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ORIGINAL ARTICLE

Late Iron Age Whaling in Scandinavia

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Abstract
The use of marine mammal bone as a raw material in the manufacturing of gaming pieces in the Scandinavian late Iron Age has been observed and discussed in recent years. New empirical studies have created a chronology as well as a typology showing how the design of the gaming pieces is tightly connected to different choices of raw material; from antler in the Roman and Migration periods, to whale bone in the sixth century, and walrus in the tenth century. Macroscopic examination can, however, rarely go beyond determining that the material is 'cetacean bone'. The following article presents the taxonomic identifications of 68 samples of whale bone gaming pieces, determined using Zooarchaeology by mass spectrometry analysis. The results demonstrate the consistent use of bones from *Balaenidae* sp. most probably the North Atlantic right whale (*Eubalaena glacialis*). This paper presents strong evidence for active, large-scale hunting of whales in Scandinavia, starting in the sixth century. The manufacture of gaming pieces was probably not the driver for the hunt, but merely a by-product that has survived in the archaeological record. Of greater importance were probably baleen, meat, and blubber that could be rendered into oil. This oil might have been an additional trading product in the far-reaching trade networks that were developing during the period. This study supports previous studies suggesting that Iron Age and medieval trade and resource exploitation had a much more severe influence on ecosystems than previously expected. It adds additional insights into anthropogenic impact on mammal populations in prehistory.

Keywords ZooMS (Zooarchaeology by mass spectrometry) · *Balaenidae* sp. · North Atlantic right whale (*Eubalaena glacialis*) · Gaming pieces · Bone · Blubber · Baleen · Vendel period · Viking age · Whaling

Introduction

Today whaling is a highly disputed and strictly regulated activity, associated with a few nations and Aboriginal groups performing subsistence hunting. This is the result of a number of whale protection programs that have developed after WW II (https://iwc.int/histo

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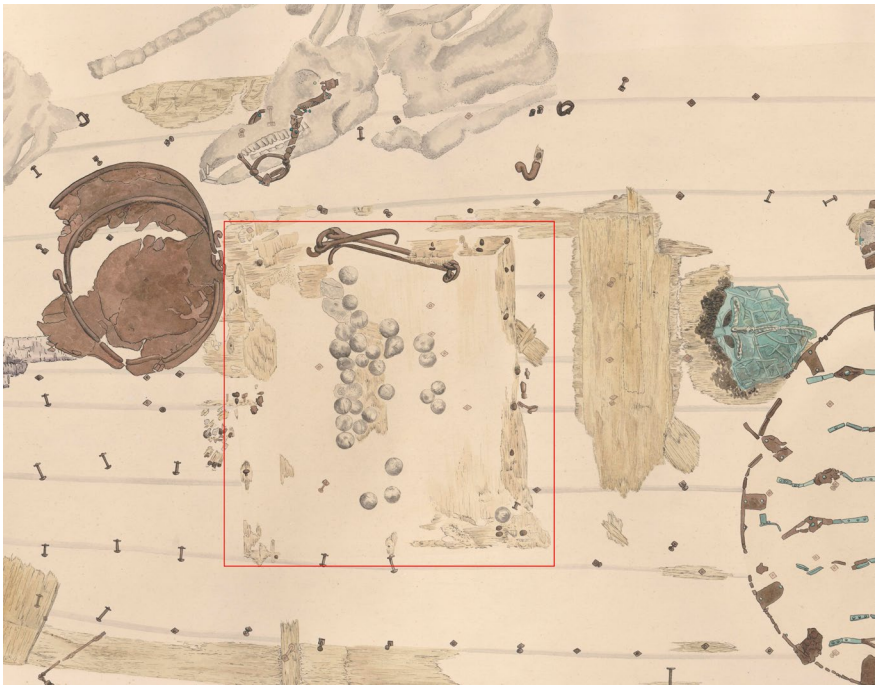

Fig. 1 The well-preserved gaming board from the late seventh century boat grave No 8 in Valsgärde, province of Uppland, Sweden. It reveals laid out whale bone gaming pieces on a riveted gaming board made of rowan wood (marked with red). The gaming board was placed in front of the feet of the buried person, surrounded by the helmet (right), an iron cauldron chain, and horses remains among other items. Picture: Museum Gustavianum. Artwork by Allan Fridell (Color figure online)

ry-and-purpose), by which point centuries of whaling had pushed several species to the edge of extinction.

Whaling was a large-scale industry from the Early Modern period, and up until the 1970s, when, above all, blubber, but also baleen, spermaceti and ambergris, were important components of the global economy (Dolin 2007, 12). The origin of whaling, however, goes much further back in time. Whaling is depicted on prehistoric rock carvings from, for example, north-western Russia (Gjerde 2013). The origin of commercial, well-organized European whaling is often ascribed to the Basques' hunt for North Atlantic right whale (*Eubalaena glacialis,* also known as Biscayan right whale) in the Bay of Biscay during the early Middle Ages (Laist 2017, 103). Recent research has discussed whaling in—for example—the Gibraltar strait and along the south coast of Spain in the Roman period, as well as in the English Channel (Bernal-Cassola 2018; Rodrigues et al. 2018; Hurk et al. 2021). In this article, a different geographic perspective is taken, as we aim to explore prehistoric whaling in northern Scandinavia. The starting point is not material evidence of whaling itself, but instead, a final refined product in the shape of gaming pieces made of whale bone found primarily in Scandinavia and neighbouring areas (see Fig. 1). In comparison with other cetacean products, such as whale oil or baleen, the preservation conditions for bone are far better. Worked whale bone, however, has rarely been identified as an indicator of whale hunting. Just as scrimshaw art, made from sperm whale teeth, can be considered a

product of massive hunts in the nineteenth century, we believe that Iron Age gaming pieces and other whale bone objects can serve a similar purpose, especially for periods lacking the textual sources or the statistics of Early Modern societies (Dyer 2018). By using ZooMS analysis (Zooarchaeology by mass spectrometry) and contextualizing the results using historical analogies, it is possible to shed light on what we argue was a large-scale commercial hunt for specific whale species in Scandinavia during the Vendel and Viking periods (Sixth to eleventh centuries AD).

Background and Previous Studies

In recent years, questions concerning raw material use and resource exploitation in late Iron Age Scandinavia have received increased interest in archaeological research. This research has started to reveal the development of large-scale production and the development of supra regional trade networks prior to the Viking Age emporia in Scandinavia (see for example Ashby et al. 2015; Lindholm and Ljungkvist 2016, Star et al. 2017; Pilö et al. 2018; Hennius 2018. 2020a, b, 2021; Baug et al. 2019; Zachrisson and Krzewińska 2019; Barrett et al. 2020; Lindholm et al. 2021). One characteristic of these new approaches is the osteological identification of bone used in the manufacturing of artefacts (e.g. Hennius et al. 2018). Gaming pieces have primarily been found in central eastern Sweden and Åland, in burials from the period AD 200–1000. Except for a minority made of either glass, amber, or horse teeth, most have previously been recorded as unspecified 'bone/antler'. The study showed that gaming pieces from the early period, in general were small, flat, and made from antler (Type 1). In the early sixth century, a new type starts to make an entrance. It is considerably larger with a hemispherical shape (Type A). The earliest example comes from "Ottarshögen", recently radiocarbon dated to the early sixth century (Ljungkvist and Hennius 2020). During the ninth century, this shape transforms into three-quarters of a sphere (Type B). The majority of Swedish Vendel and Viking Age gaming pieces of Type A and B are made from whale bone. By the middle of the tenth century, gaming pieces made from walrus start to appear more frequently (Type C). The introduction of new materials enabled new shapes, afforded by the internal structure and characteristics of antler, bone, and tooth, respectively (see Fig. 2) (Hennius et al. 2018).

Since this study was published, additional whale bone gaming pieces have been identified, expanding their spatial distribution. Inventories of items in museum collections in Norway (Oslo, UiO KHM and Trondheim NTNU) show a similar situation as that seen in Sweden, wherein large numbers of whale bone artefacts have been registered as made either from antler or as unspecified bone. Some new whale bone gaming pieces have also emerged at excavations of Iron Age settlement (see for example Hennius and Wehlin 2020). Artefacts most likely made of whale bone have also been identified from photographs in databases and publications from excavations in Sweden, Denmark, and Norway, such as Lejre (see below) and Ribe (Feveile 2006, 402, 438; Madsen et al 2014, 276; Ulriksen 2018, 262, examples found at Sydvestjyske museer collection no. 200160571/ASR 15x029, 200,064,593/ ASR 9x550, 200,326,385/SJM 3x1154 200,324,553/SJM 3x0064. For Norwegian examples see also Sjøvold 1974 or Skomsvoll 2012). Furthermore, there are finds from Truso (gaming pieces and perhaps also a navigation instrument made from whale bone, Jagodzinski 2010, 126, 179), and possible finds from Grobina and the North Sea area (Dorestad Leiden inv.no WD72 371.3.1 Willemsen and Kik 2021; Nerman 1958, 167). Whale bone gaming pieces are also distributed in the Viking colonies on the British

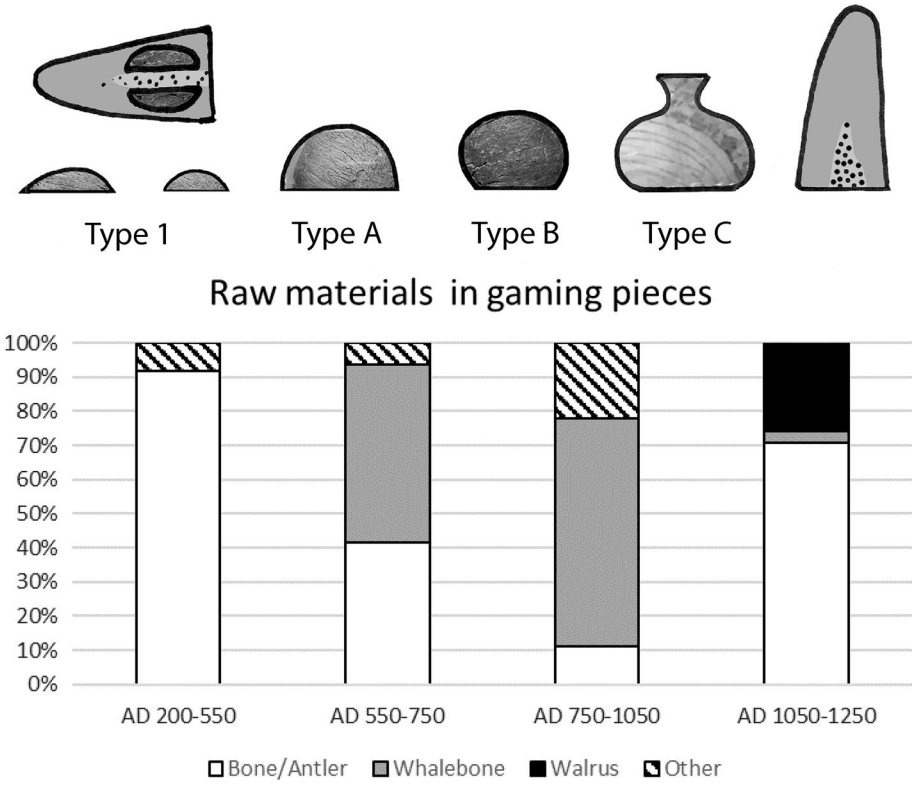

Fig. 2 Chronology, typology and raw materials of Swedish gaming pieces as presented in Hennius et al. (2018)

Islands and across the North Atlantic (Sperr 2005, 99–100, 110). Interestingly, there are areas neighbouring Scandinavia without known gaming piece finds, particularly mainland Finland (personal communication Sami Raninen, Finish heritage agency and Anna Wessman, Bergen University).

These new discoveries strengthen the previous picture that convex whale bone gaming pieces are primarily known from Scandinavian contexts, from neighbouring areas in the southern and south-eastern Baltic sphere, trading sites, and from the Viking diaspora in the North Atlantic. Outside these areas, evidence of domed gaming pieces is sparse. In the Frankish and later Carolingian realms, and at least partly Anglo-Saxon Britain, the material culture of gaming was different (Stauch 1994). A few ivory gaming pieces of continental types are also found in Scandinavia, primarily related to rich late sixth and early seventh century burials (Lindqvist 1936; Drotz and Ekman 1995; Hed Jakobsson et al. 2019). Pre-Viking hemispherical gaming pieces have been found in England in both Hamwic and York, although they were not made of whale bone (Riddler 2014, 348). There is, however, one interesting early exception. In the late sixth century Anglo-Saxon burials at Prittlewell are finds of related gaming pieces made from sperm whale (*Physeter macrocephalus*) (Blackmore and Hirst 2019, 248–249; Cameron 2019, 453). This find shows that the custom of using domed gaming pieces made from whale bone extends to some degree beyond the Scandinavian sphere.

The 2018 paper presents a number of arguments as to why the use of whale bone in the production of gaming pieces should be regarded as an indication of an active and commercial whale hunt, starting as early as the sixth century (Hennius et al. 2018). These arguments are based on several lines of evidence. (1) Whale bone gaming pieces originally deposited in Swedish Late Iron Age burials probably number in their thousands, indicating large-scale and regular imports over a period of 400–500 years. (2) The shift in raw material and design of gaming pieces in the sixth century is coherent and rapid, suggesting that it was based on rational decisions and choices. (3) There is also a parallel between the use of whale bone for gaming pieces and the use of whale bone for other types of artefacts in Scandinavia. (4) In northern Norway hundreds of Iron Age features called slab-lined pits have been recorded (see for example Henriksen 1995; Nilsen 2016, 2017). These were used for blubber processing, and the number of such features seems to increase simultaneously with the floruit of gaming pieces (see Discussion below).

Given the relationship between domed gaming pieces and Norse settlements and burials, the distribution of features related to blubber production, and the strong presence of whale bone artefacts in the material culture, the whaling grounds and gaming-piece production areas were probably in northern Norway (Hennius et al. 2018). A late ninth century account of whaling is made by the traveller and merchant Óttarr/Ohthere from Hålogaland in northern Norway. He told king Ælfred the Great that he gained substantial parts of his wealth from the sea, including from the hunting of whales and walruses (Bately 2007, 44–46). Gaming pieces found around the Baltic can thus be interpreted as traded commodities, and as such as evidence of the development of supra-regional trade networks connecting the north Atlantic coast in arctic Scandinavia with the Baltic from as early as the sixth century.

Species Determination Using ZooMS

The 2018 paper recounts five successful results using ZooMS analysis (Zooarchaeology by Mass Spectrometry) suggesting that the species utilized in their production was primarily North Atlantic right whale (*Eubalaena glacialis*) (Hennius et al. 2018). ZooMS is a peptide mass fingerprinting in which bone collagen is analysed to identify a taxonomic group or even a specific species (for a presentation of the ZooMS method see, for example, Buckley et al. 2009, 2011, 2014). For the present paper, 63 additional ZooMS analyses have been added to the previous five. These expand the empirical base for discussing preferred species in the production of gaming pieces. Furthermore, this new data fosters a better understanding of the character of the prehistoric whale hunt in Scandinavia.

The new samples originate from gaming pieces that have been macroscopically determined as whale bone, as well as two items determined to be cattle. A few additional types of artefacts are included, such as three dice, a sword hilt, and an undetermined whale bone object from Birka. The aim was to cover both a wide chronological span and to trace differences in species represented within the larger sets of gaming pieces. ZooMS only works for unburnt material, which unfortunately precludes the examination of material from the cremation burials that constitute the vast majority of gaming piece finds in Sweden. Thus, sampling was limited to finds from inhumation burials and other contexts with finds not affected by fire (primarily settlement finds). As with all destructive analysis methods, sampling was restricted according to recommendations from museum curators, and undertaken in such a way as to cause as little damage to the objects as possible. The sampling was

undertaken in the collections of Museum Gustavianum at Uppsala University and at the National Historical Museum in Stockholm. There is a geographical skewing of the dataset, in that a large proportion of samples come from eastern central Sweden. However, this is the region that has seen most frequent excavation of inhumation burials featuring whale bone gaming pieces (see Fig. 3).

About half of the samples originate from Vendel and Viking Age boat burials in the province of Uppland, with samples from Vendel boat burial III and XII, Valsgärde burials 6, 7, 8 and 13, Tuna in Alsike IV, Ultuna and Gamla Uppsala (Arwidsson 1942, 1954, 1977; Stolpe and Arne 1927; Arne 1934; Nordahl 2001; Hildebrand and Hildebrand 1873). Twenty samples originate from two boat burials found in Salme in Estonia, probably originating from eastern central Sweden (Price et al. 2020). Twelve samples come from the cultural layers in the Viking-Age trading site /emporia of Birka. There are also some samples from the central site of Lejre in Denmark (see Fig. 4).

Of the 68 samples, three gave no results, primarily due to the poor preservation of the objects. Of the remaining 65, 59 samples (91%) could be determined to be *Balaenidae sp.* (see Fig. 5 and supplementary material). One sample gave a result of sperm whale (*Physeter macrocephalus*), two were from cattle, and three samples red deer/fallow deer/elk (most probably elk or perhaps red deer) The two samples identified as cattle were taken from gaming pieces from Salme. The elk and sperm whale results all came from objects other than gaming pieces (dice: one sperm whale and two red deer/elk; the sword hilt: red deer/elk). Finally, the undetermined object from Birka was also from bones of a *Balaenidae* sp. Importantly, if we focus on the 58 samples from whale bone gaming pieces that could be identified by ZooMS, all were made of bone from *Balaenidae* sp.

Just as with the above examples of red deer/fallow deer/elk, ZooMS cannot differentiate between the species represented within the *Balaenidae* family, i.e. three types of right whales (*Eubalaena*, the North Atlantic right whale (*E. glacialis*), the North Pacific right whale (*E. japonica*) and the Southern right whale (*E. australis*) and the bowhead whale (*Balaena mysticetus*). The four species are closely related and, except for different areas of habitation, share a number of specific characteristics. Considering that the whale bones in this analysis originate from northern Europe, and that the production areas are suggested to be northern Norway, we can limit the possible species down to North Atlantic right whale (*Eubalaena glacialis*) or the bowhead whale (*Balaena mysticetus*). The two species have different, but unfortunately for this study, partly overlapping habitat and range. The North Atlantic right whale was migrating on a yearly basis at least from the Azores but probably even further south and northwards, sometimes all the way to Spitsbergen (Aguilar 1986, 192). The bowhead whale is now living exclusively in the arctic but, historically, probably had a more southern distribution, along the coasts of northern Norway (Carwardine 1995, 40; McLeod et al. 2008; Wigg et al. 2019). Even if the North Atlantic right whale is more probable, the possibility of some specimens of bowhead whales cannot be ruled out.

If the production of the gaming pieces had been dependent on stranded cetaceans, one would expect a larger variation of species to be represented among the artefacts. The current situation of whale strandings obviously differ from the historical due to markedly different populations caused by hunting and depletion but also the fact that present-day strandings are frequently a result of human activities such as the ingestion of plastics or fishing gears as well as boat collisions and other disturbances from ships and shipping. With this in mind, modern day statistics might still give an indication of the variation of stranded whale species. Statistics from the UK and Ireland during the period 1913–2015 show that the most frequently stranded species was harbour porpoise (*Phocoena phocoena*) (47%), followed by short-beaked common dolphin (*Delphinus delphis*) (18%) and long finned

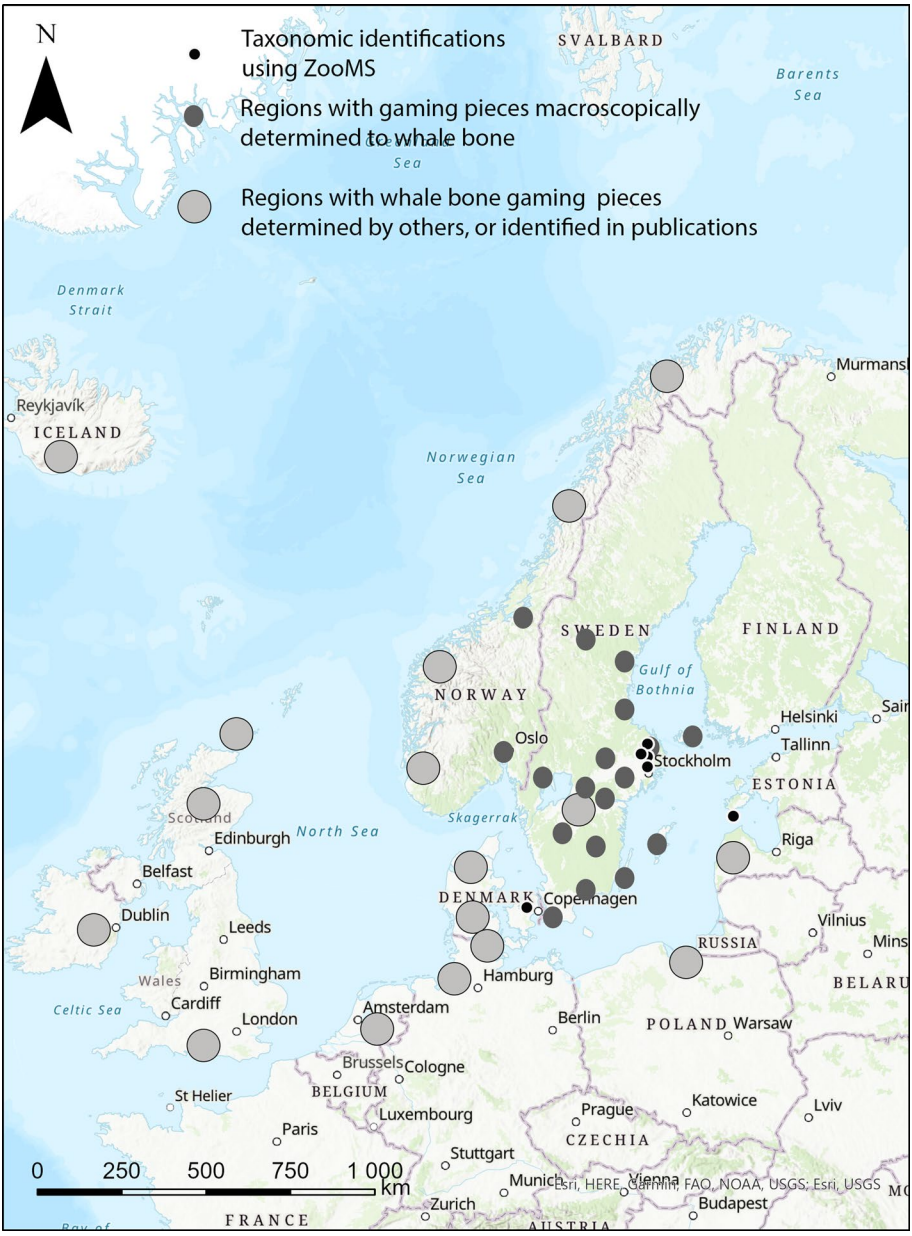

Fig. 3 Map showing the distribution of domed gaming pieces, made from whale bone found from publications and museum catalogues and also the distribution of the sampled and analysed items. Background map from ESRI (Color figure online)

pilot whale (*Globicephala melas*) (9%). Baleen whale strandings (Mysticete) were much less frequent (c. 4%) and most of these where Minke whales (*Balaenoptera acutorostrata)* (Coombs et al. 2019, 1539). Stranding statistics from Norway are hard to find but reports on whale sightings and stranding events give a similar varied picture (Ancieto et al. 2021;

Fig. 4 Sites, contexts and dates for the samples included in the study

Site	Context	Date AD
Vendel	Vendel boat burial XII	560/70–620/30
Valsgärde	Valsgärde boat burial 7	560/70–620/30
Lejre	Mysselhøjgård House XXII or XXIV	C. 650–710
Lejre (sword hilt)	Mysselhøjgård Hus XX	C. 650
Valsgärde	Valsgärde boat burial 6	660/70–710
Valsgärde	Valsgärde boat burial 8	660/70–710
Ultuna	Ultuna boat burial 1	660/70-–710
Vendel	Vendel boat burial III	710–760/70
Valsgärde	Valsgärde boat burial 13	710–760/70
Salme	SI & SII	710–760/70
Birka	Black Earth	750–980
Gamla Uppsala	Gamla Uppsala boat burial 1	850–950
Tuna in Alsike	Tuna Alsike boat burial VI	800–900

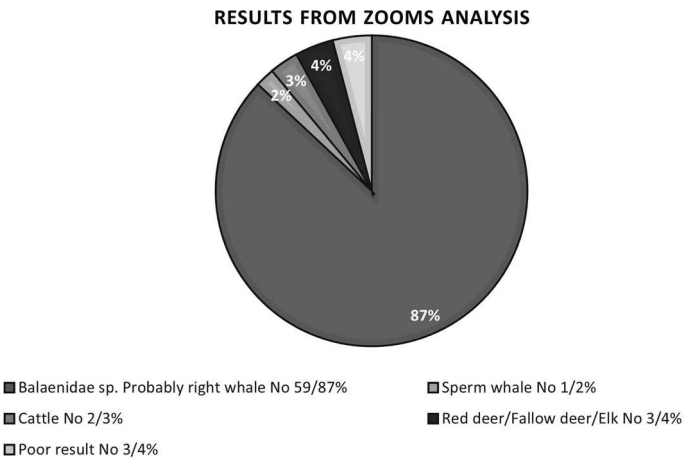

Fig. 5 Species representation in the ZooMS analysis. The sperm whale and two of the red deer/elk come from dice, one red deer/elk comes from a sword hilt. The two samples identified as cattle come from gaming pieces

Leonard and Øien 2020). The identification of a die made from sperm whale ivory in the study indicates that stranded whales could be used occasionally. This species has a pelagic way of life and was probably not subjected to extensive hunting until the introduction of

oceanic whaling ships. The overwhelming preference for the *Balaenidae* sp. (North Atlantic right whale and/or bowhead) together with the presence of only one single example of any other of the 27 cetacean species living in the North Atlantic at the time, strengthens earlier arguments for the existence of an active hunt that was targeting specific types of whales as early as the sixth century.

Historical Analogies on Whale Hunting

Historical accounts and analogies can help us understand the driving forces for how the hunt was conducted, as well as what other products could have been obtained and refined from this species, and why the North Atlantic right and bowhead whales were targeted. Historical analogies also provide us with a better understanding of prehistoric hunts, and the various remains that can be found in the archaeological record.

Catching whales and extracting different products for further refining—such as meat, blubber, baleen, or bone—can be performed in several ways. It is difficult to distinguish an active hunt from the scavenging of drifting and stranded whales purely on the basis of archaeological remains, but historical and anthropological records show that whales can be hunted in various ways. By making sounds, small whales could be rushed towards the beaches, where they could be trapped in small bays using nets or other types of traps. Whales can also be speared or shot by arrows from the shore or from boats. Killings with spears could be relatively quick, but spears and arrows could also be poisoned in order to inflict infections and a slow death, before the whale's carcass finally floated ashore (Lindquist 1994, 387–390; Szabo 2008, 112; Laist 2017, 90).

The means of retrieving whales was dependent on the behaviour of different species; some live close to the shore, while others are predominantly pelagic. Shore-living species such as North Atlantic right whale (*Eubalaena glacialis*) or bowhead whale (*Balaena mysticetus*) constituted an easier catch, if using small boats and simple tools, than the pelagic whales [such as sperm whales (*Physeter macrocephalus*) or blue whales (*Balaenoptera musculus*)] that became targets primarily in the eighteenth, nineteenth and twentieth centuries, with the availability of oceanic vessels.

The ZooMS analysis cannot yet differ between the closely related North Atlantic right whale and bowhead whale. Both are baleen whales of considerable sizes. Adults may span between 13 and 20 m in length, weighing 30–100 t (Carwardine 1995, 40–47). Both species have a very high content of blubber. This, together with the fact that they are both slow swimmers close to the shores, has caused intense hunting. The high blubber content makes the body float after death, which simplifies both handling and a controlled caretaking after the killing. The blubber, baleen, and meat have made both whales valuable catches. Today, the right whale population consists of only a few hundred individuals in the north-western Atlantic. Indeed, the North Atlantic Right whale is currently one of the most endangered whale species in the world. (Dolin 2007, 21–22; Szabo 2008, 59, 85).

Even if North Atlantic right whales are very large creatures, historical analogies show they have been hunted and killed with fairly simple tools throughout history. The earliest literary evidence of commercial whale hunting is related to the Basques. As early as 670 AD, a French Basque supplier signed a contract to deliver 40 barrels of whale oil to an abbey in Jumiege, near Le Havre in France. Perhaps as early as the seventh century, stone watchtowers were erected along the coast, so that lookouts could spot the whales (Laist 2017, 102–103). Further north along the Atlantic coast, an

English historical reference to whale hunting comes from Bede in AD 731: '… seals as well as dolphins are frequently captured and even whales' (Mulville 2002, 36 with references). Even if Bede's text should not be taken literally concerning whale hunting, there is plenty of archaeological examples from the British islands showing the utilization of whale bones as, for example, combs in whale bone found in Hamwic (see for example Riddler 2014). The early shore-whaling in Nantucket on the West Atlantic coast is also well documented. This took place several centuries after the Viking Age and Middle Ages but saw the adaptation of techniques from the eastern side of the Atlantic Ocean, where the traditions and techniques had their origin.

On both sides of the Atlantic, lookouts along the coast informed whalers to man their boats when a whale came in sight. The Basques used small, open, clinker-built boats known as "Chalupas". These were some 6–8 m long and manned with a crew of 5–10 persons, they approached the whale by rowing. When within shooting distance, the harpooner would throw his weapon, usually a double-barbed iron dart. The harpoons were not intended to kill the whale, but rather to keep it from escaping. It was thus important that the harpoon was thrown hard enough to penetrate as deep as possible through the skin and blubber and get a firm grip. The harpoon line was usually attached to a buoyant block of wood, a drogue, but the boat itself could be used for the same purpose. The first strike often led to violent and dangerous reactions from the whale; it might take off on "The Nantucket sleigh ride" with the boat in tow, or even worse, it might dive. When the whale tired, the whalers approached it once again to fasten a new drogue, or to deliver a lethal attack with a long lance, intended to puncture the lungs. When the whale had drawn its last breath, a hole was cut in the fluke, a rope inserted, and the crew could start the exhausting job of towing the carcass back to shore (Dolin 2007, 49–50, 53; Laist 2017, 103–109).

After the kill, all the valuable products from the whale had to be taken care of. Before the development of pelagic whaling, with stove-equipped oceanic vessels, all whales were processed on the shore. This protracted and extensive work had to be done as quickly as possible, since the decay process of whales is rapid, creating both gases and stench. While Nantucket whalers focused on baleen and oil and left the meat to rot—despite it being a huge source of calories—the Basques took care to salt the meat that was cut from the bones. The tongue in particular was considered a delicacy and was often donated to the church (Laist 2017, 103–109). To render the blubber into oil, it was cut into small pieces and heated in large metal cauldrons suspended over an open fire or a brick or stone-built oven. When the oil melted out from the blubber, the remaining "cracklins", i.e. skin and leftover meat, was scooped out and used as fuel in the ongoing process. The process of boiling blubber could take several days, since a 50-t North Atlantic right whale could contain as much as 20 tons of blubber. After cooling, the oil was poured into barrels (Dolin 2007, 51–52). Historically, the normal size of these was approximately 56 gallons (about 200 L), and one adult whale could yield 40–45 barrels: the equivalent of some 8000–10,000 L (see Fig. 6) (Laist 2017, 107). Besides the huge effort of extracting oil, it was also profitable to recover the baleen; this was cut loose and dried. The bones could also be put to use. Vertebrae made excellent chopping blocks, while other large bones could be used in construction, and whale bone could also be used in the production of smaller objects such as weaving tools or combs.

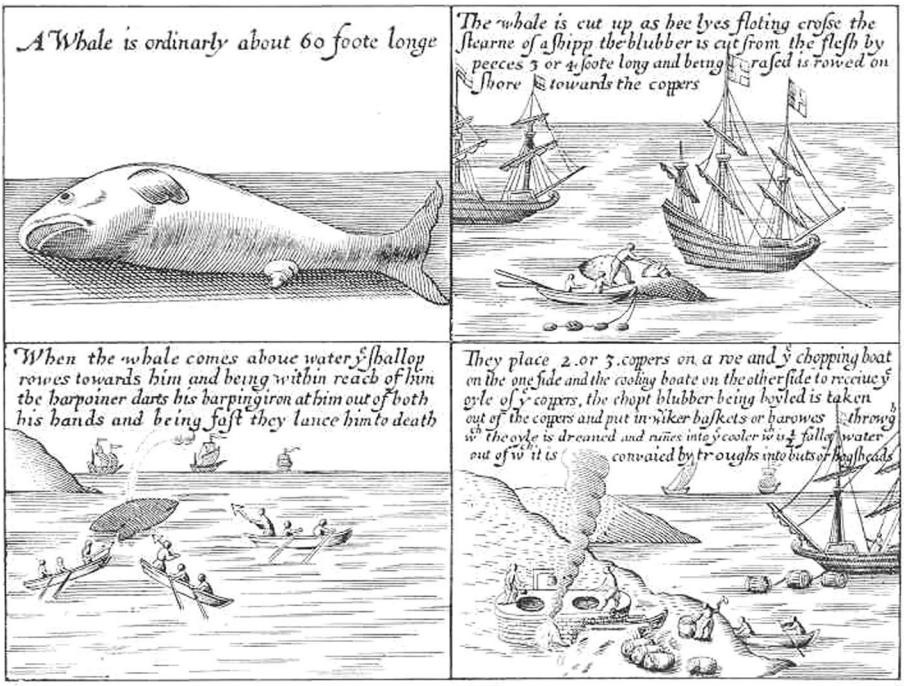

Fig. 6 19th century whaling as described by Samuel Millet (1924). Freshwater and Marine Image Bank. Wikimedia commons

Prehistoric Whaling in Scandinavia

Our knowledge of north Scandinavian whaling is primarily based on written records, with the ninth century accounts of Óttarr/Ohthere as the earliest. This traveller tells king Ælfred the Great about killing more than sixty whales—measuring 50 ells (about 20–30 m)—with his friends in just two days. This account has rightfully been disputed, since the size and number of accounted whales is staggering. But it has also been disputed that Norsemen were capable of catching such large animals during the Viking Period or had the need for doing so (see for example Bately 2007, 44–46; Bill and Damgård-Sørensen 2007, 7; Storli 2007, 90–99).

To discuss even earlier whaling in Scandinavia, we are left with the archaeological material. Except for Thorleif Sjøvold, who based his assertion for whaling on the basis of the many finds of weaving swords, plaques, and cleavers made from whale bone in northern Norway, few researchers have argued for the existence of commercial hunting before the Viking Age (Sjøvold 1971, 1204). From the above-mentioned examples of right whale hunting, the most essential tools are harpoons, spears, drogues, and boats. Harpoons with sizes suitable for whaling have not been found in prehistoric Norway. Iron spear points and arrowheads, however, become more common in Norwegian weapon burials between AD 650 and 950, and Szabo (2008, 108) suggests these could have been used for whaling with spears. In northern Norway a few very large spears have been found in burials. One

previously observed spear comes from a ninth century grave on Hundholm, Tysfjorden. The burial contained a hyoid bone from a large cetacean and a 38.5 cm-long spear head, which deviated from existing weapon typologies. Suggestions have been made that the spear was used for whaling and the buried individual might have been a whaler (Lindquist 1994, 403–404; Sjøvold 1974, 81). Another large, 53 cm-long, tanged spearhead, with observable traces of a short shaft, has been found in a boat grave on the small island Hillesøy in northern Norway (Roth Niemi 2018, 37). Like the Hundholmen spear, it cannot be fitted into any weapon typology (see for example Petersen 1919). It has clear similarities with whaling lances, particularly the very large blade, but also seems to be a short and heavy shaft. The authors of the excavation report, however, have interpreted the spear as used in bear hunting (Roth Niemi 2018, 38).

The drogue used in historical whaling was either a large piece of wood or the boat itself, and examples are thus hard to identify in the archaeological material. Scandinavian boat-building technologies made fundamental developments in the 5th to seventh centuries, including the radial splitting of logs to create thin and durable planks for clinker-built constructions, and the introduction of the hull and sail (Larsson 2007, 85, 92–95). Boat burials excavated in (for example) Hilleshøy and Bitterstad in northern Norway, or Vendel, Valsgärde and Ultuna in Sweden show the presence of smaller but well-built clinker boats around Scandinavia in this period (Arwidsson 1942, 1954, 1977; Rieck and Crumlin Pedersen 1988, 127–144; Cerbing 2016; Roth Niemi 2018). In size and construction, these boats have very close similarities to the boats that historically were used for whaling as described above (Anselm 1978).

To summarize, all the technological preconditions for a Norwegian spear-based shore hunt for right whale or bowhead whale were present in the later Iron Age. However, it is also necessary to consider how the carcasses of huge whales were handled once towed to shore, and how meat, baleen, bone, and blubber could have been refined and turned into sellable goods.

Bone, Baleen and Blubber–Products for Trade

As already mentioned in the introduction, scrimshaw art can be considered a result of the massive whale hunt in the nineteenth century. In a similar way the whale bone gaming pieces can be used as a proxy for a large-scale whale hunt emerging in the late Iron Age. There are also several other types of objects made in the same material, including weaving swords, cleavers, and plaques. The largest concentration is found in northern Norway, but objects were, to some degree, exported to other parts of the Viking world (see, for example, Sjøvold 1971, 1974 or Isaksen 2012) and are occasionally found in Sweden. Even if it is possible to manufacture thousands of gaming pieces and other items from just one carcass, the persistent presence of gaming pieces in south Swedish burials for hundreds of years—following coherent trends in design and choice of raw material—are clear indications of continuous hunting.

As already pointed out, it is important to bear in mind that bone preserves much better than other organic materials in the archaeological record, and bone artefacts are probably the only by-product from the whale hunt that could have survived in substantial numbers. There are, however, a few examples of baleen finds identified in archaeological contexts. One is the baleens used to fasten the boards in the ninth century Oseberg ship (Shetelig 1917, 294). Another example comes from a late 5th and early sixth century burial in

Högom in Sweden, where a wooden bucket was tied together with baleen (Ramqvist 1992, 131). There may be more fragments not yet identified in museum collections, as the subject has not been systematically surveyed.

Historically, the most valuable part of both right whale and bowhead whale, and the main reason for the hunt, was the blubber and the oil that could be rendered from it. The oil could be used as lamp fuel, and for waterproofing of leather, rope, and wood in the world of ships. It also had a role as nutrition, and in the soap and lubricants industry (see Nilsen 2017, 11–15). If the gaming pieces are proxies for commercial whaling, starting as early as the beginning of the sixth century, then there is a possibility that whale oil was part of the same Scandinavian trade networks. The whale oil is not preserved in the archaeological record, but the production can still be identified by the visible remains of production sites.

Basque and North American historical whale oil rendering was primarily performed using metal cauldrons placed above an open fire or stove. There are other examples of rendering oil from marine mammals. For the production of seal oil in the Baltic, the hunters would beat the blubber, still attached to the seal skin, with wooden sticks (Nilsen 2016, 201). Among Inuit cultures in the arctic, one way of rendering oil was to place the blubber in a bag made from seal skin and hang it in the sun or bury the sack in the gravel on the beach for a slow, low-temperature decomposition of the blubber to release the oil (Nilsen 2016, 199). Norwegian blubber-rendering is usually discussed from a different mode of production, with parallels further to the east and in the Baltic. In Northern Norway, a specific type of feature, "hellegrop" or slab-lined pits, have been associated with the rendering of oil from marine mammals. Analysis of lipid biomarkers show that the layers of cemented organic residues in the bottom originates from the processing of blubber from marine mammals such as seal, walrus, and whale (Henriksen 1995; Heron et al. 2010; Henriksen and Valen 2013; Nilsen 2016, 2017).

The oil rendering pits are found close to the Iron Age water levels and shorelines in northern Norway. They are usually 2–4 m long, 1–2 m wide and 0.3–1 m deep and are sometimes placed in clusters including several pits. The sides could be lined with stone slabs, revealing a carefully made construction and an intention of repeated use. Based on experiments and ethnographic analogies, Gørill Nilsen has interpreted the pits as used for the production of oil from marine mammals using preheated stones that were placed together with the blubber to release the oil. Successful experiments have been performed, in which blubber, and stones are placed in a sealskin (Nilsen 2016). Several hellegroper have a hard bottom layer consisting of a mixture of burnt animal fat/blubber, charcoal, burnt stones and sometimes bones. It has not yet been determined if the blubber originates from seals, whales, or other marine mammals, but the size of the features and the presence of bones from large whales in connection with some of the pits, point at least to some amount of whale oil rendering (Heron et al. 2010; Henriksen and Valen 2013:135, 195, 175–176, 384–386).

In northern Norway there are over 700 registered slab-lined pits. Almost all are situated in the northernmost part, in Troms and Finnmark and this region could probably be pointed out as the source of the raw material for the gaming pieces, and perhaps as the area of origin for the finished items as well. Several excavated pits show indications of reuse on repeated occasions, and these features could be seen as traces of large-scale production. A compilation of almost 100 radiocarbon samples from excavated pits has been analysed using Kernel Density Estimation. These indicate an introduction of oil production in slab-lined pits in the Roman Iron Age, but with a massively increased production in the 7th–9th centuries, ending in the Early Medieval period (see Fig. 7, samples compiled from Henriksen 1995; Heron et al. 2010; Henriksen and Valen 2013; Nilsen 2017). When comparing

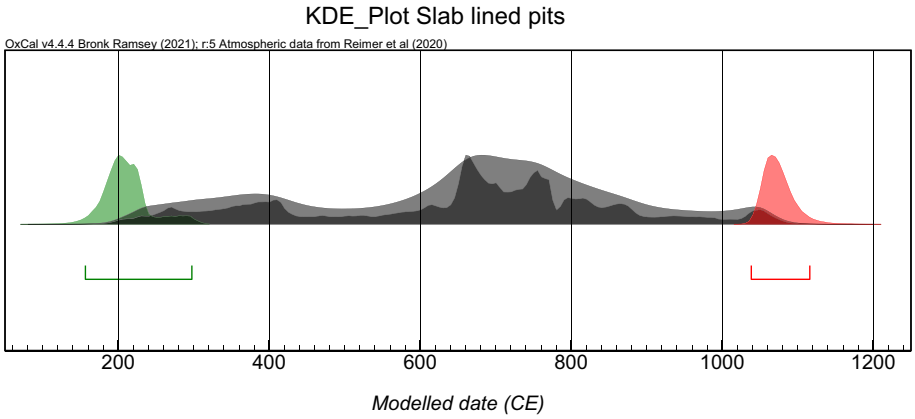

Fig. 7 KDE_plot analysis of almost 100 available radiocarbon samples, showing the chronological distribution of slab-lined pits in northern Norway (samples from Henriksen 1995; Heron et al. 2010; Henriksen and Valen 2013; Nilsen 2017)

the dating of the slab pits, and the frequency of whale bone gaming pieces, there is a broad coherence. The large increase in slab-lined pits seem to appear somewhat later than the introduction of whale bone gaming pieces in Swedish burials, but there is also a smaller increase in the Roman Iron Age. Several source-critical aspects have to be considered when interpreting the curves of calibrated and analysed radiocarbon samples, such as the use of old, slow growing wood near the arctic, the marine reservoir effect, and a long period of reuse for some pits. Since the types of marine mammals used for oil production in the pits have not yet been established (Heron et al. 2010), there is also a possibility that the pits represent oil production from several different species of whales and seals.

Gørill Nilsen argues that cauldrons were not used for whale oil in prehistoric periods, since the vessels were highly esteemed and not common outside elite settlements (Nilsen 2016, 202). There are, however, several examples of cauldrons of very large sizes, in both Sweden and Norway, suggesting a use within specialized and large-scale activities (see, for example, Grieg 1928, 135–139; Stolpe and Arne 1912). We might have overestimated both the exclusivity of the iron cauldrons and the technological skills needed in their production. Some may also have been re-forged at a later stage, meaning that their original numbers cannot be identified in the archaeological record. Perhaps we should consider the possibilities of oil-rendering using iron cauldrons in open fires, or in the slab-lined pits, and using cracklins, whale bone or peat as a fuel if wood was scarce.

Through experiments, Gørill Nilsen has estimated the oil yield in relation to blubber for the technique involving heated stones. The results show that the yield corresponds to just over half as many litres as the number of kilos of fat, i.e. 18 L of oil were rendered from 30 kg (kg) of harp seal blubber, or from 37.5 kg of common seal blubber some 21–24 L of oil were rendered (Nilsen 2016, 207). The numbers, in comparison to a 50,000 kg adult North Atlantic right whale, with some 20,000 kg of blubber, would correspond to at least 10,000 L of oil. These volumes imply a large and well-planned production, probably vastly exceeding the needs of a normal household and a local community. This suggests that whale oil was a product for sale, just as was the case for the huge volumes of antlers, furs, and ivory taken from forests and coasts in northern Scandinavia. In order to be able to sell a surplus of whale oil to distant markets, opportunities for transports are required. The

whale oil, as a product for sale, had similarities to tar and the two products could also be used in some similar contexts, including within maritime transport (Hennius 2018).

The question of the use of barrels in late Iron Age Scandinavia has so far been discussed to a very limited degree. Barrels and other containers for the transport of fluid goods had, by then, been common in regions further south for a very long time. The techniques for building wooden, stave-built, liquid-proof vessels were well known in Iron Age Scandinavia, even if proper barrels are rare. Iron hoops or barrel rings are uncommon prior to the medieval period, but wood or baleen could have filled the same function, as in the case of the bucket from Högom. Stave-built vessels, which have many technical similarities with barrels, are not uncommon in well-preserved inhumation burials. There is a find of a tar barrel from Ribe, imported from Nieder Sachsen and put to a secondary use in the construction of a well in the early eighth century (Bencard et al. 1990, 59–60). Furthermore, there are a number of large stave-built barrels in the boat graves of Oseberg and Gokstad. Four stave-built barrels are also known from Kaupang, revealing the advanced technical knowledge and capacity in this field, in Viking-Age Norway (Grieg 1928, 151–162; Pilø 2007, 218, 219). In eleventh century Schleswig, wooden troughs reveal that there were alternative ways of transporting tar (Kalmring 2010, 370–371). However, arctic Norway does not have an abundance of suitable wood, and other materials may have had to be used, unless barrels were imported. It is possible to manufacture liquid-tight containers from hides, as seen in the examples of Inuit whale oil production discussed above. However, this method would perhaps be more suitable for land transport, as soft containers might have been seen as too unstable for use in maritime contexts or even long land transports on primitive roads. If we assume the existence of a major trade in whale oil from the north, it might be worth considering the possibilities of an import of barrels/containers from the south, before their filling and export, resulting in containers being repeatedly shipped back and forth along the coast.

Nilsen and several other researchers attribute the whale oil production in slab-lined pits in arctic Norway to the Saami (Henriksen 1995; Heron et al. 2010; Nilsen 2017). This claim is based on the geographical position of the production, as well as on historical and ethnographical sources, since the slab-lined pits have parallels further to the northeast, rather than on the European continent. Ohthere collected taxes from the Saami, including both whale bone and ropes made from whale or walrus. He also bragged about the number of large whales he killed (Bately 2007, 46). But strangely enough, he does not say anything about whale oil or what he did after killing the creatures. It might very well be the case that coastal Saami hunted the whales and refined both blubber and bones, but as we are discussing large-scale production and trade, the activity may not have been limited to one actor or community. Historically whaling, just like commercial shipping, was a multi-ethnic business. It is possible that various parts of the production and refining of products in prehistory were divided between different actors from various ethnic groups and areas, as this comes with the nature of production and long-distance trade. Evidence for the finishing of whale bone objects is still evasive. Very little is known about the locations of pre-medieval whale bone handicraft production in Scandinavia, and production waste is rarely identified at excavations. Small amounts of whale bone fragments have been found on sites in central and southern Scandinavia, but these could originate from discarded or refurbished objects rather than primary production.

The turnover of goods on far-reaching, supra-regional trade networks probably involved a complex organization and administration including storage facilities, means of transportation, and infrastructure (Herschend 2009, 323). When traveling and trading along the Norwegian coast or crossing the Scandinavian mountains and forests between the Baltic

and the North Atlantic, it was also necessary to relate to the royal powers developing during the period (Skre 2020, 194–196). It has been suggested that the origin of the Scandinavian nations is to be sought in in Middle Iron Age, in the establishment of realms along the communication routes, intended to offer defence for existing trading systems already (Blomkvist 2005, 39; Skre 2020, 193, 194, 222; see also Zachrisson 2020). Nodal sites of the elite occurred in a number of core areas, but it was hard to control trade routes and communication networks or to protect the traders. These network kingdoms thus required a much higher degree of cooperations between the people involved along the routes.

Trade along the Norwegian coast was probably monitored by local elites and specific traders. One such example is Ohthere, who travelled all the way to England, passing several different trading sites on his way. It is also possible to identify some of the central sites and trace the trade networks in the archaeological records from northern Norway. The royal manor at Borg, with its famous 80 m long, 6th-century hall building, was probably one of the nodal points on the route (Roesdahl et al. 2003, 100–105). There are also recently excavated late Iron Age boat burials in northernmost Norway, at Hilleshøy och Bitterstad. Not only does the burial custom here have similarities with south Norwegian and central eastern Swedish burials, but so too do the high-quality grave goods with animal-ornamented mounts and gilded items with inset garnets (Cerbing 2016; Roth Niemi 2018). Sites with indications of far-reaching trading activities have been identified at, for example, Sandtorg, along the sailing route close to Lofoten, and with probable roots in the Migration period (Krokmyrdal 2020, 2021). We would like to suggest that the marine resources, including the refinement of products from a large-scale whaling, were important commodities on these trade networks, and one of the reasons behind the wealth seen in the region already before the Viking Age. The wealth of the natural resources in the North Atlantic has indisputably left a mark in the burials of this region, that is located more than 1700 and 2200 km respectively from the later Viking Age towns of Kaupang and Haithabu whose hinterland each have pre-Viking whale bone products.

Conclusions and Reflections

Based on the contextualization of the results of our ZooMS analyses with the other empirical material presented in this paper, it is possible to argue that an active and commercial hunt for whales from *Balaenidae* sp. developed in the sixth century. Furthermore, it is possible to identify far-reaching trade networks connecting Arctic Scandinavia and the Baltic at this time, based on the distribution of whale bone gaming pieces.

Whale bone handicraft was probably not the main reason for the whale hunt; the focus could be assumed to have been rather the meat, the production of whale oil, and perhaps the baleen. Indeed, it is very likely that whale oil was an important trading product. The high content of blubber in North Atlantic right whales has always made this species valuable, as it provides huge amounts of oil. Such a claim is, however, difficult to anchor empirically in the archaeological material, and is based upon traces of a large-scale oil rendering. We could also assume that the hunters and the processors of whales put considerable effort into streamlining and logistically managing the huge enterprises that were implicated in the processing of every whale caught. If the hunting and processing of whales involved the interests of other agents, shippers and consumers, there were joint interests in making the entire chain—hunting, processing, shipping, and distribution—as efficient as possible in order to maximize profits.

The suggestion of a large-scale North Scandinavian trade in whale products such as oil and mass-produced gaming pieces, challenges some previous assumptions of pre-Viking Age trade. The traditional way of describing the economics of Iron Age Scandinavia is that it saw a transformation from unique objects distributed through ritualized gift exchange in the early Iron Age, to a negotiated trade in serially produced, identical objects, as well as the growth of direct long-distance trade in bulk commodities and raw materials. These developments are seen to have taken place when emporia like Birka, Hedeby, Ribe, and Kaupang were founded by political elites in the 8th century (Näsman 1984, 121–123, for a discussion see Gustin 2004, 25–26 or Sindbæk 2012). However, both the serially produced gaming pieces and particularly a large-scale whale oil production, can be seen as part of a far-reaching commodity trade, with consumption goods produced in large volumes, pre-dating the Viking Age. Other—if smaller—products can be seen as mass-produced trading items and have been found in large numbers before the Viking Age. Examples include combs made from both elk and reindeer antlers, as well as glass beads. Furthermore, the presence in Denmark of reindeer antlers and combs from Arctic Scandinavia have been identified in eighth century contexts, and studies of pitfall hunting suggest a scale of hunting that far exceeded local needs even several centuries earlier (Ashby et al. 2015; Hennius 2018; Pilø et al. 2018). Unfortunately, prior to the appearance of the Viking Age emporia in the eighth century, traces of trade are vague and difficult to grasp, especially if products were transported using containers made of organic materials. However, through extended research, new questions, and the combination of archaeological and scientific methods, there are opportunities to explore this field still further. One very important aspect would be to determine the species of the whales using aDNA and also further analysis to determine the specific species utilized for oil production in the slab-lined pits. It is also important to explore the use of whalebone for different kind of handicraft. This study shows a preference for bone from *Balaenidae* sp. in the production gaming pieces but to which extent these were also used for other purposes and whale bone artefacts is still unclear.

The implications of this work are far-reaching, not least in the context of existing work on the anthropogenic impact on animal populations in prehistory. Studies on bear-hunting in Sweden (Lindholm and Ljungkvist 2016), fish from northern Europe (Barrett 2019) and walruses in Greenland (Barrett et al. 2020) suggest that Iron Age and medieval resource exploitation and trade had a much more severe influence on ecosystems than previously expected. Already in the ninth century, walruses along the Norwegian coast were rare and Ohthere had to travel far to the northeast for walrus hunting. When hunters from Northern Norway participated in the colonization of Iceland and later Greenland, they found new stocks to hunt and eradicate or deplete in a serious way. This process preceded what we see later during the early Modern colonization of the entire North Atlantic by Basque, British, and Dutch powers. Today we can only speculate to what extent these agents utilized already depleted populations of walrus, remaining eastern grey whale populations, and last, but not least, the North Atlantic right whales. Large-scale whale-hunting too, it seems, has a deep prehistory. The effects from an intensified whale hunt starting already in the sixth century on the population of the North Atlantic right whales and bowhead whales are hard to discern and are probably small in comparison to later periods. However, the results of this prolonged time of over-exploitation are clearly visible when considering the present endangered status of the right whale population in the North Atlantic.

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Declarations

Conflict of interest The authors declare that they have no conflict of interest.

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