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Professor Hein B. Bjerck (1954) is head of NTNU's study program in archaeology. Besides studies in contemporary archaeology, his is main academic focus is Stone Age studies - ranging from lithic traditions, phenomenological perspectives on cave paintings to international studies of early human-sea relation and colonization processes in seascapes. He is the leader of "Marine Ventures" – a comparative study of marine foragers in the seascapes of Scandinavia and Argentinean Tierra del Fuego. His interests in the recent past departs from his time as Cultural Heritage Officer at the Governor of Svalbard in 1996-1999, where he was involved in managing modern ruins – derelict settlements, mining enterprises, base camps from scientific expeditions.

What could the 'sea ice machine' do to its people? On the lateglacial Doggerland, marine foraging, and the colonisation of Scandinavian seascapes

Abstract
'Climate' is rarely experienced directly – contrary to day-to-day 'weather' and 'seasons' that manifest in landscapes ('weather-worlds'). This paper elaborates the role of sea ice and sea ice hunting outside the lateglacial Doggerland beaches. The winter–spring sea ice was a seasonal extension of the continental plains, and a potential meeting ground for the human hunters of the plains and the mammals of the sea. Here, the hunters could observe and experience that seals were easy prey and that seals were similar to the familiar terrestrial megafauna; providing meat and blood, bone, skin, bladders and sinews, and ample supplies of fat (blubber) that also could heat dwellings. Seals on the ice could be hunted with similar methods and equipment as terrestrial animals – without the need of boats and the risks of cold, open sea. The Doggerland sea ice was a meeting ground of land and sea that could have been imperative in the development of marine foraging and the subsequent colonisation of Scandinavian seascapes. Levi Bryant's 'Machine Oriented Ontology' may be instrumental to envision the sea ice and its potential for the lateglacial hunters in Northwest Europe.

Keywords: Sea ice and seal hunting, seascapes, seaworthy boats, Machine-Oriented-Ontology, Late Glacial/Holocene weather and climate change.

Introduction

This paper addresses one of the recurring dark horses in North European lateglacial[1] environment, the submerged North Sea land area, Doggerland. We know that the plains

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[1] In this paper, the informal chronostratigrapical unit 'lateglacial' roughly equals the period 15000 – 11700 cal BP, i.e., the last 3 – 4 millennia before the Pleistocene/Holocene transition. This correspond to the NGRIP and GISP2 sequences in the Greenland ice cores (Rasmussen et al. 2006). Thus 'lateglacial' include Bølling (15000-14000 cal BP), Allerød (14000-12900 cal BP) and Younger Dryas (12900-11700 cal BP). All dates are rounded to the nearest 100 yrs., for exact dates, see referred literature. Table in Bailey and Spikins 2010, 373-4 for calibration of radiocarbon years to calendar years.

existed, and that the borderline to the continental plains were seamless and not visible to its people (Coles 1998; van de Noort 2011). I would like to lead your attention to the even more elusive. It is not the drowned Doggerland plains and shores that have been sought and scrutinized in a series of elaborate surveys and geophysical studies in recent years (e.g., Gaffney, Thomson & Fitch 2007), but the seasonal sea ice cover that once was *outside* the Doggerland shores. It is a paradox – in archaeological debate it seems to have been eternal summertime in Doggerland – despite us knowing for a fact that there were just as many winters as there were years during the times we are studying. For clarity perhaps, all landscape reconstructions are depicted in summer mode with plains, running rivers, beaches and open sea. The equivalent Doggerland winter map would be a meaningless white rectangle, absurd in any publication. Unintentionally, the dominating summertime images tend to obscure winters, snow and ice, that was in fact very real to all Doggerland inhabitants (Fig. 1).

There are perhaps few new facts – the essence of this paper is to bring old facts together, and speculate in what may be missing. Archaeology aspires to be a scientific discipline, and thus seeks firm ground and empirical facts. This is perhaps a reason for omitting that which is vague and unseen in the archaeological record – even if we know for a fact that also non-observed things were present and made a difference in past human realities. The Doggerland sea ice is certainly one of these. The discussion explores how empirical facts could have been joined in more extensive wholes, the 'verisimilitudes' – that what resembles the truths – and the need for the speculative alongside empirical facts.

For sure, climatic proxy data (climate and ocean salinity, presence/absence of fossil fauna, details below) informs us that the Doggerland basin was covered by sea ice in all the lateglacial winters, and that substantial climatic changes in Late Pleistocene and Early Holocene periods are evident. To the 'archaeological eye' these changes are massive and rapid. However, even the most abrupt climatic events in the environmental record were perhaps still too slow to have been observed by humans and included in their 'social memory'. The environmental variations that were the most decisive in past humans' life are not necessarily the most visible in our records. The day-to-day weather and the yearly seasonal rounds are too frequent (and too many), and rendered blurred and neglected. Nevertheless, it is observations on 'weather' that call for human actions – not 'climate' (Pillatt 2012). With reference to Lamb (1972), climate is 'the sum total of the weather experienced at a place in the course of a year and over the years'. Knowingly or not, past people's environmental information were coded and transmitted in social memory across generations. Ingold (2007) suggests that weather should be understood as part of landscapes, 'weather-worlds': climate is integral to landscape, and weather is how that integration is expressed and experienced on a daily basis' (Pillatt 2012, 41). Thus, weather is intimately bound up in landscapes and ecology, and deeply embedded social and cultural formation – including human actions, behaviour and material culture – and thus as much open to archaeological investigation as any aspect of the past (ibid., 42). Yearly seasons are something in between climate and weather – seasons manifest themselves in weather, landscapes and lifecycles and are highly evident and decisive for past human actions and environment. Then – as now – seasons relate to the big clock of movements in our solar system – and are as predictable as night and day. Seasons are among the many 'constants' in the world that may be predicted (Olivier 2011). 'Machine-Oriented-Ontology' facilitates the visibility of these imperative, but evasive and invisible facts; to render the obvious, but unseen visible to the archaeological eye (Bryant 2014). 'Machines' focus how things work in co-working wholes, and Bryant urges us to ask *what things do*, not *what they are*. In the next pages, I will explore the relevance of the Doggerland seasonal sea ice during the critical Pleistocene/Holocene transition – and discuss what the 'sea ice-machine' could do to the development of marine foraging in the cold northern waters, and the subsequent colonisation of the Scandinavian seascapes in Early Holocene.

Late Pleistocene and the Doggerland sea ice

During the Late Glacial Maximum around 20 000 cal BP, the 5.5 million square kilometre large Eurasian ice sheets covered Scandinavia and most of the British Isles, including Doggerland (Huges et al. 2015, fig 1). In combination with the other vast ice sheet around the world at the time, the enormous amounts of ice build-up produced a considerable lowering of the global sea level, up to -120 meters below modern sea level (Fairbanks 1989). This explains the emergence of Doggerland, and its subsequent flooding as the water was returned to the oceans in line with deglaciation in the Late Glacial and Holocene periods. In the last millennia of Late Pleistocene, the Scandinavian and the British ice sheets parted (around 18000 cal BP), and ocean waters penetrated the Norwegian Sea; including Doggerland basin/Norwegian Trench (Huges et al. 2015: fig.6; Rasmussen at al. 2011). Geologists are mostly concerned about the permanent all-year-round ice, but seem to agree that winter/spring sea ice covered at least the inner, eastern part of these waters. The warmer climate in Allerød may have perhaps prevented a continuous ice cover, but large areas of shorefast winter sea ice is very likely. In general, the basis for the winter sea ice assumption is the considerably colder lateglacial climate, the reduced salinity (the Baltic Sea still has winter ice) due to glacial melt water (Gyllencreutz 2005, Legendre et al. 1992, Huges et al. 2015), and findings of fossil fauna; ice-dependant seals (Hufthammer 2001; Aaris-Sørensen 2009; Aaris Sørensen et al. 2010; Jonsson 2018), the Finnøy polar bear in southern Norway

(Blystad et al. 1983), the occurrence of bowhead whales (Wiig et al. 2019) and blue mussels (Mangerud & Svendsen 2017, 76) along the west coast of Norway. The absence/reduced amount of fossil finds of blue bowhead whales and blue mussels in the considerably colder Younger Dryas may indicate all-year-round sea ice along the Norwegian coast, that inevitably also would be the case in the inner parts of the Norwegian trench, i.e., outside Doggerland. The rapid warming in early Holocene (Rasmussen et al. 2006) probably put an end to winter sea ice in the Doggerland basin.

Doggerland, and the Colonization of Scandinavian Seascapes

For a long time, fishermen in the North Sea have pulled up tokens of 'submerged forests', tree-stumps, chunks of sod, occasional animal bones and artifacts (Reid 1913). Anders Nummedal, who discovered the first sites from the Early Mesolithic Fosna tradition in Norway in 1919 (Breivik & Ellingsen 2014), referred to Reid's enticing map when discussing the problem of the missing continental predecessors of the Fosna-hunters (Nummedal 1924). Since then, the submerged plains of the North Sea have been pivotal in the debate of the colonisers of the Scandinavian seascapes (e.g., Rolvsen 1972; Welinder 1981; Fischer 1991; 1996; Schmitt 1994; 2015; Bjerck 1995; 2009; Kindgren 1996; Fuglestvedt 2007; 2012; Nordqvist 2009; Bang-Andersen 2012; Glørstad 2014; Ballin & Bjerck 2016).

Nummedal believed that the Fosna tradition had its roots in the coastal parts of Doggerland. Later, with reference to findings from Ahrensburg, Anders Fisher (1991; 1996) and others (e.g. Kindgren 1996; Schmitt 1994; 2015) have suggested a seasonal counterpart to the Ahrensburg reindeer hunters along the shores of Doggerland that related to the slightly younger Fosna/Hensbacka traditions in Norway/Western Sweden.

There are abundant Holocene finds from Doggerland, but few are of pre-Holocene age. Nevertheless, nobody disputes human presence on the submerged plains in the last millennia of the Pleistocene. Empiric facts are few, and the human imprint in coastal areas is still in the dark. There is the spectacular barbed point that was picked up from Leman and Ower Bank (Burkitt 1932), dated to *c.* 13600 cal BP (Bonsall & Smith 1989). Older finds closer to Doggerland coasts are unclear. There is the piece from the Viking Bank (Long, Wickham-Jones & Ruckley 1986), a scarred piece of flint, negative flake scars on all sides. It is no flake, that is by far the most common stone artefact. At best it is a sort of core – but not a diagnostic core, and its status as 'artifact' is dubious. There is also the peculiar perforated basalt pebble (Bjerck 1995, 133). In spite of optimistic speculation, this piece has no parallel in neither lateglacial nor Holocene records. Yet, how could any natural agency make such a precise perforation? During a recent study trip to Iceland, beaches strewn with holed basalt pebbles was observed. Obviously, 'perforations' are remnants of elongated gas-bladders in running basalt lava – that when cooled and broken apart will host fragments of these gas-tubes – cylindrical holes. They are peculiar, rare things perhaps, but no artefacts. Recently, Dutch researchers have published new finds from Younger Dryas (Amkreuz et al. 2018); a decorated bison bone (13400 cal BP), and a fragment of a human skull (12900 cal BP). Information from this skull fragment and a few other lateglacial human remains at the continent all point at diets based on abundant freshwater resources (Terberger et al. 2018). Erwin Cziesla (2018) has published interesting arguments for seal hunting in continental river systems. However, all of these finds are located hundreds of kilometres from what was coastal Doggerland, and evidence of human presence at the beaches is still in the dark.

Today, very few scholars (if any) believe in a direct crossing from Doggerland to the seascapes of Norway – a migration route via the archipelagos of Western Sweden seems more plausible (e.g., Bjerck 2009; Glørstad 2014; Schmitt 2018). Despite this, Doggerland was an ancestral region for the colonisers of Scandinavian seascapes (e.g., Ballin & Bjerck 2016). Nummedal's Early Holocene Fosna complex is still held as the pioneers in the Norwegian seascapes. At present, the record holds close to 800 Fosna sites, i.e. settlements older than 10000 cal BP (Breivik 2014). Western Sweden seem to host an even greater number (Schmitt 2018). Contrary to the presumed submerged settlements in coastal Doggerland, sites in Scandinavia are found at elevated shorelines (isostatic movement) where site patterns and placements may be studied, a base of knowledge that is mostly neglected in the quest for Doggerland coastal settlements. A majority of Early Holocene settlements in Norway, more than 90%, are found along the coast. Most sites are situated on what were islands at the time, and site locations clearly indicate seaworthy vessels – probably skin-boats similar to Greenland umiaks (Bjerck 2010; 2013; Breivik 2014; Svendsen 2018; Wickler 2019) (Fig.2 and 6). Seal hunting probably was a key factor in the pioneers' subsistence. However, they retained most of the lithic techniques that we recognize from the reindeer-hunters in Ahrensburg (Fuglestvedt 2007). A few mountain settlements reveal that they also maintained skills and motivation to hunt for reindeer (Breivik & Callanan 2016; Svendsen 2018).

In spite of a rapidly expanding archaeological record, the timing of the migration to Scandinavia remains a puzzle. We know that the Norwegian archipelagos were out of the glaciers since the early parts of Bølling – vegetation and fauna that could sustain human hunters are evident from c. 14700 cal BP (Mangerud & Svendsen, submitted). Still, nobody has been able to produce a single pre-Holocene site. It seems that for 4000 years these bountiful hunting grounds were uninhabited (Bjerck 2009). This is in contrast to the abundant Early Holocene settlements, as documented by Breivik (2014). It is suggested that the vast Norwegian coastline was colonised in a short time, perhaps less than 200 years soon after 11500 cal BP (Bjerck 2009). Of course, it is impossible to exclude a few earlier settlements. Anyway, this cannot be compared to the extensive settling in the first centuries after 11500 cal BP.

What can explain the 'delayed' settling of the region? And why is the colonisation apparently so extensive, and fast? If the maritime Fosna tradition already existed in Doggerland the lateglacial times, why are there no movements to the plentiful coastal Scandinavia during all those years? The neglect of Norwegian seascapes has all the signs of some kind of barrier to the people involved.

It is suggested that the barrier is to be found in the human life style (Bjerck 2009; 2010; Bjerck et al. 2016); that the main reason is that marine foraging was peripheral in the lateglacial subsistence system in northwest Europe. Bathymetric information (e.g. Coles 1998) show that the Doggerland beaches lacked the sheltering archipelagos and bountiful marine biotopes that characterise Scandinavia, that are very beneficial to marine foragers. Hence, the Doggerland hunters probably also lacked the indispensable knowledge and equipment – above all sea-worthy boats. Thus, it was their lifestyle and technological profile that blocked their ability and motivation to migrate to the archipelagos of the north, where it was not even possible to move around without these vessels. This may explain the absence of pre-Holocene human presence in Norway.

Håkon Glørstad (2014) has suggested an alternative, a natural barrier for the northern expansion. Glørstad points at a 50–60 km stretch of ice-shelf across the Oslo fjord that existed around 11300 cal BP (9300 BC), and claims that this was a natural barrier to the first settlers:

> 'Until approximately 9.3 cal ka BC, this route was blocked by a very large ice barrier covering the present Oslo area. (…) A likely conclusion is that human colonization of the Norwegian coast was dependant on the creation of a sheltered passage of islands and peninsulas from the Swedish western coast to the ice-free coasts of southern and western Norway' (Glørstad 2014).

No doubt that Glørstad is right about the physical setting. However, in spite of problems with shore-line dating, it is reason to believe that there are settlements in the west coast of Norway that predates Glørstad's Oslo fjord 'barrier' (Breivik 2016, 61; Breivik & Bjerck 2018). Nevertheless, Glørstad's main problem is that he fails to ask if the Oslo fjord ice-shelf really could hold up as a barrier for the people in question. Sea ice are floating archipelagos that calms waves and make safer travels, and are prosperous hunting grounds (e.g., Nelson 1969). As presumed by Glørstad and others (e.g., Schmitt 2018) marine foraging was already established in coastal Western Sweden shortly after 12 000 cal BP, where frequent settlements on the outer islands demonstrate the use of seaworthy vessels and ability to hunt in near-shore open sea. Very likely, sea and ice was *not* a hostile environment that potential colonisers to Norway could not pass – meaning that the Oslo fjord sea ice cannot serve as a barrier.

Machine-Oriented-Ontology (MOO) – making Dark Horses appear

Perhaps we need to acknowledge that what were the most important to past humans do not necessarily appear as the most evident in the archaeological record – as the mentioned seasonal weather differences vs. climatic periods. To advance, I believe it fruitful to include the more elusive and less visible in this discussion. Recent archaeological advancements entail increasingly detailed insights to smaller and smaller facts. Each and one are scholarly victories, but are in vain without the verisimilitudes of the setting – speculations on the dynamics of the unseen.

Recent 'thing-theory' explores the existential nature of things (in the widest sense), and what they do in the world. These theories aim at insights to how things relate and co-work to make up the worlds that humans are part of, and are just as relevant for deep-time studies as for the contemporary (e.g., Olsen 2003; 2010; Bogost 2012; Morton 2013; 2018; Bryant 2014; Olivier 2014; Harman 2016).

Subsistence systems and ecologies may be viewed as 'machines' in line with Levi Bryant's theory of machines and media, that is elaborated in his 'Machine-Oriented-Ontology' (Bryant 2014). Bryant stresses that the world is made up of stuff, and that all stuff are 'things'. He labels things as 'machines' to underline that all things consist of and combine smaller parts, and also that things are integrated in more extensive co-working wholes. The label 'machine', highlights this meshwork of integrated, co-working parts. In Bryant's words, 'a machine is a system of operations that perform transformations on inputs thereby producing outputs' (Bryant 2014, 38).

Bryant stands on the shoulders of those who formulated 'Actor-Network theory' and theories of 'entanglement' and 'meshwork'. But Bryant's machines are freed from the anthropocentric bias – machines may include both human and non-human parts, animate as well as the inanimate. A bird in your garden is a machine – as is a bicycle. A man riding a bicycle on the road is also a machine, a machine that have other abilities than the naked bicycle, or for that matter, a human without a bicycle. An insurance company with its people and material infrastructure is yet another, but far more complex machine, as is a Bronze Age ship with its crew and cargo, or a camp of Mesolithic hunters. Even a simple flake combines a multitude of parts and is a machine in itself, but it is also a part of bigger machines. Flakes took part in shaping an implement, blows inflicted by a human, and involve the skills, experience and intentions of that human being; and also relate to the wider world, the surrounding social system and ecology[2] . A Mesolithic machine involves a wide array of non-human actors; there is a 'gravity' between tools and equipment, garments, transport facilities and topography, animals and ambient factors, fireplaces and fuel, dwelling structures for sure, probably also dogs, perhaps boats, remedies for production and maintenance, seasonal movements, relations to neighbouring groups. Each of these are machines that have certain capabilities, their combination in bigger integrations expand capabilities.

Thus, machines are a series of meaningful and definable entities, that are linked and joined in more complex machines. Their outer limits are difficult to imagine, and even worse to delimit. But what lies within is a series of entangled entities that rule how the world works. As machines always are material, I believe that there is hope for archaeology – the discipline of things (Olsen 2010). As material fragments, many of the parts in past machines are recognisable to the archaeological eye. In fact, all things in the archaeological record are remnants of machineries that once were active.

Once a machine gets going, the integration of its many parts is a self-stabilising factor. It is held together by its function, so to speak, and may account for stability of traditions that we may observe in the archaeological record. However, entropy is always near (Bryant 2014, 93). A machine may need new parts to cope with new challenges. A vital input that the machine depends on may no longer be available. New parts may be difficult to adapt to old parts. Small changes may in sum inflict substantial

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[2] Dormant for millennia, but in the hand of an archaeologist it proves its ever ability to come back, as the flake continues to act as an active part in the machine that is 'archaeology'.

rearrangements, and allow for new things. This could be a changed subsistence system – a machinery that produces other outputs on different inputs. However, no machine is totally new in the world, there are always parts that relates to the old. In short, viewing subsistence systems as machines, may account for repetition and stability. But it is likewise clear that machines (like traditions) change, sometimes slow, other times fast – it is the ever-going debates of stability and change that are so well-known to archaeology.

One of the many spin-offs in Bryant's Machine-Oriented-Ontology, is that it highlights the fragments in the archaeological record as the parts of once well-greased machineries that once co-worked. Parts that are no longer present are brought to light. The attention may shift from sorting artefacts in size-groups and typological listings – to study their integration in past machineries. The imperative question is not 'what things are' – but 'what things do'. Machine-Oriented-Ontology does not discriminate between humans and non-human parts, it makes brings attention to the invisible entities that are rarely considered as archaeological facts, but at the same time were indispensable in how the world worked for past people. It stresses "amongstness", and blurs the nature-culture dichotomy, and also the distinction between animate and non-animate parts. It bridges Morton's non-observable 'hyper-objects' (2013) (e.g., the solar system, ecological biotopes, ocean currents, climate, atmospheric pressure) to what were tangible for past people and called for actions – like weather-worlds and animal life within their mobility range.

Discussion: The Doggerland 'Sea Ice Machine'

As said, it is a paradox – images of coastal Doggerland are biased towards summer and ice-free seas and beaches – in spite of the fact that sea ice covered the Doggerland basin for around half of the year during the Late Glacial period (Gyllencreutz 2005). The record contains proxy data that relates to the sea ice, even though the sea ice itself vanished millennia ago. Fossil faunal finds, and the considerable lower salinity combined with a colder climate support that the Doggerland sea ice existed, and may be seen as integrated in weather-worlds landscapes. In the referred discussion on weather vs climate, Pillatt (2012) suggests that both phenomenological and ethnographical may be of value alongside with traditional facts. In the following, I will attempt to combine this with Bryant's perspectives.

Sea ice probably formed during late fall, established during winter months and lingered during spring and early summer. The sea ice – a machine of its own – is an integration of sea water abilities and climatic conditions that produces an extended machine that hosts thousands of biological companions; microorganisms, crustaceans, fish, birds and marine mammals (e.g., Legendre et al. 1992). Could human predators have room in this machinery?

I have once been a part in the sea ice machine, travelling and hunting seals, feeling the cold, and facing risks where plain luck saved me during a three years stay at Svalbard, north of the present Polar Front in the Atlantic Ocean. This is probably similar to lateglacial conditions along the Doggerland beaches. I could observe for myself how snow and ice changes mobility, how sea ice merges land and sea. Even on foot, you will soon encounter the marine mammals living out here, in a landscape that was open water just a couple of months ago. There was once a tourist – after traveling miles and miles on the fjord-ice, the company encountered a seal basking in the sun by its breathing hole: 'Nice … but what is it doing up here in the valley?' This is how sea ice may be experienced; it is both land and sea at the same time, marine and terrestrial separated by a thin layer of frozen water.

Accounts from present day Arctic makes it possible to study the sea ice machinery up close (e.g., George et al. 2004; Gosnel 2005; Laidler 2006) and ethnographical sources (e.g., Nelson 1969). It is a world of variations. As winter progresses, waves, wind and currents tend to arrange the ice-floes in pressure ridges that anchor near-shore sea ice. Outside this, there is normally a floating add-on of solid ice. Both these zones are considered quite stable once they have established during the peak of winter. Farther towards open sea, thinner ice and wave action produce more unstable conditions, open leads and moving ice floes, and loose drift merging into open water (Fig. 3). The sea ice normally stays in springtime and often lingers to the early parts of summer.

Animal life here depends on the sea ice in breeding and subsistence strategies. There are the polar bears, of course, that are actually listed as a marine mammal. And the pagophilic (ice-dependent) seals, similar to what is documented in the Doggerland/Skagerrak area; Ringed seal (*Pusa hispida),* Harp seal (*Phoca groenlandica),* Bearded seal (*Erignathus barbatus)*, and Walrus (*Odobenus rosmarus)* (see elaboration in Bjerck et al. 2016). Most of them are considerably bigger than an average reindeer (*Rangifer tarandus*). Average sized male reindeer weigh 160–180 kg (female 80–120 kg); a ringed seal, the smallest of the ice-seals, reaches 45–100 kg. The other pinnipeds that the Doggerland sea ice hosted are considerably larger: harp seal (120–135 kg), bearded seals (250–450 kg), and the sexually dimorphic walrus 800–1500 (male)/500–1000 (female) (cf. details in Bjerck et al. 2016).

As observed today, ice-dependant seals prefer different biotopes. Harp seals are mostly in outer regions; open sea and ice floes. Bearded seals and walrus prefer more stable ice floes and ample leads, but feed on benthic organisms and thus prefer shallow waters. Ringed seals, however, prefer the solid ice nearshore. They hunt mysids, shrimp and small fish in the water below the ice and rely on a system of carefully maintained breathing holes that also are imperative for resting and breeding. The very noticeable breathing holes are their most vulnerable point (Fig. 4). Polar bears hunt them here – and are reported to study details of their breathing holes to foresee from which direction the vulnerable back of the head of the seal will appear as it emerges. Although being the smallest, ringed seals are the main prey of polar bears. The fact that its habitat is in the inner, walkable part of the sea ice, could probably also interest human predators. In spring days, they enjoy basking in the sun, close to their breathing holes for rapid escapes.

If lateglacial hunters ever roamed the Doggerland coast during winter and spring, they would soon come across parts from the sea ice machinery. Some parts are very noticeable, like the huge tracks of polar bears (Fig. 5). And if they followed the tracks to where polar bears were feeding, they would soon find the bloody breathing holes, and the horrifying remains of ripped seal bodies. Very likely, they soon would experience that the chubby seal bodies were like other big animals they already knew, similar, but also different. Evidently, as a machine, seals were composed of familiar parts; the hide, meat, blood – lots of it – intestines, bladders, teeth and bones, tendons. And above all, the thick layers of fat – blubber. The northern hunters probably already knew that animal fat 'could do' more than filling hungry stomachs. It could soften, impregnate and preserve tools and equipment – but above all be a source of fuel that is always scarce in the northern barrens.

Pinnipeds are adapted for both water and land, as they also depend on being out of the water (Bjerck et al. 2016). Their adaptation to water is highly specialized, and quite impressive. However, on land or ice, their senses and ability to move are clearly inferior to terrestrial animals. Their inferior vision, hearing, olfaction, and clumsy locomotion are all hunters' benefits. They were professional killers, and would soon learn that it was no big deal to catch a seal, perhaps from studying polar bears stalking breathing holes. If the hunters of the plains ever visited beaches during the long sea ice season, they would surely acknowledge the potential benefits of the sea ice machinery. They already possessed most skills and equipment to take part in it. No boats were needed to hunt at the breathing holes in the inner, walkable sea ice that hosted ringed seals. In fact, it is possible that seals quite rapidly were incorporated in their subsistence patterns – still without the need for boats and risking the hazards of open water.

I think this is imperative. The sea ice allowed terrestrial hunters to hunt marine mammals without adding new parts to their machine. In a way, it was business as usual. I highly recommend the book by Richard Nelson, 'Hunters of the Northern Ice' from 1969. It is an affluence of information about the sea ice, hazards and benefits, how to move, and how to hunt. Nelson states that a day stalking breathing holes normally would produce two seals. Two big animals in one day, each the size of a reindeer. It took loads of patience, but where else within their mobility range could the hunters expect a yield like this on a regular basis?

The sea ice machine made access to an affluence of marine mammals, by using their familiar, terrestrial machine. Hunters could get here by walking, probably sledges to haul their catch, and perhaps also expand their reach to riskier parts of the sea ice with very simple boats to cross leads. At first, they probably were quite impressed by the amounts of fat that was stored in the blubber of the captured seals. But perhaps not so long after, they may have found themselves dependant on the blubber that they recently had included in their lifestyle. Blubber was valuable fuel that allowed for melting water for drinking and for heating dwellings; but soon became a necessity that they could not do without.

Well, the machine was running smoothly, and no reason to worry. But it also kept them in place; they were captured in their own, well-greased machinery so to speak. Today, we know that the sea ice was not to be forever. Along with the substantial climatic change in the Pleistocene/Holocene transition, the Oceanic Polar Front moved northwards, and with it the sea ice and all that was part of it (Rasmussen et al. 2011). Without the sea ice, the machine the hunters now were part of, faced entropy. What could be the hunters' response?

It could be to downscale seal hunting to what was possible to reach from the shore, and likewise downscale their dependency of seal inputs to their machine. As very little could substitute blubber in the heating of dwellings, this would probably be a hard decision. Alternatively, the machine could be modified with new parts; skills, tools and equipment that enabled chasing seals in open water. Some kind of boats were hardly unknown to them. Light boats could have been included in sea ice hunting, and for sure to cross the waterways and collect freshwater resources in the plains. Open sea was another matter. Anyway, the vanishing ice would certainly be a considerable motivator to elaborate simple boats to seaworthy vessels. Without the sea ice, the calmer (and perhaps more bountiful) waters of the archipelagos of what today is Western Sweden surely would be more attractive. Subsequently, the modified machine was able to move into the sheltered and bountiful seascapes in coastal Scandinavia – an area that hitherto had been inaccessible due to inferior vessels. Of course, it was possible to walk here on the sea ice. But it was a long way, perhaps too long to be safe back before the spring sea ice melted. Surely, to be stuck on an island up north for the summer/fall was a bad prospect. Improved boats changed everything. Perhaps the presumed blubber fuelled fireplaces that are found in Early Mesolithic tent foundations in Norway (Bjerck 2017;

Pettersson & Wikell 2018) are remnants from the lateglacial sea ice seal-hunting machine?

Yes, I know, many things to be explored, elaborated, discussed and perhaps dismissed. The objective of the paper is to highlight the possible implications of the Doggerland sea ice, and its potential role in the cultural development towards early marine foraging and the subsequent colonisation of Scandinavian coasts. The trajectory discussed also explain the many thousand years of absence of human predators in Scandinavian seascapes during Bølling, Allerød and Younger Dryas. If there is an essence, it is this: Sea ice may very well have been more of a bridge than a barrier in this cultural development – and quite contrary to the referred ice-barrier theory proposed by Glørstad (2014). The sea ice could just as well have prepared southern hunters for marine foraging in open sea, that eventually allowed for colonizing coastal Norway (Fig. 7). Thus, the lateglacial hunters' barrier to the northern seascapes was probably the constrains of machine that hosted them – and not an inevitable response to a single environmental event.

Conclusions

Levi Bryant urges us to ask 'what things do' – and not 'what things are'. The difference is significant. It is a perspective that brings forward how things – 'machines' – work. The archaeological record consists of things that once were part of complex machines that not only depended on human skills, tools and chosen prey – but also a much wider world of non-human parts, animate and in animate, many times more than what we are able to document in the archaeological record. Machine-Oriented-Ontology facilitate to envision the parts that are in the dark, like weather-worlds. Machine-Oriented-Ontology transforms lists of typological artifacts (what things are) to active players in co-working wholes (what things do).

The increasingly brighter and more detailed insight to empiric facts are exiting, but can never do the job alone. For the archaeological discipline to grow, there needs to be accompanying rooms for the speculative where the obscured and untestable matrix that reveal how past machines may have been joined and how they worked. Brilliant empiric pieces must be sought, always. However, insights in machines past people took part in also depend on the speculative. The Scientific discourse needs both.

The sea ice is a telling example. We may produce a scientific account for that it existed. We may deduce what the machine was. But what the sea ice machine *did* for human hunters is probably just as difficult to document as the sea ice that melted 11–12000 years ago. The discussion on weather, climate and social memory (Pillatt 2012) is exactly about this – ‘we need to think less about climate, and more about weather’ (ibid., 33), the conspicuous parts of the machineries that humans were part of, the things that were tangible and called for actions.

Hypothesis’ that seem impossible to test should not be dismissed as futile endeavours. Perhaps better, they should be welcomed as useful frameworks (good or bad) for future empiric facts. Any direct evidence of sea ice hunting is probably vanished for good. We can hope for human remains from Doggerland coastal areas that may reveal relative amounts of marine diets, perhaps also seasonal information that may imply sea ice hunting. In meantime we need the speculative, the ‘verisimilitudes’; to prepare the questions that may contextualise empiric facts to ideas about past machines and how they worked.

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FIGURE CAPTIONS

Figure 1. Stages in the lateglacial and Holocene development of Northwest Europe. Without saying, the map displays ‘summer’ – the ‘winter’ equivalent would be a white rectangle, meaningless to modern readers. Nevertheless, this landscape has hosted just as many winters as summers – a reality to the Doggerland inhabitants. Map: Image 1512141, William Mcnulty/National Geographic Creative. Reprinted with permission, RR3-265409-2.

Figure 2. The Early Holocene Mohalsen 1 settlement (c 10900 cal BP) is located at the island Vega in Northern Norway, c. 20 km open water distance from the mainland at the time (B. Skar, pers. comm; Lorentzen 2014). At present, the site is situated at an elevated shoreline c. 80 m a.s.l., and it is difficult to imagine that it was encircled by rough seas. However, it is not difficult to imagine that sea-worth vessels were needed to reach here, and to hunt in the surrounding seascapes. Photo Å. Hojem, NTNU.

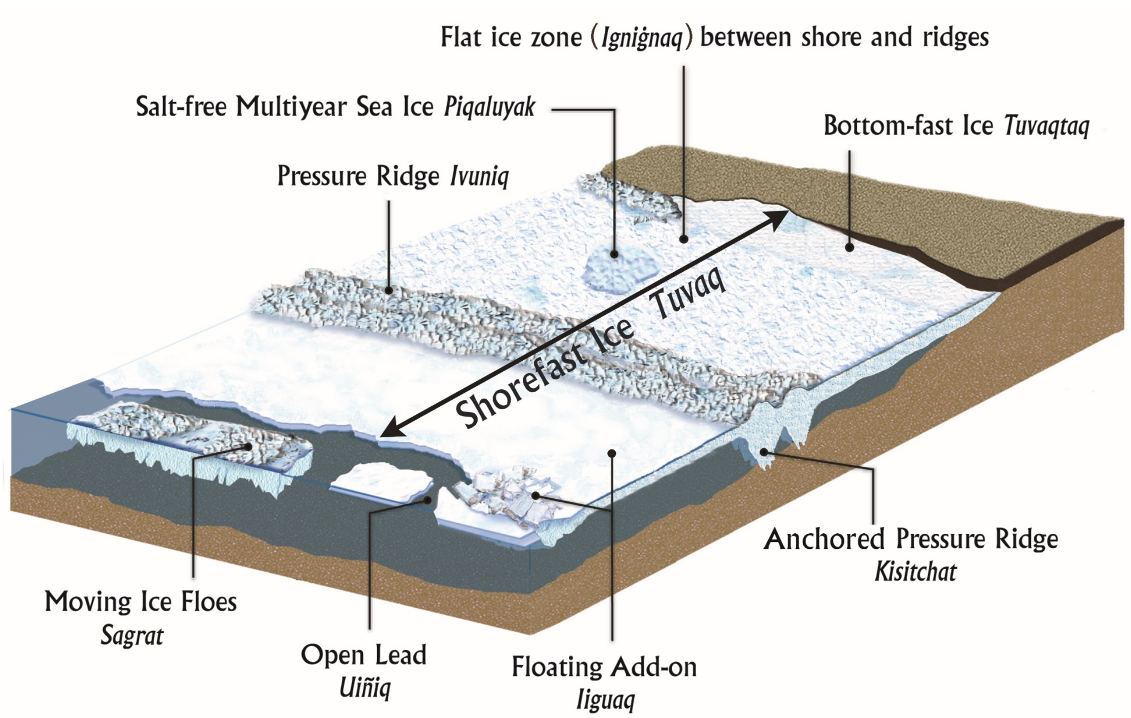

Figure 3. Coastal sea ice build-up in the Chuckchi Sea, Alaska, with Inuit terms added. Illustration in George et. al. 2004, fig. 1). Reprinted with permission.

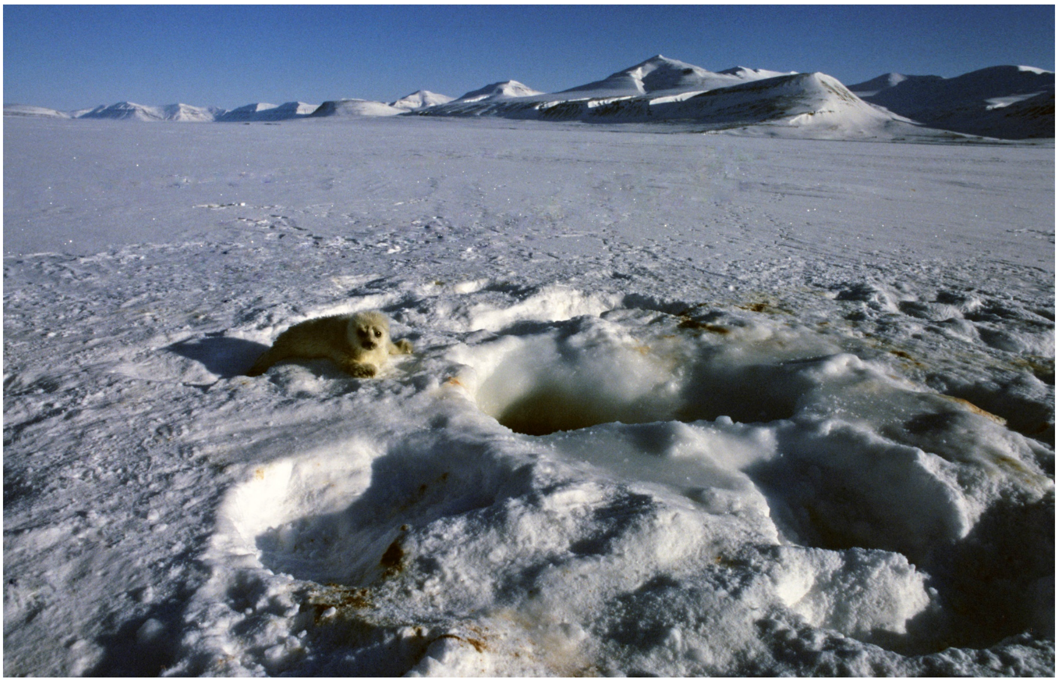

Figure 4. Ringed seal pup by a breathing hole in the sea ice of Sassenfjorden in Svalbard (1999). Note the frozen sea water splash to the right of the breathing hole, revealing the direction of the surfacing seal. Photo H. Bjerck.

Figure 5. Polar bear tracks on the sea ice of Isfjorden, Svalbard. Did continental lateglacial hunters ever follow these tracks to the sea ice machine? Photo H. Bjerck.

Figure 6. The Early Holocene settlement Mohalsen 2 (*c*. 10300 cal BP) at Vega, situated at a raised beach c. 75 m a.s.l. (Fretheim et al. 2018). The site holds of two dwelling foundations, tents or light huts. Fireplaces packed with fist-sized rocks in sooty matrix are found at many early settlements in Norway, and seem to be blubber-fuelled. The pack of rocks probably functioned as heat-storage (Bjerck 2017). The Mohalsen sites are typical for the pioneer settlements in Norway, confided, expedient and situated at good landing places for seafaring – boats, high mobility and seal-hunting seem pivotal in their lifestyle. Did their seal-hunting traditions originate from the Doggerland "sea ice machine"? Photo Å. Hojem, NTNU.

Figure 7. Camping on floating ice. Sea ice is not *per se* hostile to humans. Photo S. Kazlowski, reprinted with permission. http://d2ouvy59p0dg6k.cloudfront.net/img/kazlowski_13202_362028.jpg.