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Arctic Archaeology and Climate Change

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Abstract

An enduring debate in the field of Arctic archaeology has been the extent to which climate change impacted cultural developments in the past. Long-term culture change across the circumpolar Arctic was often highly dynamic, with episodes of rapid migration, regional abandonment, and—in some cases—the disappearance or wholesale replacement of entire cultural traditions. By the 1960s, researchers were exploring the possibility that warming episodes had positive effects on cold-adapted premodern peoples in the Arctic by (*a*) reducing the extent of sea ice, (*b*) expanding the size and range of marine mammal populations, and (*c*) opening new waterways and hunting areas for marine-adapted human groups. Although monocausal climatic arguments for change are now regarded as overly simplistic, the growing threat of contemporary Arctic warming to Indigenous livelihoods has given wider relevance to research into long-term culture–climate interactions. With their capacity to examine deeper cultural responses to climate change, archaeologists are in a unique position to generate human-scale climate adaptation insights that may inform future planning and mitigation efforts. The exceptionally well-preserved cultural and paleo-ecological sequences of the Arctic make it one of the best-suited regions on Earth to address such problems. Ironically, while archaeologists employ an exciting and highly promising new generation of methods and approaches to examine long-term fragility and resilience in Arctic social-ecological systems, many of these frozen paleo-societal archives are fast disappearing due to anthropogenic warming.

1. INTRODUCTION: LONG-TERM CULTURE–CLIMATE INTERACTIONS IN THE ARCTIC

When compared with the complex, richly seriated culture-historical sequences of more southerly regions, the archaeology of large parts of the Arctic can, at first glance, appear relatively straightforward. The culture history of the circumpolar Arctic has been characterized in terms of abrupt migrations, replacements, and regional abandonments. The argument that climate change could have driven Arctic culture change began to emerge only in the late 1960s (see McGhee 1970, 1981). A common argument was that warmer conditions—widely considered inherently beneficial for human settlement of the Arctic—led to a retreat of heavy sea ice during cold seasons, which, in turn, increased both the abundance and the geographic range of high-utility marine mammal species, such as whales and walruses. Marine-adapted hunter-gatherer cultures simply followed on behind (see Friesen & Mason 2016a, p. 9).

Such monocausal, environmentally deterministic arguments assuming direct links between climate change and cultural response can, and should, be challenged on several fronts. First, they imply a lack of agency among Arctic peoples, whose decisions are reduced to automatic reactions to stark environmental pressures. Second, the relationship between climate and the availability of game resources in the Arctic is far more complex than was once assumed. Indeed, warmer temperatures in cold biomes do not necessarily result in increased ecological productivity. While warmer temperatures can lead to a decline in some ice-adapted seal populations, for example, colder temperatures and increased storminess can—counterintuitively—actually increase biological productivity (Mason & Barber 2003 in Friesen & Mason 2016a, p. 9). Finally, effective cultural responses to new environmental/ecological conditions may take many generations to gather pace, while existing traditions and methods may persist long after new environmental circumstances have rendered them locally inefficient.

Increased recent scholarly interest in past Arctic social-ecological systems has been stimulated by concern over the impacts of contemporary anthropogenic global warming on the livelihoods, cultural health, and ecological heritage of Arctic Indigenous communities (Hollesen et al. 2018). A deeper temporal dimension remains poorly integrated into research on cultural adaptation and planning efforts. Historical disciplines, such as Arctic archaeology, have the unique ability to contribute multigenerational human-scale data to the analysis of climate-adaptation dynamics (Fitzhugh et al. 2018, Jackson et al. 2018b). The deep-time perspective promised by archaeology may eventually play a vital role in future climate change mitigation strategies. The complex, long-term interactions between climate and culture have risen again to the highest levels of the social-scientific research agenda "and will remain a central theme in Arctic archaeology for the foreseeable future" (Friesen & Mason 2016a, p. 9).

We begin our review with a brief summary of the earliest human migrations into the Arctic—traditionally linked to deglaciation and climate change. We then present four case studies on the complex role of climate change in long-term human ecodynamics across the region. We conclude with a discussion of how contemporary warming has impacted the lifeways and cultural heritage of today's Arctic Indigenous peoples. A clear genetic and cultural link exists between these modern groups and many of those responsible for the archaeological remains found across the Arctic. Because of this direct culture-historical link, we believe it is important to consider the changing lifeways of modern Indigenous peoples—representing one end of a cultural continuum linked uniquely to a changing environment. Such examinations may also generate new opportunities for archaeologists to produce research with timely, modern social relevance.

Figure 1

Physical geography of the contemporary Arctic, showing coastlines, sea ice coverage (April 2010), and the modern tree line (*green*). Numbers mark the locations of the four case studies: (1) Paleo-Inuit Tradition; (2) Norse Greenland; (3) Neo-Inuit Tradition; (4) Northern Fennoscandia cultures. Map by F. Steenhuisen.

2. CLIMATE CHANGE IN AN ALREADY RISK-LADEN ENVIRONMENT

Broadly speaking, the Arctic can be defined as a large, frozen ocean surrounded by the landmasses of northern Eurasia, northern North America, and Greenland (**Figure 1**). Only limited and seasonally uneven solar radiation reaches these higher latitudes, resulting in unique biomes characterized by relatively short food chains and low species diversity. Coastal regions exhibit some of the highest levels of productivity, especially where upwelling ocean currents bring nutrients to the surface, with marine mammal species migrating seasonally into perennially frozen Arctic waters. Freshwater Arctic biomes are generally somewhat lower in productivity, though occasional migration of anadromous fish species from ocean-to-freshwater habitats results in seasonal resource concentrations. Terrestrial Arctic biomes are characterized by tundra and exhibit generally impoverished soils—with continuous permafrost at higher latitudes—and inhibited vegetation growth owing to low temperatures, snow cover, and aridity, though plants complete rapid growth in the short summers, supporting vast herds of migrating caribou (Freeman 1984).

On an interannual basis, these diverse land- and seascapes present a series of fundamental and interrelated challenges to hunter-gatherer survival, including short-term, yet potent shifts in seasonal weather patterns, as well as the uneven distribution of food resources for both humans and animals at different times of the year (Rowley-Conwy 1999). Due to the lack of edible vegetation at higher latitudes, premodern Arctic cultures exhibited an overwhelming reliance on animal protein—especially that of marine mammals—for survival (Friesen & Mason 2016a, p. 8). For example, in some seasons, premodern Inuit in the Eastern Arctic (Arctic/Subarctic Canada and

Greenland) may have been almost entirely dependent on a single prey species—small, ice-adapted seals—with few alternatives to fall back on (Desjardins 2018).

The fundamental challenge for groups living in such dynamic environments is whether existing strategies or activities (e.g., traditional hunting practices) are flexible enough to allow for focused adaptation to changing conditions or whether more fundamental social and/or technological reorganization is required. Major cultural adjustments, such as changes to seasonal rounds or wholesale migration, take time and must proceed from an existing knowledge base. Cultural adaption may be better understood as "pathways of change and response" exhibiting a deeper temporal dimension (Adamson et al. 2018) and may eventually reveal internal limits to adjustment (see Dugmore et al. 2007, 2012).

These considerations render long-term human–environment interactions in the Arctic both complex and inherently difficult to predict and model. As noted previously, monocausal explanations are rarely sufficient, and a new generation of research is experimenting with more integrative analytical frameworks, of which the most promising are (*a*) cultural fragility, stability, and resilience within a social-ecological systems approach and (*b*) long-term "human ecodynamics." The utility of such approaches lies in their capacity to integrate data on long-term cultural and ecological trends, combined with the application of new methods, such as paleodemographic modeling (Bradtmöller et al. 2017, Fitzhugh et al. 2018, Jackson et al. 2018b).

3. LONG-TERM CLIMATE–CULTURE INTERACTIONS

The relatively low species richness across the Arctic's maritime, freshwater, and terrestrial biomes means that climatic or environmental perturbations are more likely to have an immediate effect throughout the wider ecological system. Between 1906 and 2005, the world's surface temperatures rose approximately 0.74°C (IPCC 2007, pp. 2, 30). At high latitudes, even a modest increase can have significant impacts, such as the disruption of food webs of marine mammals that depend on specific seasonal fluctuations in sea ice and open water. Such impacts may also be felt by modern Indigenous people who in many regions of the Arctic continue to depend on both hunted food resources ("country foods") as highly meaningful symbols of cultural identity, as well as important stopgaps to food insecurity (Arctic Council 2016).

Deterministic framing notwithstanding, episodes of both warming *and* cooling appear to have bracketed most major known Arctic cultural-historical developments, though the precise nature of climate–culture interactions in many such cases remains unclear. Human occupation of the world's Arctic regions began in earnest in the Late Pleistocene, continuing into the mid-Holocene (see **Figure 2**). Dates from sites in the Russian Arctic indicate that the first human forays above the Arctic Circle occurred sometime about 27,000 BP, though the region was abandoned again during the Late Glacial Maximum. By about 13,000 BP, people had reappeared in Arctic Northeast Asia, and by about 11,500 BP had crossed Beringia and entered Alaska; pioneering groups were also moving even further southward into the rest of the Americas (see Kornfeld & Politis 2014, Goebel & Potter 2016). At this time, however, most of Arctic North America was still depressed beneath three massive ice sheets, which prevented human occupation for several more millennia.

By the Late Pleistocene, Arctic Europe was also slowly emerging from beneath a large ice sheet; the earliest human populations in this region followed the resource-rich, ice-free coastlines of Norway northward (Bjerck 2008), reaching Finnmark (Arctic Norway) shortly after 10,000 BP (Kleppe 2018). About 1000 years later, new populations reached the same region via an inland route, through northern Finland (Rankama & Kankaanpää 2008, Sørensen et al. 2013, Damlien 2016, Damm et al. 2019). From this point onward, Arctic Europe enjoyed a sustained and varyingly prosperous human presence (Riede 2014). Human settlement of the wider Eurasian Arctic

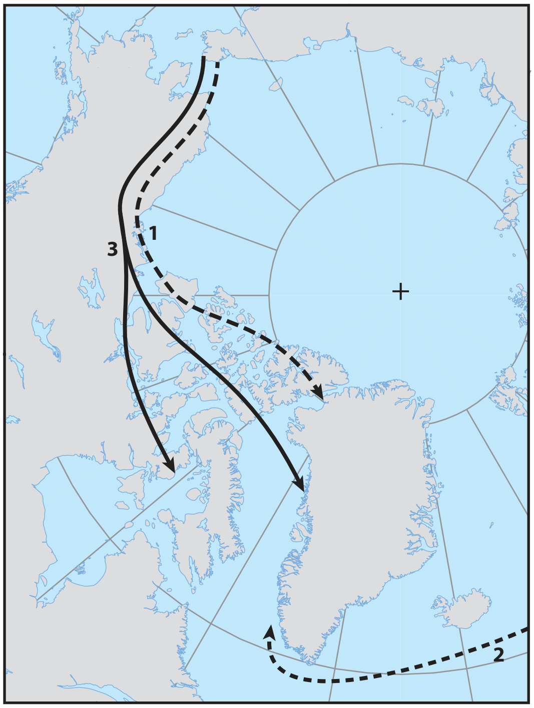

Figure 2

Likely origin, dispersal routes, and dates (in uncalibrated years BP) of some of the major cultural traditions that have entered in the North American Arctic and Greenland: (1) Paleo-Inuit Tradition (ca. 4500 BP); (2) Norse expansion into Greenland (ca. 965 BP); (3) Neo-Inuit Tradition (ca. 750 BP). Map by F. Steenhuisen.

took the form of similarly steady and economically stable occupation sequences throughout the Holocene (Hoffecker 2005), reflecting a series of important economic adaptations, such as coastal fishing and marine mammal hunting and, in later periods, large-scale reindeer pastoralism (e.g., Krupnik 1993).

Significant environmental changes took place during the Pleistocene–Holocene transition, followed by a series of climate change episodes during the Holocene, such as the (relatively) brief 8.2-kiloyear BP cooling episode, a Neoglacial cooling episode from about 2800 to 2000/1800 BP (Barry et al. 1977, D'Andrea et al. 2011); the Medieval Warm Period (MWP) or Medieval Climatic Anomaly (about 1000 to 700 BP) (Mann et al. 2009); the Little Ice Age (LIA) (about 675/650 to 150/100 BP) (Bradley & Jones 1993, Miller et al. 2012); and, finally, modern anthropogenic warming.

Below, we present four regional case studies from across the circumpolar Arctic that engage in distinct ways the question of how climate change influenced cultural development.

3.1. The Rise and Demise of the Paleo-Inuit Tradition

The first and longer-lasting of the Eastern Arctic's two great cultural traditions, the Paleo-Inuit Tradition comprised a number of distinct culture groups, including the early and short-lived Independence I in northern Greenland; Saqqaq in west, southern, and eastern Greenland; Pre-Dorset across Northern Canada; and the various phases of the Dorset culture throughout the Eastern

Arctic. [Notably, a revision in the nomenclature and general classification of early Dorset culture has taken root in recent scholarship: The earliest Dorset populations in Northern Canada continue to be known as Early Dorset, whereas those in Greenland are now referred to as Greenlandic Dorset—a designation that also includes the previously separate Independence II culture (see Jensen 2016).] Of particular interest to the present analysis is how climate change influenced (*a*) the transition from Pre-Dorset/Saqqaq to Early/Greenlandic Dorset, and (*b*) the development and trajectory of Dorset life in the Eastern Arctic before the onset of the MWP and the arrival of the Neo-Inuit peoples (**Figure 3**).

The role of climate change in both the emergence and the decline of the Paleo-Inuit cultures has long been a topic of great interest to archaeologists. The arrival and spread of Paleo-Inuit from Siberia and the Bering Strait region could—in the absence of archaeological evidence of cultural

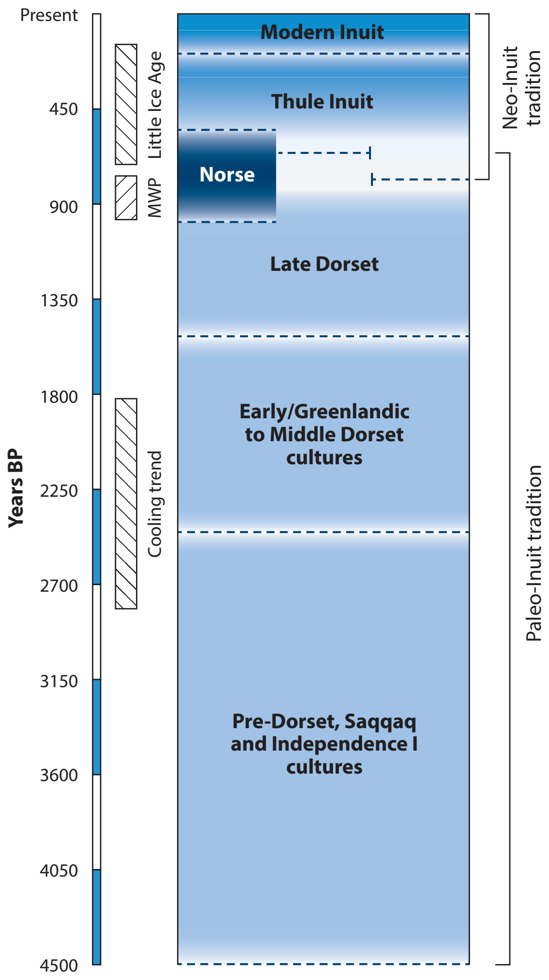

Figure 3

A timeline of major cultural transitions and episodes of climate change (in uncalibrated years BP) in the Eastern Arctic. (Note that the Middle Dorset tradition does not appear in Greenland, with a significant gap in occupation between the Greenlandic and Late Dorset cultures.) Abbreviation: MWP, Medieval Warm Period. Figure by F. Steenhuisen.

push and pull factors—be attributed to the literal emergence of new territory: Large amounts of land were rising after millennia of burial beneath the ice. Although rates of deglaciation and associated isostatic adjustment (or postglacial rebound) varied widely across the Eastern Arctic (see Sella et al. 2007), it is clear that ice covering the western portion of northern Foxe Basin, one of the Eastern Arctic's most ecologically productive regions, began to break up sometime about 6900 BP (Dredge 2001).

By about 4500 BP, Pre-Dorset, Independence I, and Saqqaq groups had established presences in their respective ecological niches of the postglacial Eastern Arctic (Savelle & Dyke 2009, Friesen 2016, Grønnow 2016). In terms of their settlement patterns, hunting practices, and composition of their tool kits, these early culture groups were distinct from one another in many notable ways. Even within each culture, there is a curiously high degree of technological and architectural variability (see Milne & Park 2016 for a discussion of the great variability among Pre-Dorset groups). It is ironic that poor preservation of organic materials—due in part to climate change—has skewed a more complete picture of artifact use and diet during these early Paleo-Inuit times.

Paleo-Inuit entered the Eastern Arctic during the tail-end of a lengthy episode of global warming known as the Holocene Thermal Maximum (HTM) or the Holocene Climate Optimum (Finkelstein 2016). Paleo-climatic reconstructions based on pollen from lake sediment cores across the Eastern Arctic indicate marked HTM warming persisted in much of the Canadian Arctic, as well as western and northern Greenland, until about 5.2 ka BP (Gajewski 2015). These warmer conditions may have been ideal for both terrestrial and marine prey species favored by pioneering Paleo-Inuit groups (Friesen 2016, p. 677).

The succession from Pre-Dorset/Saqqaq to Early/Greenlandic Dorset occurred sometime between 2600 and 2500 BP in both Northern Canada and Greenland (Jensen 2016, Ryan 2016). Analyses of both mitochondrial and nuclear DNA from Paleo-Inuit hair, teeth, and bone material recovered from archaeological sites across Arctic North America have proven this transition to have occurred in situ, with no wholesale influx of new genetic material from outside the Eastern Arctic (Raghavan et al. 2014); this finding is despite notable differences in both material culture and subsistence/settlement systems between the earliest Dorset cultures and Pre-Dorset. Such cultural changes have traditionally been explained away as responses to significantly cooler temperatures. Indeed, multiproxy reconstructions confirm a near-millennium-long Neoglacial cooling episode (from about 2800 to 2000/1800 BP) (D'Andrea et al. 2011). Such a trend would have likely forced a series of major adaptations to expanded landfast-ice and floe-edge habitats, including changes to technology and resource scheduling to favor ice hunting of small seals.

Preservation of organic materials at Dorset sites is generally better than at earlier sites; even so, determining whether Dorset groups across the increasingly cool Eastern Arctic were more or less food secure than their ancestors can be difficult. Archaeological evidence indicates that the Dorset tool kit, though meager in comparison to that of the Neo-Inuit, was well adapted to the new, cooler conditions. The relationship between Dorset cultural resilience and environmental productivity has been closely examined in the Foxe Basin region of Arctic Canada, which has been at various times classified as the "core area" of Dorset cultural development (McGhee 1972; Maxwell 1976; Maxwell 1985, p. 81). Despite an effective critique by Savelle & Dyke (2014) of the core area model's precepts of near-continuous Dorset occupation in Foxe Basin, it is clear that populations in the region were generally large and healthy, subsisting on a relatively wide range of available resources, including walruses, seals, and caribou (Murray 1996, 1999). It was likely in the Foxe Basin region, about 1500 BP, that the Middle Dorset culture transitioned to the distinct Late Dorset culture, which soon repopulated most of the Eastern Arctic (Appelt et al. 2016). About 950 BP, the culture was confronted by significantly warmer temperatures of the MWP, which likely significantly opened waterways throughout the Arctic Archipelago during the warmer months of the year.

Complicating our understanding of Late Dorset responses to the MWP is that the event immediately preceded the arrival into the Eastern Arctic of an entirely new culture group—Thule Inuit (the first culture of the Neo-Inuit Tradition)—from the Bering Strait and north Alaska, about 750 BP (Friesen & Arnold 2008, Friesen 2016) (see Section 3.3 below). Although some evidence indicates that occupations of these two groups overlapped in certain regions, the precise nature of these interactions is unclear (for contrasting perspectives on the succession, see Park 1993, 2016; Friesen 2000, 2016). Genetic comparisons by Raghavan et al. (2014) indicate minimal admixture with the Thule Inuit migrants, suggesting that no widespread cultural assimilation or absorption occurred. With no archaeological evidence of conflict, the most reasonable explanation holds that Late Dorset groups were outcompeted by Thule Inuit for choice hunting and settlement locales. Indeed, at the time of their disappearance from the archaeological record some time about 700 BP, Late Dorset had been relegated to the fringes of the North American Arctic: northwest Greenland, Nunavik (Northern Quebec) and the Coronation Gulf area—all comparatively more game-scarce regions than, for example, Foxe Basin.

Throughout their time in the Eastern Arctic, Paleo-Inuit peoples struggled to cope with the effects of dramatic cooling and warming episodes, any of which may have added or subtracted vital subsistence resources from land- and seascapes. In sharp contrast to Neo-Inuit, there is little archaeological evidence for sophisticated open-water, or even near-shore, boating technology among Early and Middle Dorset in the Canadian Arctic (see Ryan 2016, p. 770) and somewhat doubtful evidence for the use of single-person vessels (*qajait*/kayaks) among Late Dorset at a single site—Nunguvik (PgHb-1), northern Baffin Island (Mary-Rousselière 1979; Appelt et al. 2016, pp. 785–87). This lack of watercraft would have significantly complicated Late Dorset responses to the MWP and its resulting increase in warm-season open water resources, such as walruses and whales. Such struggles would have been compounded greatly by the arrival of Thule Inuit, who had a well-developed, robust array of specialized technologies for harvesting marine mammals in a variety of open water and ice conditions.

3.2. The Norse Experiment in Greenland

The existential consequences of climate change have played a central role in long-running debates over the failure of the Norse colonization of Greenland, which began about 965 BP—near the onset of the MWP. The decline and ultimate disappearance of the Norse from the island about 475 BP coincide with another significant climatic episode—the intense cooling of the LIA (see Mann et al. 2009). The cultural-ecological relationship was brought to widespread attention by Jared Diamond in his popular science book *Collapse* (2005), in which he argues that the Norse settlements failed because the colonists clung to familiar, but increasingly unsuitable practices, such as farming and animal husbandry, which may have been initially possible in Greenland only because of the anomalously high temperatures of the MWP. Diamond (2005, p. 265) positions cultural intransigence (a "bad attitude" toward Indigenous peoples and practices, generally) as a singular threat to Norse survival and implicitly suggests that the only tenable response to the cooling temperatures would have been a major subsistence shift from agriculture to marine hunting and fishing—Dorset and Thule Inuit mainstays.

In fact, rather conclusive evidence demonstrates that Norse made significant adjustments to their subsistence regime over time to meet the challenges of the LIA, including hunting and consuming large amounts of protein from the sea. The most compelling evidence is fairly recent: An analysis of stable carbon and nitrogen isotopes of 80 Greenlandic Norse burials shows that consumption of marine protein gradually increased from a low of ~15% of the total measurable diet during the early phase of the occupation to between 50% and 80% by the final stages in the fifteenth century AD (Arneborg et al. 2012, Nelson et al. 2012). Zooarchaeological analyses of multiple farmsteads support these findings; most assemblages show that the majority of animal bones present were of seal (McGovern et al. 1996, Arneborg et al. 2012). And while it is true that fish remains are typically rare at Greenlandic Norse sites (see, for example, McGovern et al. 1996, pp. 106, 115), this does not necessarily mean that the colonists did not fish. A compelling possibility is that fish bones were devoured and broken down by domestic dogs—a process that would leave little archaeological evidence; Whitridge (2001, pp. 24–25) has suggested consumption by dogs as one of several reasonable explanations for a similar lack of fish bones in many Neo-Inuit contexts.

Recent research on the Greenlandic Norse experience has moved away from environmentally deterministic explanations toward those highlighting—in addition to climate change—social factors, such as increasing economic isolation from Europe. Greenlandic Norse had developed a relatively lucrative trade in luxury raw materials endemic to the Arctic, such as animal furs/skins, walrus ivory, and even live polar bears, in exchange for iron and other locally unavailable goods (Dugmore et al. 2012, Frei et al. 2015, Jackson et al. 2018a). As the Norwegian trading economy changed focus toward bulk, rather than exotic, commodities in the late fourteenth and early fifteenth centuries AD, the market for Greenlandic goods largely disintegrated (Dugmore et al. 2012). This economic downturn may have proven as catastrophic for the Norse Greenlanders as the increasingly cool temperatures. Additionally, a lack of wood to build large watercraft rendered the colonists reliant almost entirely on an increasingly disconnected Europe, not only for trade, but also for the regular transmission of information and in- and outflows of new settlers (Jackson et al. 2018a).

The degree to which the Norse were stubbornly wedded to their known experience in the face of climate change has likely been overstated in the past; it is still arguably misunderstood today. Even so, although the colonists had made major adjustments to their ways of life in response to both climate change and cultural/geographic isolation, certain cultural limits, or "disequilibria" between dominant Norse lifeways and the local environment (Jackson et al. 2018a), may have prevented them from the kind of fundamental, culturally reorienting change that would have allowed them to survive on the island over the very long term (something even Neo-Inuit found difficult to do in northeast Greenland as the LIA intensified) (see Grønnow et al. 2011).

3.3. Thule Inuit Responses to the Little Ice Age

As noted previously, Thule Inuit—the direct ancestors of modern Inuit—first entered the Eastern Arctic near the end of the MWP. Multiple motivations for the initial migration have been proposed, including population and resource stress in the Bering Strait (Friesen 2016, p. 682) and economic interest in both Norse and meteoritic iron in Greenland (see McGhee 1984, 2009). The most likely factor—possibly coupled with the abovementioned—was the opening of warm-season waterways for bowhead whales (*Balaena mysticetus*), which Bering Strait Thule peoples hunted in abundance. The migration to northwestern Greenland is believed to have been very rapid—perhaps as short as a few years—and likely consisted of relatively small, multifamily groups of about 15–50 people traveling by a combination of multiperson boats (*umiat*) and dog-drawn sleds (*qamutiit*), depending on the season (Friesen 2016, pp. 680–81).

Arguably the most emblematic phase of Thule Inuit culture—Classic Thule Inuit—emerged shortly after the pioneering expansion, and is characterized by active, open-water hunting of bowhead whales, an activity that facilitated the establishment of sometimes-large, socially complex cold-season villages of up to several dozen semisubterranean sod-and–whale bone houses in regions such as Prince Regent Inlet (Savelle 1987; Whitridge 1999, 2016) and northern Foxe Basin (Desjardins & Ross 2010; Desjardins 2017, 2018), Nunavut. A multisite survey of artifact records from across the Eastern Arctic suggests that Classic Thule Inuit around Prince Regent Inlet engaged in a robust trade in whale surplus material (blubber, baleen, etc.) in exchange for exotic raw materials (e.g., native copper, meteoric iron, nephrite jade, and amber) unavailable locally (Savelle & Desjardins 2010).

As the LIA progressed, Thule Inuit faced a subsistence crisis as warm-season sea ice increased and bowhead whale populations collapsed across the Canadian Arctic Archipelago. This inherent vulnerability in the Thule Inuit social-ecological system was reflected in a shrinking of Thule Inuit winter villages, as well as a significant social reorganization; groups became smaller and more mobile during the most intense phase of LIA cooling (about 500 to 250 BP) (Mann et al. 2009, Dawson 2016). Each year, groups likely spent a greater amount of time hunting ringed seals (*Pusa hispida*) on the landfast ice, and *iglu* (snow house/igloo) villages replaced land-based sod house villages.

New archaeological evidence points to a significant degree of Thule Inuit subsistence resilience during the LIA, with groups in regions nearby to polynyas (areas of year-round open water) being both larger and more food secure for longer than was previously thought possible. The multiseason village site of Pingiqqalik (NgHd-1), northern Foxe Basin, Nunavut, was occupied from Classic Thule Inuit times to the early twentieth century AD. During this time, site residents experienced enough ecological and social stability to construct 119 cold-weather sod houses (Desjardins 2018). The key to this resilience and relative prosperity appears to have been a resource shift from bowhead whales to locally plentiful Atlantic walruses (*Odobenus rosmarus rosmarus*), a species capable of thriving within the local recurring polynya system. A total of 587 gravel pit features were found scattered across the beach ridge system surrounding Pingiqqalik; these may be archaeological analogs to modern gravel caches used for aging (or, as locally described, "fermenting") walrus meat into *igunaq*, a widely consumed delicacy among local Inuit today (**Figures 4** and **5**).

The premodern surpluses of walrus protein at Pingiqqalik would have generated significant long-term food security for site residents, allowing for a modified form of cultural continuity that had been established centuries earlier. Similar responses to the LIA have been documented by Grønnow et al. (2011) at Walrus Island, a warm-weather site in northeast Greenland, where Thule Inuit also conducted intensive harvesting of walrus from the local Sirius Water Polynya, caching surplus meat for later use. This storage regime enabled Thule Inuit to persist in the region until about the mid-nineteenth century AD, when temperatures eventually dropped so low that human occupations could no longer be supported.

3.4. Investigating Long-Term Human Ecodynamics in Arctic Europe

The European Arctic/Subarctic has a long and largely unbroken archaeological record extending back to the early Holocene (Damm et al. 2019). Intensive research efforts over many decades have generated high-resolution archaeological and paleo-environmental records offering unique opportunities for investigating long-term human ecodynamics (Fitzhugh et al. 2018), especially the relationships between climatic shifts and cultural resilience. For example, Manninen et al. (2018) have recently completed an integrated analysis of early- and mid-Holocene cultural and climatic proxies from the relatively large region of Eastern Fennoscandia (encompassing Finland, Karelia, the Kola Peninsula, and northeastern Norway). The authors identify both gradual cultural changes in response to the major climatic trends and more abrupt changes—especially in more sensitive ecological transitional zones.

Focusing on the wider region of Arctic Norway, Jørgensen (2018) investigates whether early- and mid-Holocene populations fluctuated over the 10,000 years following the first human settlements in the region, as well as the extent to which climate change correlated with paleodemographic developments. Through modeling of a large regional-scale radiocarbon data

Figure 4

Pouches (*ungirlaat*) of walrus meat, skin, and blubber, awaiting burial in beach-gravel caches by modern Inuit during the summer for consumption the following winter (northern Foxe Basin, Nunavut, 2012). The resulting food is known as *igunaq*. Photo by S. Desjardins.

set ($n = 1205$), the author identifies a clear trend toward higher population levels among these coastal foragers, punctuated by three statistically significant population boom-and-bust cycles, peaking about 5500, 3500, and 2000 BP. These fluctuations appear to correlate closely with paleo-environmental shifts, especially with regard to marine bioproductivity.

Damm et al. (2019) undertake a more multiscalar synthesis of the same cultural and paleo-ecological sequences, focusing in particular on Finnmark County in Arctic Norway. This research

a **b**

Figure 5

Full (*a*) and emptied (*b*) modern gravel *igunaq* caches (Igloolik, Nunavut, 2011 and 2010, respectively). Thule Inuit of this region used similar caching strategies to cope with the climatic downturn of the Little Ice Age. Photo by S. Desjardins.

Figure 6

A cluster of prehistoric house pits on a raised premodern shoreline at Taborshamn, southwestern Sørøya Island, Arctic Norway. Changes in the frequency of such features over time may suggest major fluctuations in prehistoric population levels. Photo by M. Skandfer.

integrates an abundance of data from local archaeological sites and features—particularly, the hundreds of prehistoric house pits that remain visible in the modern coastal landscape (**Figure 6**). Although several phases of cultural transformation appear to correlate broadly with environmental changes, the pace and timing of local cultural responses are often more complex and include substantial delays. The authors conclude that much more research is needed at regional, local, and even site-based levels before a reasonable understanding of climate–culture interactions can be generated.

Finally, Tallavaara & Pesonen (2018) have researched long-term ecodynamics among early- and mid-Holocene Subarctic hunter-gatherer societies along the Baltic Sea coast of Ostrobothnia, western Finland. They integrate paleo-ecological data and temporal frequency distributions of 754 shoreline-dated settlement sites to investigate the potential impacts of environmental change on population dynamics and settlement and mobility patterns. They also examine potential shifts in social interaction patterns, including evidence of conflict. They conclude that the prehistoric population dynamics were strongly influenced by shifts in the productivity of terrestrial and marine environments. Moreover, the degree of residential mobility—as indicated by the frequency of house pit sites—correlated strongly with population size; higher overall population levels were associated with large villages and large coresidential units. The authors note that the frequency of the large residential sites dropped sharply when populations decreased. Notably, the intensity of conflicts (as indicated by the frequency of defensive structures) appears to have peaked when environmental productivity began to decline; increased conflict was potentially caused by growing imbalances between populations and available local resources. These factors appear to converge in a dramatic population crash—of around 76% within 200 years—that appears to be largely climate driven, as it coincided with the onset and acceleration of the Late Holocene cooling trend. Lower levels of ecological productivity persisted long afterward, perhaps preventing hunter-gatherer societies from fully recovering from this major demographic collapse.

4. DISCUSSION: ARCTIC INDIGENOUS RESPONSES TO CONTEMPORARY CLIMATE CHANGE

Many modern Arctic Indigenous peoples are mere decades removed from seasonally mobile hunting lifestyles. Most now live in modern homes in growing towns; traditional subsistence bases, religious belief structures, and economic systems have been altered dramatically by the impacts of colonialism. In addition to negotiating the social uncertainty that has been accelerating since European contact, Indigenous groups must now grapple with a disruption to the delicate environments and threatened animal species that traditionally sustained them. Indeed, perhaps the greatest danger posed by climate change for Indigenous people may be its power to increase uncertainty and volatility in forecasting both short-term weather and long-term climatic trends (Arctic Council 2016).

Anthropologists, archaeologists, and environmental historians now widely acknowledge the importance of locally based knowledge systems—or traditional ecological knowledge (TEK)—that represent sophisticated understanding of local environmental dynamics. Moreover, many Indigenous peoples in the Arctic are culturally and spiritually committed to maintaining traditional practices that have long been part of their cultural identity and heritage. This commitment is deep and can serve as a source of resilience for coping with future challenges. These traditions are often dynamic and flexible, building upon centuries of history, as acknowledged by the Arctic Council's (2016, p. 100) *Arctic Resilience Report*.

Although TEK is inherently useful, the speed of current change may be so rapid that local understandings may no longer be relevant to new situations, resulting in uncomfortable confrontations between traditional practice and changing conditions. Moreover, a short-term focus on current TEK may be insufficient for large-scale planning efforts seeking to address general climate adaptation challenges. Improved knowledge of long-term, multigenerational responses is required to understand what drives both fragility and resilience in Arctic social-ecological systems. It is here that historical and archaeological disciplines may be able to make a unique contribution through their focus on developing "deep time" perspectives on cultural responses to climate change (Jackson et al. 2018b).

Proponents of this research agenda do not argue that the experiences of past Arctic peoples are always directly comparable with those of modern societies, but that—as completed experiments—premodern responses to climate change offer an important source of human-scale evidence of (*a*) how Indigenous communities have dealt with the challenges of climate-related uncertainty and food insecurity over multiple generations, as well as (*b*) the conditions for sociocultural limits to adaptation (the Norse experiment in Greenland being a good example). Applied research of this kind is new to the Arctic, but forms part of wider efforts by archaeologists and historians to apply data on long-term trends to addressing and informing modern social and environmental challenges, including adaptation to new climates (Jackson et al. 2018b), as well as to managing dynamic human–environmental interactions for more sustainable goals (Fitzhugh et al. 2018). More generally, this research would form a logical extension of integrating the social sciences and humanities into "global change research" (Jackson et al. 2018b).

A troubling irony is that as general interest in, and methods for investigating, long-term human–environment interactions grows, the rich but very fragile archaeological data sets on which further research depend are under threat owing to thawing permafrost, intensified coastal erosion, and other climate change–related factors (see Hollesen et al. 2018 for a review). In some situations, however, the retreat of ice and snow patches yields delicate, well-preserved material culture, including textiles and organic objects (Ødegård et al. 2017), but only if recovery efforts are prompt. It is clear that new coordinated mitigation efforts are urgently needed across the Arctic to address the documentation, loss, and recovery of heritage before it is too late (Jensen 2019).

5. CONCLUSIONS AND OUTLOOK

The complex relationships between changing climates and human cultural responses are set to remain a central theme in Arctic research in the coming years and decades. Contemporary Arctic societies, which will be of research interest to future archaeologists, are facing a major climatic shift, the severity and impacts of which remain unknown. As academic interest increases, new concepts, methods, and techniques will be needed to close the major knowledge gap into what drives fragility and resilience in long-term cultural responses to changing conditions in the Arctic.

Arctic archaeologists can play a major role in this investigation, and much fundamental work remains to be done, ranging from collecting new archaeological data in the many underinvestigated regions (including much of Arctic Russia) to developing a new generation of higher-resolution chronological frameworks for better integration and analysis of cultural-, climatic-, and paleoenvironmental data. Archaeologists also need to find effective ways to deal with the rapid loss of important archaeological material due to modern warming. They must also do more to make their research more societally relevant, including engaging meaningfully with Arctic Indigenous communities (Lyons 2016), as well as communicating the relevance and utility of their potentially significant insights to a variety of nonlocal stakeholders, including the wider public and policy makers who seek solutions to the challenges of modern climate change (Jackson et al. 2018b).

Still, while the data and resulting long-term insights generated by Arctic archaeologists can offer valuable insights into how past generations have coped—often successfully—with major climatic and environmental changes, they have yet to demonstrate conclusively how such data can generate effective solutions to some of the major future challenges faced by today's Arctic Indigenous communities.

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LITERATURE CITED

Adamson GCD, Hannaford MJ, Adamson R. 2018. Re-thinking the present: the role of a historical focus in climate change adaptation research. *Glob. Environ. Change* 48:195–205

Appelt M, Damkjar E, Friesen TM. 2016. Late Dorset. See Friesen & Mason 2016b, pp. 783–806

Arctic Council. 2016. *Arctic resilience report*, ed. M Carson, G Peterson. Rep., Stockh. Environ. Inst., Stockh. Resil. Cent., Stockh. **http://hdl.handle.net/11374/1838**

Arneborg J, Lynnerup N, Heinemeier J. 2012. Human diet and subsistence patterns in Norse Greenland AD c.980–c.1450: archaeological interpretations. In Special Volume: *Greenland Isotope Project: Diet in Norse Greenland AD 1000–AD 1450. J. North Atl.* 3:119–33

Barry RG, Arundale WH, Andrews JT, Bradley RS, Nichols H. 1977. Environmental change and cultural change in the Eastern Canadian Arctic during the last 5000 years. *Arct. Alpine Res.* 9(2):193–210

Bjerck HB. 2008. Norwegian Mesolithic trends: a review. In *Mesolithic Europe*, ed. G Bailey, P Spikins, pp. 60–106. Cambridge, UK: Cambridge Univ. Press

Bradley RS, Jonest PD. 1993. 'Little Ice Age' summer temperature variations: their nature and relevance to recent global warming trends. *Holocene* 3(4):367–76

Bradtmöller M, Grimm S, Riel-Salvatore J. 2017. Resilience theory in archaeological practice—an annotated review. *Quat. Int.* 446:3–16

Cummings V, Jordan P, Zvelebil M, eds. 2014. *The Oxford Handbook of the Archaeology and Anthropology of Hunter-Gatherers*. Oxford, UK: Oxford Univ. Press

D'Andrea WJ, Huang Y, Fritz SC, Anderson NJ. 2011. Abrupt Holocene climate change as an important factor for human migration in West Greenland. *PNAS* 108(24):9765–69

Damlien H. 2016. Eastern Pioneers in westernmost territories? Current perspectives on Mesolithic hunter-gatherer large-scale interaction and migration within Northern Eurasia. *Quat. Int.* 419:5–16

Damm CB, Skandfer M, Jørgensen EK, Sjögren P, Vollan KWB, Jordan PD. 2019. Investigating long-term human ecodynamics in the European Arctic: towards an integrated multi-scalar analysis of early and mid-Holocene cultural, environmental and palaeodemographic sequences in Finnmark County, Northern Norway. *Quat. Int.* **https://doi.org/10.1016/j.quaint.2019.02.032**

Dawson P. 2016. The Thule-Inuit succession in the Central Arctic. See Friesen & Mason 2016b, pp. 915–35

Desjardins SPA. 2017. *Whither sod houses? Evaluating the evidence for land- and ice-based overwintering among Post-classic Thule and historic Inuit*. Paper presented at the 50th Annual Canadian Archaeological Association (CAA) Meeting, Ottawa/Gatineau

Desjardins SPA. 2018. Neo-Inuit strategies for ensuring food security during the Little Ice Age climate change episode, Foxe Basin, Arctic Canada. *Quat. Int.* **https://doi.org/10.1016/j.quaint.2017.12.026**

Desjardins SPA, Ross JM. 2010. *New considerations for Thule Inuit settlement and subsistence, eastern Melville Peninsula, Nunavut*. Paper presented at the 43rd Annual Canadian Archaeological Association (CAA) Meeting, Calgary

Diamond J. 2005. *Collapse: How Societies Choose to Fail or Survive*. London/New York: Allen Lane/Penguin Books

Dredge LA. 2001. Late Pleistocene and Holocene glaciation and deglaciation of Melville Peninsula, Northern Laurentide Ice Sheet. *Géogr. Phys. Quat.* 55:159–70

Dugmore AJ, Keller C, McGovern TH. 2007. Norse Greenland Settlement: reflections on climate change, trade, and the contrasting fates of human settlements in the North Atlantic islands. *Arct. Anthropol.* 44(1):12–36

Dugmore AJ, McGovern TH, Vésteinsson O, Arneborg J, Streeter R, Keller C. 2012. Cultural adaptation, compounding vulnerabilities and conjunctures in Norse Greenland. *PNAS* 109(10):3658–63

Finkelstein SA. 2016. Reconstructing Middle and Late Holocene paleoclimates of the Eastern Arctic and Greenland. See Friesen & Mason 2016b, pp. 653–71

Fitzhugh B, Butler VL, Bovy KM, Etnier MA. 2018. Human ecodynamics: a perspective for the study of long-term change in socioecological systems. *J. Archaeol. Sci. Rep.* 23:1077–94

Freeman MMR. 1984. Arctic ecosystems. In *Arctic Handbook of North American Indians*, Vol. 5: *Arctic*. ed. D Damas, pp. 36–48. Washington, DC: Smithson. Inst. Press

Frei KM, Coutu AN, Smiarowski K, Harrison R, Madsen K, et al. 2015. Was it for walrus? Viking Age settlement and medieval walrus ivory trade in Iceland and Greenland. *World Archaeol*. 47(3):439–66

Friesen TM. 2000. The role of social factors in Dorset-Thule interaction. In *Identities and Cultural Contacts in the Arctic. Proceedings from a Conference at the Danish National Museum, Copenhagen, November 30 to December 2 1999*, ed. M Appelt, J Berglund, HC Gulløv, pp. 206–20. Copenhagen: Dan. Polar Cent.

Friesen TM. 2016. Pan-Arctic population movements: the early Paleo-Inuit and Thule Inuit migrations. See Friesen & Mason 2016b, pp. 673–91

Friesen TM, Arnold CD. 2008. The timing of the Thule migration: new dates from the western Canadian Arctic. *Am. Antiq*. 73(3):527–38

Friesen TM, Mason OK. 2016a. Introduction: archaeology of the North American Arctic. See Friesen & Mason 2016b, pp. 1–24

Friesen TM, Mason OK, eds. 2016b. *The Oxford Handbook of the Prehistoric Arctic*. New York: Oxford Univ. Press

Gajewski K. 2015. Quantitative reconstruction of Holocene temperatures across the Canadian Arctic and Greenland. *Glob. Planet. Change* 128:14–23

Goebel T, Potter BA. 2016. First traces: Late Pleistocene human settlement of the Arctic. See Friesen & Mason 2016b, pp. 223–52

Grønnow B. 2016. Independence I and Saqqaq: the first Greenlanders. See Friesen & Mason 2016b, pp. 713–35

Grønnow B, Gulløv HC, Jakobsen BH, Gotfredsen AB, Kauffmann LH, et al. 2011. At the edge: high Arctic walrus hunters during the Little Ice Age. *Antiquity* 85:960–77

Hoffecker JF. 2005. *A Prehistory of the North: Human Settlement of the Higher Latitudes*. Piscataway, NJ: Rutgers Univ. Press

Hollesen J, Callanan M, Dawson T, Fenger-Nielsen R, Friesen TM, et al. 2018. Climate change and the deteriorating archaeological and environmental archives of the Arctic. *Antiquity* 92:573–86

IPCC (Intergov. Panel Clim. Change). 2007. *Climate Change 2007: Synthesis Report. Contribution of Working Groups I, II and II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, ed. RK Pachauri, A Reisinger. Geneva: IPCC

Jackson RC, Arneborg J, Dugmore AJ, Madsen C, McGovern T, et al. 2018a. Disequilibrium, adaptation, and the Norse settlement of Greenland. *Hum. Ecol. Interdiscip. J.* 46(5):665–84

Jackson RC, Dugmore AJ, Riede F. 2018b. Rediscovering lessons of adaptation from the past. *Glob. Environ. Change* 52:58–65

Jensen AM. 2019. Critical information for the study of ecodynamics and socio-natural systems: rescuing endangered heritage and data from Arctic Alaskan coastal sites. *Quat. Int.* **https://doi.org/10.1016/j.quaint.2019.05.001**

Jensen JF. 2016. Greenlandic Dorset. See Friesen & Mason 2016b, pp. 737–60

Jørgensen EK. 2018. The palaeodemographic and environmental dynamics of prehistoric Arctic Norway: an overview of human-climate covariation. *Quat. Int.* **https://doi.org/10.1016/j.quaint.2018.05.014**

Kleppe JI. 2018. The pioneer colonisation of northern Norway. In *Early Economy and Settlement in Northern Europe*. Vol. 3: *Pioneering, Resource Use, Coping with Change*, ed. HP Blankholm, pp. 13–58. Early Settl. North. Eur. Ser. Sheffield, UK: Equinox

Kornfeld M, Politis GG. 2014. Into the Americas: the earliest hunter-gatherers in an empty continent. See Cummings et al. 2014, pp. 405–33

Krupnik I. 1993. *Arctic Adaptations: Native Whalers and Reindeer Herders of Northern Eurasia*. Hanover, NH/London: Univ. Press New Engl./Dartmouth Coll.

Lyons N. 2016. Archaeology and Native northerners. The rise of community-based practice across the North American Arctic. See Friesen & Mason 2016b, pp. 197–219

Mann ME, Zhang Z, Rutherford S, Bradley RS, Hughes MK, et al. 2009. Global signatures and dynamical origins of the Little Ice Age and Medieval Climate Anomaly. *Science* 326:1256–60

Manninen MA, Tallavaara M, Seppa H. 2018. Human responses to early Holocene climate variability in eastern Fennoscandia. *Quat. Int.* 465:287–87

Mary-Rousselière G. 1979. A few problems elucidated…and new questions raised by recent Dorset finds in the North Baffin Island region. *Arctic* 32:22–32
Mason OK, Barber V. 2003. A Paleo-geographic preface to the origins of whaling: Cold is better. In *Indigenous Ways to the Present: Native Whaling in the Western Arctic*, ed. AP McCartney, pp. 69–108. Edmonton, Alta.: Can. Circumpolar Inst. Press
Maxwell MS. 1976. Introduction. In *Eastern Arctic Prehistory: Paleoeskimo Problems*, ed. MS Maxwell, pp. 1–5. Mem. Soc. Am. Archaeol. 31. Washington, DC: Soc. Am. Archaeol.
Maxwell MS. 1985. *Prehistory of the Eastern Arctic*. Orlando, FL: Academic
McGhee R. 1970. Speculations on climate change and Thule cultural development. *Folk* 11–12:173–84
McGhee R. 1972. Climate change and the development of Canadian Arctic cultural traditions. In *Climate Changes in Arctic Areas During the Last Ten Thousand Years*, ed. Y Vasari, H Hyvarinen, S Hicks, pp. 39–60. Oulu: Univ. Oulu
McGhee R. 1981. Archaeological evidence for climate change during the last 5,000 years. In *Climate and History: Studies in Past Climates and Their Impact on Man*, ed. TML Wigley, MJ Ingram, G Farmer, pp. 162–79. Cambridge, UK: Cambridge Univ. Press
McGhee R. 1984. The timing of the Thule migration. *Polarforschung* 54(1):1–7
McGhee R. 2009. When and why did the Inuit move to the eastern Arctic? In *The Northern World, AD 900–1400: The Dynamics Of Climate, Economy, and Politics in Hemispheric Perspective*, ed. HDG Maschner, OK Mason, R McGhee, pp. 155–63. Salt Lake City: Univ. Utah Press
McGovern TH, Amorosi T, Perdikaris S, Woollett J. 1996. Vertebrate zooarchaeology of Sandnes V51: economic change at a chieftain's farm in West Greenland. *Arct. Anthropol.* 33(2):94–121
Miller GH, Geirsdóttir Á, Zhong Y, Larsen DJ, Otto-Bliesner BL, et al. 2012. Abrupt onset of the Little Ice Age triggered by volcanism and sustained by sea-ice/ocean feedbacks. *Geophys. Res. Lett.* 39:L02708
Milne SB, Park RW. 2016. Pre-Dorset culture. See Friesen & Mason 2016b, pp. 693–712
Murray MS. 1996. *Economic change in the Paleoeskimo prehistory of the Foxe Basin, N. W. T*. PhD Thesis, McMaster Univ., Hamilton
Murray MS. 1999. Local heroes. The long-term effects of short-term prosperity—an example from the Canadian Arctic. *World Archaeol*. 30:466–83
Nelson DE, Heinemeier J, Lynnerup N, Sveinbjörnsdóttir ÁE, Arneborg J. 2012. An isotopic analysis of the diet of the Greenland Norse. In Special Volume: *Greenland Isotope Project: diet in Norse Greenland AD 1000–AD 1450. J. North Atl*. 3: 93–118
Ødegård RS, Nesje A, Isaksen K, Andreassen LM, Eiken T, et al. 2017. Climate change threatens archaeologically significant ice patches: insights into their age, internal structure, mass balance and climate sensitivity. *Cryosphere* 11:17–32
Park RW. 1993. The Dorset-Thule succession in Arctic North America: assessing claims for culture contact. *Am. Antiq*. 58:203–34
Park RW. 2016. The Dorset-Thule transition. See Friesen & Mason 2016b, pp. 807–26
Raghavan M, DeGiorgio M, Albrechtsen A, Moltke I, Skoglund P, et al. 2014. The genetic prehistory of the New World Arctic. *Science* 345:1255832
Rankama T, Kankaanpää J. 2008. Eastern arrivals in post-glacial Lapland: the Sujala site 10,000 cal BP. *Antiquity* 82:884–99
Riede F. 2014. The resettlement of Northern Europe. See Cummings et al. 2014, pp. 556–81
Rowley-Conwy P. 1999. Introduction: human occupation of the Arctic. *World Archaeol*. 30(3):349–53
Ryan K. 2016. The "Dorset problem" revisited: the transitional and Early and Middle Dorset periods in the Eastern Arctic. See Friesen & Mason 2016b, pp. 761–81
Savelle JM. 1987. *Collectors and Foragers: Subsistence-Settlement Systems in the Central Canadian Arctic, AD 1000–1960*. Oxford, UK: Br. Archeol. Rep.
Savelle JM, Desjardins SPA. 2010. *Bowhead whales, exchange networks and social inequality amongst prehistoric Thule Inuit*. Paper presented at the 75th Annual Society for American Archaeology (SAA) Meeting, St. Louis
Savelle JM, Dyke AS. 2009. Paleo-Eskimo demography on western Boothia Peninsula, Arctic Canada. *J. Field Archaeol.* 34:267–83

Savelle JM, Dyke AS. 2014. Paleoeskimo occupation history of Foxe Basin, Arctic Canada: implications for the Core Area model and Dorset origins. *Am. Antiq.* 79:249–76

Sella GF, Stein S, Dixon TH, Craymer M, James TS, et al. 2007. Observation of glacial isostatic adjustment in "stable" North America with GPS. *Geophys. Res. Lett.* 34:L023056

Sørensen M, Rankama T, Kankaanpää J, Knutsson K, Knutsson H, et al. 2013. The first eastern migrations of people and knowledge into Scandinavia: evidence from studies of Mesolithic technology, 9th-8th millennium BC. *Nor. Archaeol. Rev.* 46:19–56

Tallavaara M, Pesonen P. 2018. Human ecodynamics in the north-west coast of Finland 10,000–2000 years ago. *Quat. Int.* **https://doi.org/10.1016/j.quaint.2018.06.032**

Whitridge PJ. 1999. *The construction of social difference in a prehistoric Inuit whaling community*. PhD Diss., Ariz. State Univ., Tempe

Whitridge PJ. 2001. Zen fish: a consideration of the discordance between artifactual and zooarchaeological indicators of Thule Inuit fish use. *J. Anthropol. Archaeol.* 20:3–72

Whitridge PJ. 2016. Classic Thule [Classic precontact Inuit]. See Friesen & Mason 2016b, pp. 827–49

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