norse site in Greenland, suggesting that this technology was not widely adopted by Norse sealers. This failure is remarkable in light of recent evidence for regular contact between the Norse and the Late Dorset of Greenland and (probably) Arctic Canada (Sutherland 2000) for at least 200 years before the arrival of the Thule culture Inuit in North Greenland from Alaska ca AD 1200.

Equally remarkable is the absence of the large number of marine fish bones recovered so regularly from contemporary Icelandic and British Isles sites. Despite repeated fine-mesh and flotation recovery strategies and modern zooarchaeological analyses by multiple workers, no substantial quantity of fish bones have been found on any site in Greenland. Despite conditions of organic preservation far better than found on most Icelandic sites, and recovery strategies that produced substantial collections of insects, hair, and small seeds, Norse Greenland's archaeofauna show only trace percentages of fish at the same time that Icelandic sites are often dominated by gadid bones (McGovern 2000, 1994 Enghoff 2003). Measurement of carbon isotope ratios in domestic mammal bones (both cattle and caprine) do not thus far suggest that these were regularly fed large amounts of fish or other marine fodder in Greenland, and we know historically that fish offal was also fed to stock in Iceland and the Northern Isles without so completely altering the zooarchaeological record. While negative evidence is always weak in archaeology, enough work has been done by enough scholars to indicate that fishing simply did not play a major role in Norse Greenland subsistence in either the Viking Age settlement period or the later Middle Ages (McGovern et al. 2001, Amorosi et al. 1996).

Differences in marine climate, shortage of boats and of material for effective hand line fishing, distance to markets, or even a dietary preference for high-fat sea mammals have all been proposed as causes for this puzzling de-emphasis on fishing in Greenland in contrast to the rest of the Norse N Atlantic. Recent demographic reconstruction work by Niels Lynnerup (2000, 1998) suggests that conflicting labor requirements may be another cause for de-emphasis of fishing in Norse Greenland. Working from a number of lines of evidence, Lynnerup has argued that the traditional maximum estimates of population in Norse Greenland of about 3–4,000 in the Eastern Settlement and about 1,000 in the Western Settlement are too high, and proposes a substantially lower estimate in the neighborhood of 2,000 settlers total (Lynnerup 2000: 385).

While any archaeological reconstruction of population size is inevitably imprecise, Lynnerup's study suggests that labor may have been a far scarcer commodity in Norse Greenland than in Iceland or the rest of the contemporary North Atlantic. In Iceland, fishing was possible year-round, and the most productive fisheries were actually in winter, targeting the cod spawning grounds. In medieval and early modern times, unemployed paupers, low ranking farm hands, and some middle ranking boat owners concentrated at seasonally occupied coastal stations (booths) to take large amounts of cod and halibut during the agricultural low season (Edvardsson 1996, Edvardsson et al. 2004, Vesteinsson 2000). As in Iron Age Norway, the fish taken were usually preserved as stockfish or split fish by drying and used as a storable subsistence product as well as an item of local and (later) international trade. The production of stockfish (requiring temperatures fluctuating close to the freezing point for prolonged periods) is also a winter activity. In Greenland, winter fishing with traditional open boats would have been far more difficult, facing regular winter sea ice and lower winter temperatures that would have made stockfish production less reliable. If a winter fishery was not possible in Greenland, then any summer fishery would compete for scarce labor with both the labor-intensive portion of the farming cycle and with the long-distance hunt to the Northern Hunting Grounds (Norðursetur). This remarkable long-distance hunt produced the low bulk, high value, Arctic prestige goods that were the mainstay of overseas trade with Europe from Viking times down to the end of the settlements.

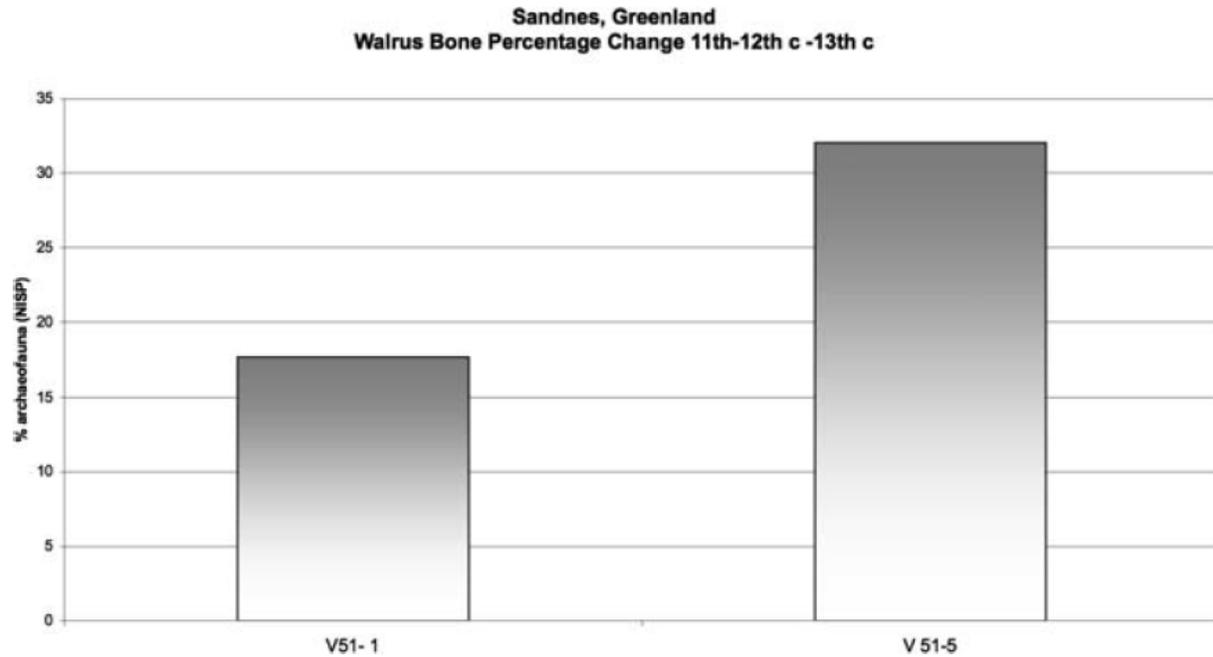
#### *Norðursetur: Walrus Hunting in Greenland*

The Norse Greenlanders are known to have provided a range of items to traders from Europe: Falcons, seal skins, sea mammal oil, hides, and soapstone. The helpful King's Mirror which provides this list also notes that one can charge the Greenlanders remarkably high prices for commodities bought cheaply in Europe, making the long voyage profitable: "...whatever comes from other lands is high in price, for the land is so distant from other lands that men seldom visit it. And everything that is needed to improve the land must be purchased abroad, both iron and all the timber." (King's Mirror, ca AD 1217–1260, Transl. Larsen 1917:142). But the most important and valuable items that were not available closer to the continental markets were the Arctic products of walrus ivory and walrus and polar bear skin. The dense tusk ivory was in considerable demand in 10th–13th century Europe for both secular and ecclesiastical consumers: book ornaments,

reliquaries, and chess men (the most famous being the Lewis sets, Stratford 2001, Mann 1977, MacGregor 1985, Roesdahl 1985) and was a widespread substitute for scarce elephant ivory. Walrus hide was cut into strips for high quality ships line, and polar bear skins (and the occasional live bear) were royal status objects providing extremely high prestige. In AD 1127, the Greenlanders are reported to have traded a live bear to the King of Norway for their first bishop (who proceeded to acquire the largest and most productive manor at Gardar in the Eastern Settlement, *Snorri Sokkason's Story*, Transl. Jones 1987).

While some walrus and polar bear appear all over Greenland, the largest concentrations of walrus have probably always been in the Holstiensborg-Disko Bay area in the central west coast (Vibe 1967). This area still produces most of the walrus taken by modern Inuit Greenlanders, and was the center for 18th-19th century European walrus hunting (McGovern 1985). The few documentary references to the Nordursetur also appear to place these "northern hunting grounds" in the same area, and a few Norse structures (including the well-known stone building at Nugssuak on the north end of Disko Bay) likewise seem to localize Norse Arctic hunting in this region (for discussion see McGovern 1985). This Northern Hunting Ground was nearly 800 km north of the northernmost permanent Norse farm, and we know from a few references that it took weeks of sailing in the "six oared boat" used for standard voyage estimates (Gad 1970) for hunters to reach this prime walrus hunting area. If we assume that the summer hunting season was from the end of June though late August, the transit time alone would ensure that any Nordursetur hunters and their valuable boats would be unavailable for any intensification of summer fisheries.

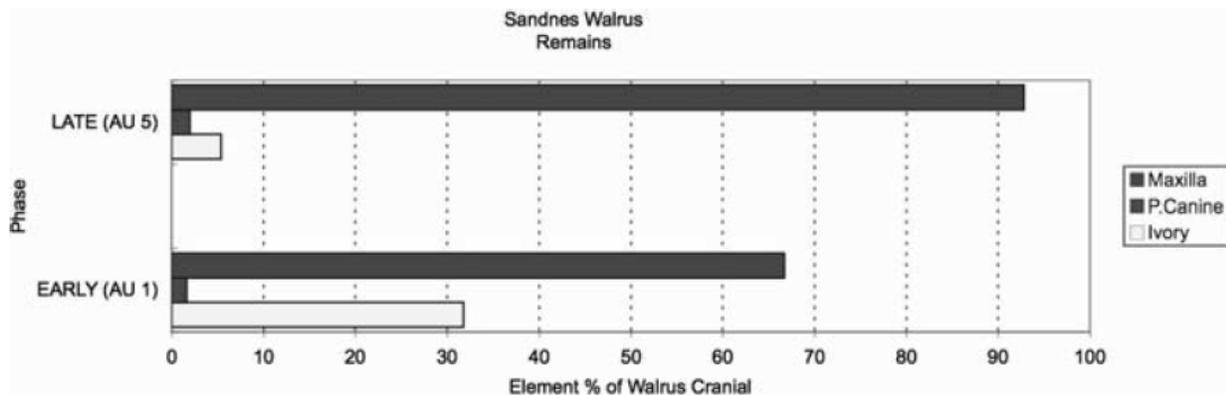
Our zooarchaeological evidence suggests that participation in the Nordursetur hunt was widespread. While tusk ivory or artifacts made from ivory is extremely rare on most sites, and post-cranial bones are also rare, the extremely dense maxillary bone fragments from around the tusk roots are common finds in archaeofauna from both Eastern and Western Settlements. These fragments are the result of a specialized butchery pattern (still practiced by Bering Sea Inuit communities) in which the tusk-bearing maxilla is cut from the heavy skull and transported home for tusk extraction. The deep roots of the tusks make in-field extraction impossible, and the breaking away of the maxilla to loosen the roots is a time consuming and skilled task. While a few of the peg-like post canine teeth were retained for local craftwork, nearly all the extracted tusk ivory was saved for transatlantic consumption. The Norse Greenlanders were thus not themselves consumers of walrus ivory, but they were intensively involved in its production. Virtually every animal bone collection larger than a handful of fragments has produced one or two of the distinctive maxillary bone chips, even those from inland sites many hours walk from the sea. It appears that some individuals from most farms participated in the hunt at one time or another. This pattern is made understandable by Lynnerup's revised population figures, which suggest that generating Nordursetur boat's crews would have required mobilization of a large percentage of the most physically active young men (and perhaps women as well). We have some scattered evidence for magical reinforcement for this long and dangerous trip in the form of widespread pierced walrus post canines carved into walrus, bird, and polar bear forms (Gullov 2000: 321) and the presence of a line of narwhal and



**Figure 7.** Walrus bone percentage change.

walrus skulls buried inside the sacred churchyard dyke at the bishop’s cathedral at Gardar (Degerbøl 1929). The Nordursetur hunt appears to have become firmly embedded in the cultural framework of Norse Greenland, with magic and ritual (and perhaps rites of passage?) associated with participation in the exciting and dangerous long hunt north.

Zooarchaeology also provides evidence of more prosaic craft processing of walrus and bear products on the home farms after the Nordursetur hunts. Polar bear bones are less common than walrus maxillary fragments, and the bones that survive (mainly cranial and foot bones) suggest final finishing of skins taken from bears killed some distance



**Figure 8.** Sandnes walrus remains.

away (McGovern 1985). The widespread walrus skull fragments are rather hard to reasonably quantify (one skull could generate a great many fragments), but the deeply stratified middens at the chieftains' farm of W51 Sandnes excavated 1984 (McGovern et al 1996) may provide some useful evidence. W51 has the highest overall percentage of walrus bone from known archaeofauna in the Western Settlement, and the percentage increases through time from the 11th-12th century to the 13th century (Figure 7). Not only do absolute numbers of fragments increase, but so does the average fragment size so that the increase is not simply due to increased fragmentation. As figure 8 illustrates, the craft workers at W51 Sandnes seem to have become more skilled at extracting the ivory without chipping it as time passed, as there is a marked reduction in the proportion of ivory chips and flakes relative to maxillary or post-canine fragments. The household at this elite farm continued to be active in hunting walrus and processing walrus ivory throughout the 350- year period of occupation, if anything showing increased activity and increased professional skills as the Viking period passed into the high Middle Ages. The few documentary sources indicate that this was not an atypical pattern. While their relatives elsewhere in the North Atlantic were intensifying fishing for subsistence and trade in high bulk, low value staple goods, the Norse Greenlanders seem to have been modestly intensifying their *Norðursetur* hunt and the production of low bulk, high value prestige goods.

In 1327 the Greenlanders contributed about 668 kg of walrus ivory to a crusade against heretics and for the support of the papal household (Gad 1970: 136-137, see discussion in McGovern 1985:290-91). However, by the 14th century walrus ivory was going out of fashion as a prestige good throughout Europe, and much of the surviving correspondence about the papal contribution concerns the best strategy for unloading such a large shipment without glutting the limited market and depressing prices still further. Our last written evidence for Norse society in Greenland dates to 1408, when a group of merchants who had been blown off course and forced to over winter in Greenland reported that they had been compelled by the Greenlanders to buy *Norðursetur* trade goods (which they were not licensed to carry) as well as provisions (Gad 1970). While there may be a bit of fiction in this account, it is clear that by the 14th-early 15th centuries demand for walrus ivory, polar bears and other Viking Age/early medieval prestige goods had waned in Europe, and closer sources of similar Arctic products were being developed in Karelia and Northern Norway (Edgren 2000). The Norse Greenlanders seem to have been intensifying the production of a commodity suffering falling demand.

As the climatic cooling of the later Middle Ages set in (Ogilvie and Jonsson 2001, Barlow et al. 1997, Buckland et al. 1996), the risks of both the *Norðursetur* trip and of transatlantic merchant voyages increased dramatically, especially with the onset of summer drift ice between Iceland and Greenland after AD 1250 (Jennings and Weiner 1996, Jennings et al. 2001). Contact with the immigrating Thule Inuit is still poorly understood, but most current models see possibility of growing conflict between the Thule and both Late Dorset and Norse (Appelt and Gullov 1999, Gullov 1999, McCullough 1989, Schleder-mann 1990, 2000, Sutherland 2000). Sometime in the late 13th-early 14th centuries, Thule people established a large and unusually nucleated winter settlement at Sermermuit in the southern end of Disko Bay (Mathiassen 1958). If hostilities broke out between

Norse and Thule people, the Sermermuit settlement would be well placed to interdict Norse travel to the most productive parts of the *Norðursetur*. It would seem likely that costs of the *Norðursetur* hunt were rising as demand for its products was dropping, and the possibilities of catastrophic loss of life and irreplaceable wooden boats was likewise climbing. While the causes for the end of the Norse society in Greenland are still subject to debate (McGovern 1992, Berglund 1991, Arneborg 1991, Keller 1991, McGovern 2000), one contributing factor is certainly their failure to attract and expand transatlantic European contacts and to achieve a better balance between the requirements of their subsistence and export economies. While it is easy to blame Norse elites for mismanaging their economy (McGovern 1981) if the *Norðursetur* hunt was indeed as complexly integrated into the fabric of this small society as the magical items indicate, it may have become enwebbed by a multitude of social reinforcements and inducements that may have promoted its maintenance and survival long past any strictly economic threshold of profitability. For whatever combination of causes, the Norse Greenlanders seem to have become extinct by the mid-15th century.

### **Staples, Subsistence, and Survival**

Iceland and Greenland thus present closely related, but strongly contrastive cases. The Norse Greenlanders appear to have established the basic outlines of both subsistence and export economies soon after the 11th century *Landnám*. While their subsistence economy was driven towards increased sealing, their Viking Age export economy continued an increasingly dangerous *Norðursetur* voyage that produced growing piles of inedible and increasingly unsalable walrus tusks. Given their different seasonal round, the Greenlanders probably had fewer options for deploying their scarcer labor supplies than did their Icelandic relatives. Icelanders also lacked a significant external military threat, while the Norse Greenlanders may have faced increasing competition for seasonal sealing grounds from the Thule people in the 13th and 14th centuries. The cooling of the early and mid-14th century (Barlow et al. 1997) certainly had more direct and more adverse impact on the Greenlandic settlements.

On the eve of the 14th century climate changes, many similarities existed between the related settlements of Iceland and Greenland. Both societies had inflicted significant environmental impacts upon their landscapes, and both had constructed high medieval societies boasting major churches, manors, and monastic centers. Both appear to have been dominated by cattle-rich great farmers (secular and ecclesiastical) whose wealth ultimately rested upon rich pasture vegetation soon to be threatened by climate change. Both to some extent had created vulnerabilities to environmental change of any sort. Both provisioned their societies as much from marine resources as from imported domesticates. In both islands, only marine resources were capable of further significant intensification—even before the cooling of the 14th century pasture areas—and productivity was certainly in decline in both settlements.

Still, the contrast between the pathways of economic intensification followed by Iceland and Greenland is profound. The Icelanders built upon an Iron Age strategy that allowed them to combine marine fishing and fish curing to reliably produce a storable

bulk staple good that could eventually undergo commoditization and become one of the key resources of the European mercantile states. The Greenlanders instead seem to have pursued some of the Viking Age prestige goods mentioned so prominently by Ottar (who does not mention stockfish in his boasts to King Alfred). As the European economy developed, it was to acquire a nearly insatiable appetite for cured fish but was to lose interest in walrus ivory ornaments. Even if demand for walrus products had remained high, the Norse Greenlanders were still faced with scheduling conflicts with subsistence tasks in an environment of increasing risk. While Iceland had the potential for further intensification of fishing (ultimately underwriting political independence after AD 1944 and a flourishing urbanized Scandinavian society today), the Greenlanders' choice to devote scarce labor and resources to the *Norðursetur* hunt led literally to a dead end.

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### References

- Amundsen, C. 1999. Early Medieval Iceland and Paleofisheries Research: A Preliminary Report. Paper presented at Historical Dimensions of Human Adaptability and Environmental Change in the North Atlantic Regions, workshop hosted by NABO and the Stefansson Arctic Institute, Akureyri, Iceland, July 16-21, 1999.
- Amundsen, C. P. 2004. Farming and maritime resources at Midbaer on Flatey in Breiðfjörð, north-west Iceland. In R. A. Housely and G. Coles (eds.). *Atlantic Connections and Adaptations: Economies, Environments, and Subsistence in Lands Bordering the North Atlantic*. AEA/NABO Environmental Archaeology Monographs 21. Oxbow Books.
- Amundsen, C., S. Perdikaris, T. H. McGovern, Y. Krivogorskaya, M. Brown, K. Smiarowski, S. Storm, S. Modugno, M. Frik, and M. Koczela. 2004. Fishing booths and fishing strategies in medieval Iceland: An archaeofauna from the of Akurvík, north-west Iceland. *Environmental Archaeology* 10(2): 127-142.
- Amorosi T., J. W. Woollett, S. Perdikaris, and T. H. McGovern. 1996. Regional zooarchaeology and global change research: Problems and potentials. *World Archaeology* 28(1): 126-157.
- Appelt, M., and H. C. Gulløv. 1999. Late Dorset in high Arctic Greenland. Dansk Polar Centre and Nationalmuseet, Copenhagen, Denmark.
- Arneborg, J., J. Heinemeier, N. Lynnerup, H. L. Nielsen, N. Rud, and Á. E. Sveinbjörnsdóttir. Change of diet of the Greenland Vikings determined from stable carbon isotope analysis and C-14 dating of their bones. *Radiocarbon* 41: 157-168.
- Barlow L., T. Amorosi, P. C. Buckland, A. Dugmore, J. H. Ingimundarsson, T. H. McGovern, A. Ogilvie, and P. Skidmore. 1997. Interdisciplinary investigations of the end of the Norse Western Settlement in Greenland. *The Holocene* 7(4): 489-499.

- Barrett, J. 1995. "Few know Earl Fishing-clothes": Fish Middens and the Economy of the Viking Age and Late Norse Earldoms of Orkney and Caithness, Northern Scotland. PhD thesis, University of Glasgow.
- Barrett, J., R. Nicholson, and R. Cerón-Carrasco. 1997. Fish trade in Norse Orkney and Caithness: A zooarchaeological approach. *Antiquity* 71: 616–638.
- Barrett, J., R. Beukens, I. A. Simpson, P. Ashmore, S. Poaps, and J. Huntley. 2000. What was the Viking Age and when did it happen? A view from Orkney. *Norwegian Archaeological Review* 33: 139.
- Bigelow, G. 1984. Subsistence in Late Norse Shetland: An Investigation into a Northern Island Economy of the Middle Ages. Ph.D. thesis, University of Cambridge, Cambridge, United Kingdom.
- Buckland, P. C., T. Amorosi, L. K. Barlow, A. J. Dugmore, P. A. Mayewski, T. H. McGovern, A. E. J. Ogilvie, J. P. Sadler, and P. Skidmore. 1996. Bioarchaeological and climatological evidence for the fate of the Norse farmers in medieval Greenland. *Antiquity* 70(1): 88–96.
- Carneiro, R. 1981. The chiefdom: Precursor of the state. In G. D. Jones and R. R. Krantz (eds.). *Transition to Statehood in the New World*. Cambridge University Press, Cambridge, United Kingdom, pp. 37–79.
- Christensen, A. E. 2000. Ships and navigation. In W. W. Fitzhugh and E. Ward (eds.). *Vikings: The North Atlantic Saga*. Smithsonian Institution Press, pp. 86–99.
- Degerbøl, M. 1929. Animal bones from the Norse ruins at Gardar. *Meddelelser om Grønland* 76 (1).
- Durrenberger, P. 1992. The dynamics of medieval Iceland. In *Political Economy and Literature*. University of Iowa Press, Iowa City, Iowa, USA.
- Durrenberger, P. 1989. Anthropological perspective on the Commonwealth period. In P. Durrenberger and G. Palsson (eds.). *The Anthropology of Iceland*. University of Iowa Press, Iowa City, Iowa, USA, pp. 228–246.
- Durrenberger P. 1991. The Icelandic family sagas as totemic artifacts. In R. Samson (ed.). *Social Approaches to Viking Studies*. Cruithne Press, Glasgow, Scotland, pp. 11–20.
- Earle, T. 1987. Chiefdoms in archaeological and ethnohistorical perspective, *Annual Review of Anthropology* 16: 279–308.
- Earle T. (ed.) 1991, *Chiefdoms: Power, Economy, and Society*. Cambridge University Press, Cambridge, United Kingdom.
- Edgren, T. 2000. The eastern route: Finland in the Viking Age. In W. W. Fitzhugh and E. Ward (eds.). *Vikings: The North Atlantic Saga*. Smithsonian Institution Press, Washington, DC, USA, pp. 103–115.
- Edvardsson, R. 1996. Fornleifaskráning í Bolungarvík, fyrsti hluti, Kaupstaðurinn og jarðirnar næstar honum. *Fornleifastofnun Íslands*.
- Edvardsson, R., S. Perdikaris, T. H. McGovern, N. Zagor, and M. Waxman. 2004. Coping with hard times in North-West Iceland: Zooarchaeology, history, and landscape archaeology at Finnbogastaðir in the 18th century, *Archaeologica Islandica* 3: 20–48.
- 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, Denmark.
- Feinman, G., and J. Neitzel. 1984. Too many types: An overview of sedentary prestate societies in the Americas. *Advances in Archaeological Method and Theory* 7: 39–102.
- Gad, F. 1970. *A History of Greenland*, volume 1. D. Hurst, London, United Kingdom.
- Gulløv, H. C. 1999. The Eskimo cultures of Greenland and the medieval Norsemen: A contribution to history and ethnohistory. In I. Sigurdsson (ed.). *Proceedings of the International Congress on the History of the Arctic and Sub-Arctic Regions*. University of Iceland, Reykjavik, pp. 54–71.
- Gulløv, H. C. 2000. Natives and Norse in Greenland. In W. W. Fitzhugh and E. Ward (eds.). *Vikings: The North Atlantic Saga*. Smithsonian Institution Press, Washington, DC, USA, pp. 318–327.
- Hedeager, Lotte, 2000, From Warrior to Trade Economy, in Fitzhugh W. W. and E. Ward (eds.). *Vikings: The North Atlantic Saga*. Smithsonian Institution Press, Washington, DC, USA, pp. 84–86.
- Hughes, M. K., and H. F. Diaz. 1994. Was there a "medieval warm period" and if so, where and when? *Climate Change* 26: 109–142.

- Jennings, A. E., and N. J. Weiner. 1996. Environmental change in eastern Greenland during the last 1300 years: Evidence from foraminifera and lithofacies in Nansen Fjord 68N. *The Holocene* 6(2): 179-191.
- Jennings, A. E., S. Hagen, J. Harðardóttir, R. Stein, A. E. J. Ogilvie, and I. Jónsdóttir. 2001. Oceanographic change and terrestrial human impacts in a post-A. D. 1400 sediment record from the southwest Iceland shelf. In A. E. J. Ogilvie and T. Jónsson (eds.). *The Iceberg in the Mist: Northern Research in Pursuit of a "Little Ice Age."* Kluwer Academic Publishers, London, United Kingdom.
- Jones, G. 1987. *The Norse Atlantic Saga*, 2nd ed. Oxford University Press, Oxford, United Kingdom.
- Larsen, L. M. (translator). 1917. *The King's Mirror*. American Scandinavian Foundation, New York, New York, USA.
- Lund, N. (ed.). 1984. *Two Voyagers at the Court of King Alfred*. W. Sessions, York, United Kingdom.
- Lynnerup, N. 1998. *The Greenland Norse: A biological-anthropological study*. Meddelelser om Grønland, Man and Society 24. Copenhagen, Denmark.
- Lynnerup, N. 2000. Life and death in Norse Greenland. In W. W. Fitzhugh and E. Ward (eds.). *Vikings: The North Atlantic Saga*. Smithsonian Institution Press, Washington, DC, USA, pp. 285-294.
- Mann, V. B. 1977. *Romanesque Ivory Tablemen*. PhD thesis, New York University, New York, New York, USA.
- MacGregor, A. 1985. *Bone, Antler, Ivory, and Horn: The Technology of Skeletal Materials Since the Roman period*. Academic Press, London, United Kingdom.
- Mathiassen, T. 1958. The Sermermiut excavations 1958. *Meddelelser om Grønland* 161(3).
- McCullough, K. M. 1989. The ruin Islanders: Early Thule culture pioneers in the Eastern High Arctic. *Archaeological Survey of Canada Mercury series* 141.
- McGhee, R. 1984. Contact between Native North Americans and the medieval Norse: A review of the evidence. *American Antiquity* 49(1): 45-62.
- McGovern, T. H. 1981. The economics of extinction in Norse Greenland. In T. M. L. Wigley et al. (eds.). *Climate and History*. Cambridge University Press, Cambridge, United Kingdom, pp. 404-434.
- McGovern, T. H. 1985a. The Arctic frontier of Norse Greenland. In S. Green and S. Perlman (eds.). *The Archaeology of Frontiers and Boundaries*. Academic Press, New York, New York, USA, pp. 275-323.
- McGovern, T. H. 1985b. Contributions to the Paleoecology of Norse Greenland. *Acta Archaeologica* 54: 73-122.
- McGovern, T. H. 1991. Climate, correlation, and causation in Norse Greenland. *Arctic Anthropology* 28(2): 77-100.
- McGovern, T. H. 1992. Bones, buildings, and boundaries: Paleoeconomic approaches to Norse Greenland. In C. D. Morris and J. Rackham (eds.). *Norse and Later Settlement and Subsistence in the North Atlantic*. Glasgow University Press, Glasgow, United Kingdom, pp. 157-186.
- McGovern, T. H. 2000. The demise of Norse Greenland. In W. W. Fitzhugh and E. Ward (eds.). *Viking Voyagers*. Smithsonian Institution Press, Washington, DC, USA, pp. 327-340.
- McGovern, T. H., P. C. Buckland, G. Sveinbjarnardóttir, D. Savory, P. Skidmore, and C. Andreasen. 1983. A study of the faunal and floral remains from two Norse farms in the Western Settlement, Greenland. *Arctic Anthropology* 20(2): 93-120.
- McGovern T. H., T. Amorosi S. Perdikaris, and J. W. Woollett. 1996. Zooarchaeology of Sandnes V51: Economic change at a Chieftain's Farm in west Greenland. *Arctic Anthropology* 33(2): 94-122.
- McGovern, T. H., G. F. Bigelow, T. Amorosi, and D. Russell. 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., and S. Perdikaris. 2000. What went wrong with the Norse voyages: The silent saga. *Natural History Magazine* 2000(Oct): 50-55.
- McGovern, T. H., S. Perdikaris, and C. Tinsley. 2001. Economy of Landnám: The evidence of zooarchaeology. In A. Wawn and T. Sigurdardóttir (eds.). *Approaches to Vinland*. Sigurdur Nordal Institute studies 4, pp. 154-165.

- Munch, G. S., and O. S. Johansen. 1987. Borg in Lofoten: A chieftain's farm in Arctic Norway. In J. Knirk (ed.). *Proceedings of the 10th Viking Congress*, Larkollen, Norway.
- Nicholsen, R. 1998. Fishing in the Northern Isles: A case study based on fish bone assemblages from two multi-period sites on Sanday, Orkney. *Environmental Archaeology* 2: 15–29.
- Ogilvie, A., L. K. Barlow, and A. E. Jennings. 2000. North Atlantic climate ca. AD 1000. *Weather* 55(2): 34–45.
- Ogilvie, A., and T. H. McGovern. 2000. Sagas and science: Climate and human impacts in the north Atlantic. In W. W. Fitzhugh and E. Ward (eds.). *Viking Voyagers*. Smithsonian Institution Press, Washington, DCM USA, pp. 385–394.
- Perdikaris, S. 1990. Åker: a zooarchaeological perspective on a Norwegian Iron Age site. Master's thesis, Hunter College CUNY.
- Perdikaris, S. 1996. Scaly heads and tales: Detecting commercialization in early fisheries. In A. Morales (ed.). *Archaeofauna, Ichthyoarchaeology and the Archaeological Record: Proceedings of the 8th meeting of the ICAZ Fish Remains Working Group*. Madrid, Spain, pp. 21–33.
- Perdikaris, S. 1998. The transition to a commercial economy: Lofoten fishing in the Middle Ages, a preliminary report. *Anthropozoologica* 25–26: 505–510. [Proceedings of the 7th ICAZ conference, September 1994, Konstanz, Germany].
- Perdikaris, S., C. Amundsen, T. H. McGovern. 2001. Zooarchaeology of Tjarnargata 3C, Reykjavík, Iceland: Report on file at the Arch Institute of Iceland. *Environmental Archaeology*.
- Roesdahl, E. 1995. *Hvalrostand elfenben og nordboerne I Grønland*. Odense University Press.
- Sawyer, P. H. 1982. *Kings and Vikings*. Methuen, London, United Kingdom.
- Scott, G. R., C. M. Halfsmann, and P. I. O. Pedersen. 1991. Dental conditions of medieval Norsemen in the north Atlantic. *Acta Archaeologica* 62: 183–207.
- Schledermann, P. 1990. *Crossroads to Greenland: 3,000 Years of Prehistory in the Eastern High Arctic*. [Komatic series 2]. Arctic Institute of North America, Calgary, Alberta, Canada.
- Schledermann, P. 2000. Ellesmere: Vikings in the far north. In W. W. Fitzhugh and E. Ward (eds.). *Vikings: The North Atlantic Saga*. Smithsonian Institution Press, Washington, DC, USA, pp. 248–257.
- Simpson, I. A., S. Perdikaris, G. Cook, J. L. Campbell, and W. J. Teesdale. 2000. Cultural sediment analyses and transitions in early fishing activity at Langenesvaeret, Vesterålen, northern Norway. *Geoarchaeology* 15: 743–763.
- Simpson, I. A., A. J. Dugmore, A. Thomson, and O. Vésteinsson. 2001. Crossing the thresholds: Human ecology and historical patterns of landscape degradation. *Catena* 42: 175–192.
- Sutherland, P. 2000. The Norse and Native North Americans. In W. W. Fitzhugh and E. Ward (eds.). *Vikings: The North Atlantic Saga*. Smithsonian Institution Press, Washington, DC, USA, pp. 238–247.
- Stratford, N. 2001. *Lewis Chessmen and the Enigma of the Hoard*. British Museum Press, London, United Kingdom.
- Thorsteinn, V. 2001. Navigation and Vinland. In A. Wawn and T. Sigurdardóttir (eds.). *Approaches to Vinland*. Sigurdur Nordal Institute studies 4, pp. 107–121.
- Thurston, T. L. 1999. The knowable, the doable, and the undiscussed: Tradition, submission, and the 'becoming' of rural landscapes in Denmark's Iron Age. *Antiquity* 73: 661–671.
- Vesteinsson, O. 1998. *Patterns of Settlement in Iceland: A Study in Pre-History*. *Saga-Book of the Viking Society* XXV, pp. 1–29.
- Vesteinsson, O. 2000a. *The Christianization of Iceland: Priests, Power and Social Change 1000–1300*. Oxford University Press, Oxford, United Kingdom.
- Vesteinsson, O. 2000. The archaeology of Landnám: The shaping of a new society in Iceland. In W. W. Fitzhugh and E. Ward (eds.). *Vikings: The North Atlantic Saga*. Smithsonian Institution Press, Washington, DC, USA, pp. 164–174.
- Vésteinsson, O., T. H. McGovern, and C. Keller. 2002. Enduring Impacts: Social and environmental aspects of Viking Age settlement in Iceland and Greenland. *Archaeologica Islandica* 2: 98–136.
- Vibe, C. 1967. Arctic animals in relation to climatic fluctuation. *Meddelelser om Grønland* 170(5).