Research Square

Preprints are preliminary reports that have not undergone peer review.
They should not be considered conclusive, used to inform clinical practice,
or referenced by the media as validated information.

Southwards by Sea: Maritime Migration and the Making of Bronze Age Scandinavia

Johan Ling

johan.ling@archaeology.gu.se

Univeristy of Gothenburg

Guus Kroonen

Leiden University

Mikael Fauvelle

Lund University

Boel Bengtsson

Univeristy of Gothenburg

Malou Blank

Univeristy of Gothenburg

Martin Sikora

University of Copenhagen

Ashley Green

Univeristy of Gothenburg

Linn Nordvall

Univeristy of Gothenburg

Hugh McColl

University of Copenhagen

Research Article

Keywords:

Posted Date: November 24th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11714669/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Additional Declarations: No competing interests reported.

Southwards by Sea: Maritime Migration and the Making of Bronze Age Scandinavia

Johan Ling[1], Guus Kroonen[2,3], Mikael Fauvelle[4], Boel Bengtsson[1], Malou Blank[1], Martin Sikora[5,6], Ashely Green[1], Linn Nordvall[1], Hugh McColl[1,5,6]

Affiliations

[1] Department of Historical Studies, University of Gothenburg, Gothenburg, Sweden.

[2] Leiden University Centre for Linguistics, Leiden University, Leiden, The Netherlands.

[3] Department of Nordic Studies and Linguistics, University of Copenhagen, Copenhagen, Denmark.

[4] Department of Archaeology and Ancient History, Lund University, Lund, Sweden.

[5] The Lundbeck Foundation GeoGenetics Centre, Globe Institute, University of Copenhagen, Copenhagen, Denmark.

[6] Centre for Ancient Environmental Genomics, Globe Institute, University of Copenhagen, Copenhagen, Denmark.

Corresponding author: Johan Ling
Department of Historical Studies, University of Gothenburg, Sweden
johan.ling@archaeology.gu.se

.

Abstract

Established models of the transition from the Late Neolithic to the Nordic Bronze Age (c. 2000–1700 BC) have traditionally emphasised the northward spread of technological, economic, and social innovations into Scandinavia from continental Europe via Denmark. Recent archaeogenetic evidence, however, challenges this predominantly south-to-north perspective by identifying the emergence of Eastern Scandinavian ancestry in Sweden around 2000 BC and its subsequent expansion into the Danish Isles, Norway, and Jutland. This article reassesses established models for the formation of Bronze Age Scandinavia by integrating archaeogenetic evidence with settlement patterns, burial practices, material culture, metal circulation, maritime imagery, and ocean-voyage modelling. We examine three interrelated dimensions of population movement: mobility, connectivity, and directionality. Particular attention is given to two potential maritime migration corridors connecting western Sweden with Denmark: a direct crossing of the Kattegat towards Jutland and a coastal route through Halland, Scania, and the Öresund towards the Danish Isles. Voyage simulations demonstrate the feasibility of both routes under favourable conditions, while archaeological and genomic evidence provides a framework for evaluating their potential roles in sustained population movement. Drawing on the Maritime Mode of Production, we propose that demographic growth, agricultural surplus, exchange networks, and maritime organisation created mutually reinforcing conditions for repeated mobility and settlement. We argue that maritime demographic expansion provides a new explanatory framework for the emergence of Bronze Age Scandinavia, highlighting the active role of Sweden in demographic, economic, and social transformations traditionally understood primarily through Denmark.

Keywords: Late Neolithic; Nordic Bronze Age; archaeogenetics; maritime migration; ocean-voyage modelling; Maritime Mode of Production.

1. Introduction

The Late Neolithic II (LN II, c. 2000–1700 BC) was a critical period of transformation in southern Scandinavia that ultimately led to the formation of the Nordic Bronze Age (Vandkilde 1996, 2017). Traditionally, Denmark, and particularly Jutland and the Danish Isles, occupied a central position in accounts of this transformation. Changes in metallurgy, burial practices, domestic architecture, subsistence, and the widespread use of flint daggers are commonly understood through models in which continental European technological and social impulses reached Scandinavia via Denmark and subsequently spread northwards into the Scandinavian Peninsula (Montelius 1905; Sprockhoff 1936; Kristiansen 1998; Kristiansen & Larsson 2005; Müller & Vandkilde 2021).

A growing body of evidence, however, suggests the dynamics behind this critical transformation were more complex and multidirectional than has been traditionally understood. Gallery graves, changes in house construction, new sickle traditions and metal circulation are strongly indicative of interactions

between Sweden and Denmark, including influences from the Scandinavian Peninsula onto Jutland and the Danish Isles (Winther Johannsen et al. 2024). These developments coincided with population growth, agricultural intensification and expanding settlement during the later third and early second millennia BC (Kristiansen 2015; Artursson 2009; Winther Johannsen et al. 2024). Parts of eastern, southern and western Sweden may therefore have played a more significant role in the transformational processes leading to the Nordic Bronze Age than previously recognised.

To this, archaeogenetic research has recently added a new demographic dimension to this picture. Based on Identity-by-descent analysis, McColl et al. (2026) identify a previously unknown ancestry component, appearing in Sweden around the beginning of the second millennium BC and subsequently spreading into the Danish Isles, Norway and Jutland. Insight into the formation of the so-called 'Eastern Scandinavian' groups can be gleaned from a small increase in Hunter-Gatherer ancestry in these individuals, as well as a Y-haplogroup ('I1') not seen in earlier Corded Ware populations, which indicate an admixture event occurred in a region in which Hunter-Gatherer ancestry persisted in high proportions during the Late Neolithic. While the specific source of hunter-gatherer ancestry remains elusive, it is best modelled by populations east of the Baltic Sea, suggestive of population connections across the Baltic or its north-eastern coastline. These new genomic insights thus suggest a hitherto unknown demographic process involving large-scale population movements from Sweden into other parts of Southern Scandinavia.

The archaeological dimensions of this process, however, are currently still poorly understood. Genomic evidence can identify changes in ancestry and broad patterns of population movement, but does not in itself reveal how people moved through prehistoric landscapes and seascapes, what technologies enabled such movements, or which social and economic mechanisms sustained them. These questions are particularly important to southern Scandinavia of the Late Neolithic. Here, terrestrial regions are ostensibly divided by the Baltic Sea, Kattegat, Skagerrak and Öresund, but the genomic evidence suggests that they were in fact deeply connected. While primary genomic data is mainly land-biased, being collected from archaeological excavations, the seas should not by default be treated as geographical barriers separating archaeological regions, but rather as potential corridors through which people, animals, materials, and ideas could circulate.

More generally, we note that maritime dimension remains comparatively underdeveloped in archaeological discussions of prehistoric migration. Archaeogenetic studies now allow us to reconstruct population histories across large geographical areas, yet archaeological distributions are still frequently mapped primarily in terrestrial terms. As a result, the mechanisms that connected populations situated on interconnected littorals are rarely investigated in comparable detail. The latter perspective is central to the *Maritime Encounters* project, which seeks to approach seas and waterways as infrastructures for the movement of people, resources and technologies (Koch et al. 2025). In the present context, the question is therefore not simply whether demographic movement occurred between Sweden and Denmark, but rather *if such movement can be modelled archaeologically within a maritime landscape.*

In this study, we take the demographic pattern identified by McColl et al. (2026) as our starting point and evaluate to what extent its chronology and direction match independent archaeological evidence. To do this, we compare the chronological and geographical distribution of radiocarbon-dated individuals

with Eastern Scandinavian ancestry with the distribution of archaeological evidence from the same period. We draw on published data and models concerning burial practices and settlement patterns, as well as flint technology, metals and metalworking, and early maritime imagery. Together, these provide independent archaeological lines of evidence that can be examined in relation to the chronology and geography of the demographic changes inferred from ancient DNA. Specifically, we investigate to what extent these lines of evidence imply 1) connectivity, 2) mobility, and 3) directionality.

Next, we scrutinize the viability of two principal maritime corridors as possible vectors of population movement. Both depart from Västergötland in inland western Sweden, an area with a notable concentration of radiocarbon-dated individuals with Eastern Scandinavian ancestry, before diverging into two different maritime routes. The first connects western Sweden and Bohuslän with Jutland across the Kattegat; the second follows a route southward along the Swedish west coast towards Scania and across the Öresund into Sjælland and the Danish Isles. We investigate how these potential vectors relate to topography, river systems, radiocarbon-dated coastal settlements (Nordvall in press), maritime hubs and emerging boat technology, before testing their relative feasibility through ocean-voyage modelling (Bengtsson et al. 2025).

Finally, we consider the social mechanisms through which repeated maritime mobility could have developed into sustained demographic expansion. Rather than treating migration simply as population displacement, we explore how push and pull factors, demographic growth, access to raw materials and exchange routes, kinship and marriage networks, economic opportunities, and maritime organisation could have interacted to produce a cumulative process of population movement and settlement.

In this context, the Maritime Mode of Production (MMP, see section 8) provides a framework for understanding how such mobility could be organised and reproduced over generations (Ling et al. 2018). Central to the MMP is the investment of surplus generated by agro-pastoral production into boats, crews, provisioning and maritime knowledge, creating the organisational capacity for repeated and increasingly long-distance mobility. This is particularly relevant to LN II, a period characterised by demographic growth, agricultural expansion and increasing connectivity across long-distance maritime vectors. Using the framework of the MMP, we show how maritime investment could have transformed demographic and economic growth into expanding networks of mobility, exchange and settlement.

By contrasting archaeological, genomic, geographical and social perspectives, we seek to test a model in which the spread of Eastern Scandinavian ancestry occurred within a broader process of maritime demographic expansion. While various datasets have previously been discussed in relation to demographic expansion, exchange, mobility and interaction, we underline that we do not treat any of these archaeological features as direct proxies for the movement of genetic ancestry groups. Rather we evaluate these to explore whether or not they support a model in which seas, coasts and waterways served as infrastructure for population mobility and in which maritime organisation provides the social mechanisms through which such movement could be sustained during the transition from the Late Neolithic to the Nordic Bronze Age. Within a MMP framework, what push and pull factors may have triggered and sustained population movement from Sweden towards Denmark during LN II? Can the Maritime Mode of Production help us understand the social, economic and organisational mechanisms

by which repeated maritime mobility could develop into sustained demographic expansion in the low-density societies of Bronze Age southern Scandinavia?

2. Eastern Scandinavian ancestry: demographic mobility and linguistic implications

The demographic process considered here was first discerned in the archaeogenomic evidence presented by Allentoft et al. (2024), who documented a genetic structure present within Scandinavia by 4000 BP and suggested a population movement into Denmark shortly after the spread of the I1 Y-haplogroup. Of particular significance was the identification of early occurrences of I1 among individuals from Falköping in Västergötland dating to around 4000 BP. This finding does not establish Västergötland as the geographical origin of Eastern Scandinavian ancestry, but places an important early genomic signal within one of the major Late Neolithic settlement and burial regions of inland western Sweden.

This finding was substantially refined in McColl et al. (2026). Their extended genomic dataset reaffirmed that this 'Eastern Scandinavian' ancestry is distinct from contemporary Western and Southern Scandinavian ancestries prominent in Norway and Jutland. Due to limitations of the genomic dataset, McColl et al. were unable to establish the precise geographical source region of Eastern Scandinavian ancestry. However, Early Eastern Scandinavian ancestry combines Corded Ware-related ancestry with a Hunter-Gatherer component more closely related to earlier Baltic Hunter-Gatherer groups than Scandinavian Hunter-Gatherers, possibly associated with I1 Y-haplogroups. McColl et al. thus suggest that a previously unknown Late Neolithic population movement into Scandinavia occurred, possibly from across the Baltic or along its north-eastern coastline, that was distinct from the migrations contemporary with the first emergence of the Battle Axe culture.

The authors further speculate that archaeological and isotopic evidence provides an independent context for connections across this broader Baltic zone. Late Neolithic mobility documented in south-western Sweden suggests connections with more northern and eastern regions (Blank 2021; Blank et al. 2021). Similarities in pottery styles of the so-called "Third Type" potentially link Sweden with the Kiukainen cultural sphere (4500–3800 BP) of south-western Finland and Åland (Larsson 2009; Brorsson et al. 2021; see also Fig.1), and Kiukainen influences have been recognised by some scholars at coastal Swedish sites such as Hedningahällan, Norvik, Nynäsgård and Stora Förvar (Holm 2003, 95–100; Forskning & Framsteg 2025). However, these sites are primarily associated with the Middle Neolithic Pitted Ware Culture, and the pottery similarities suggest that networks of interaction across the Baltic were already established towards the end of the Middle Neolithic (Larsson 2009, 367). Such earlier connections provide an important archaeological context for, but do not directly demonstrate, the later population movements considered by McColl et al. (2026).

The authors additionally note that the identification of Eastern Scandinavian ancestry has a potential bearing on the formation of the Northern European linguistic landscape, of which Germanic languages historically form a prominent component. The Iron Age linguistic ancestor of the Germanic languages, Proto-Germanic, is generally located in northern Germany and southern Scandinavia (Schwantes 1950;

Birkhan 1970; Polomé 1985; Schmidt 1991; Nielsen 2000; Ringe 2017), based on prehistoric lexical borrowing involving Finnic and Celtic (Kallio 2012; Koch 2020; Van Sluis, Jørgensen & Jørgensen 2023). While its earlier geographical history is uncertain, traditional models associate the introduction of the Pre-Iron Age precursor of Proto-Germanic, sometimes called Palaeo-Germanic, with third-millennium BC Corded Ware-related populations, i.e. with the appearance of either the Single Grave Culture in Denmark or the Battle Axe Culture in Sweden (Childe 1926; Glob 1945; Forssander 1933; Hinsch 1956; Kristiansen 1989; Price 2015; Iversen & Kroonen 2017). These interpretations form part of the broader discussion of the Indo-European dispersal, now widely attributed to the population expansions from the EBA western Eurasian steppe (Haak et al. 2015; Allentoft et al. 2015; Lazaridis et al. 2025). The identification of Eastern Scandinavian ancestry, however, opens up a third hypothetical scenario, in which the emergence and diffusion of Paleo-Germanic is associated with its appearance in Sweden around 4000 BP (2050 BC) and subsequent distribution across Scandinavia by around 3500 BP (1550 BC). This recalls older archaeological studies concerned with the question of the formation of Germanic, which have indeed pointed to archaeological continuity from the dagger period as an argument for assuming linguistic continuity into the historical period (Müller 1913: 169; Karsten 1928: 55–57; Güntert 1934).

For the purposes of this study, the demographic development of the Late Neolithic and Bronze Age can be structured into three broad phases. **Phase 1, c. 2200–2000 BC**, represents the formation or arrival of Eastern Scandinavian ancestry through population connections across the Baltic or its northeastern coastline (Fig. 2a-b, Table 1). **Phase 2, from around 2000 BC**, represents its establishment within Sweden. Västergötland and Falköping are of particular importance here in view of the initial appearance of I1 in the exceptionally dense Late Neolithic archaeological record of the region (although this does not necessarily imply that Falköping and its surroundings were the geographical origin of this haplogroup). **Phase 3, from 2000 BC and onwards,** represents its subsequent expansion from Västergötland/Falköping, Sweden into other parts of Scandinavia during the Late Neolithic and Bronze Age (Fig. 2a-b, Table 1). McColl et al. show that its demographic impact was strongest on the Danish Isles, followed by Norway and Jutland, and that Eastern Scandinavian ancestry was widespread across Scandinavia by the Bronze Age. The geographical implications of Phase 3 are central to our study. Movement from inland western Sweden towards Denmark would have required combinations of terrestrial routes, rivers, lakes and coastal corridors before either crossing the Kattegat or continuing southwards towards Scania and the Öresund. We therefore approach this phase as a process of maritime and riverine demographic dispersa**l,** broadly corresponding to LN II, c. 2000–1700 BC Fig 2a-b).

3. Archaeological evidence for mobility, directionality and connectivity

The expansion of Eastern Scandinavian ancestry identified genomically provides direct evidence for substantial population movements.. We may therefore ask whether this process can be identified independently in the archaeological record. The period around 2000 BC witnessed demographic growth, agricultural intensification, changes in settlement and house construction, new burial practices, developments in flint technology and increasing metal circulation (Vandkilde 1996; Apel 2001; Kristiansen & Larsson 2005; Kristiansen 2006; Artursson 2009; Iversen 2015; Simonsen 2017; Tornberg

2018; Blank et al. 2021; Blank in press; Winther Johannsen et al. 2024, see also Fig 3). Our analytical principle is one of combining rather than one-to-one identification: the null hypothesis remains that no grave, house type, artefact or rock-art motif must be equated directly with Eastern Scandinavian ancestry. Instead, we interrogate whether independent archaeological changes display compatible chronology and distribution. In addition, we evaluate them for *connectivity* and *directionality*.

3.1 Demographic growth and settlement expansion: conditions for mobility

Drawing on radiocarbon dates, pollen records, archaeological distributions, palaeoenvironmental evidence, a supra-regional population increase is identified culminating around 2100 BC and a pronounced population boom in western southern Sweden between c. 2250 and 2000 BC (Blank et al. 2020; Blank 2021; Winther Johannsen et al. 2023; 2024), which may have contributed to migration towards the west (Fig. 4). Intriguingly, this population growth further coincides with a decrease in southern Finland c. 2200–2000 BC (Tallavaara, Pesonen & Oinonen 2010). Winther Johannsen et al. (2023; 2024) further identify regional differences, including population growth in northern and eastern Denmark and depopulation in western Jutland around the transition to the Late Neolithic.

These demographic developments coincided with agricultural intensification and increasingly substantial settlements. Cereal cultivation gained importance, cultivation exploited a wider range of crops, and bifacial crescent-shaped flint sickles became widespread across southern Scandinavia. At the same time, the reappearance of substantial two-aisled houses, introduced at the beginning of the Neolithic yet sparse during most of the 3rd millennium BC (cf. Nielsen 2019), larger settlements and crop-storage facilities indicate increased sedentism and investment in agricultural production (Björhem & Säfvestad 1989; Sarauw 2006; Brink 2013; Simonsen 2017; Winther Johannsen et al. 2024).

These developments provide an important demographic context for population movement. Winther Johannsen et al. (2024) explicitly link increased agricultural productivity with population growth and identify population increase as a potential driver of migration (Fig. 4). The population boom in southern Sweden may therefore have created conditions favouring outward expansion, although population growth need not have caused migration directly. Importantly, archaeological evidence also suggests geographical directionality. Winther Johannsen et al. (2024) identifies new sickle types, Fosie-type houses and gallery graves appearing in eastern Denmark as traditions originating on the Swedish Peninsula and discuss these alongside possible migration from southern Sweden to Denmark from around 2000 BC. Although none of these features individually demonstrates migration, their convergence with demographic growth and increased mobility provides an archaeological pattern compatible with increased population movement from southern Sweden towards eastern Denmark (Winther Johannsen et al. 2024).

3.2 Directionality and mobility: Gallery graves, isotopes and material traditions

Gallery graves provide particularly important evidence. Representing a renewed phase of megalithic burial during the Late Neolithic, they extend across a much wider geographical area than earlier passage graves (Blank et al. 2020, 2021). The scale of the phenomenon is striking: at least 2,000 gallery graves are known from Sweden, compared with approximately 120 from Denmark, with particularly high

densities in Västergötland and Småland (Blank et al. 2020). Falbygden is of particular interest, with approximately 125 known gallery graves and intensive use during LN II (Sjögren 2003; Weiler 1994; Blank et al. 2020, 2021). Blank et al. (2020) suggest that this intensive use may reflect the importance of Falbygden as a densely populated region during the Neolithic.

Isotopic analyses provide independent evidence for mobility into and away from Falbygden during the Neolithic. Some individuals have isotopic values compatible with origins outside the region, although the two individuals potentially linked to Scania or Denmark date to the Middle Neolithic B, c. 2500 BC (Blank et al. 2021). Particularly significant in relation to the maritime vectors proposed here is the wider geographical distribution of gallery graves in western Sweden. Port-hole gallery graves occur in a distinct belt extending from northern Halland and Bohuslän across Dalsland and Västergötland towards Östergötland and Närke, with their principal concentration in Västergötland. Multi-roomed gallery graves and graves with portal stones show a broadly comparable distribution (Blank et al. 2020). Connections between Västergötland and both the western and eastern coastal regions are also reflected in the distribution of slate and amber pendants (Blank 2021; Blank in press) and flint daggers (Apel 2001). Together with the distribution of port-hole gallery graves, these material-cultural patterns indicate an established west–east-oriented network during the Late Neolithic (Blank 2021; Blank in press).

This distribution broadly corresponds to the geographical corridor connecting the Falbygden area with Lake Vänern and, through the Göta älv system, the Kattegat coast (Fig. 5). The potential significance of this corridor has a long history in archaeological research: Montelius (1905) proposed that the port-hole gallery-grave tradition reached the Swedish west coast and subsequently spread through the Göta älv estuary and inland along waterways into Västergötland (Blank et al. 2020). Although the proposed external origins of these grave forms remain debated, their distribution points to connections along a corridor linking the interior of western Sweden with the coast.

At the same time, these connections should not be understood as straightforward cultural diffusion. Gallery graves display pronounced regional variation. Danish, Scanian and eastern Swedish examples are generally smaller, whereas larger and more complex forms are characteristic of southwestern Sweden, particularly central Västergötland (Blank et al. 2020). The evidence therefore suggests interaction across southern Scandinavia combined with the maintenance and transformation of distinctive regional burial traditions. In the context of the present study, gallery graves are consequently important not as direct markers of migration, but as evidence for networks of interaction and mobility linking inland western Sweden, the west coast and neighbouring regions during the period in which the demographic changes discussed here were taking place.

These patterns of mobility and interaction formed part of wider networks through which people, technologies and materials circulated. Flint daggers and sickles, changing house traditions and increasingly extensive exchange networks connected communities across southern Scandinavia, while the circulation of metals increasingly linked them to wider European networks. These patterns become particularly significant in Scania and the Öresund region, where settlements, burial traditions and metalworking indicate an important zone of communication between Sweden and the Danish Isles.

3.3 Connectivity: metals, flint daggers and exchange networks

Another dimension to the interaction between Sweden and Denmark is added by metal circulation. The Pile hoard in Scania, dated around 2000 BC, provides important evidence for the emergence of local bronze production within wider European exchange networks (Vandkilde 2017, 2022). The assemblage contains locally produced flanged axes drawing on British and Central European traditions, while lead isotope analyses indicate copper from both Welsh and Central European sources (Vandkilde 2022). The hoard notably also contains Scandinavia's oldest silver find (Vandkilde 2017). This demonstrates that southern Sweden was already integrated into long-distance networks through which metals, technological knowledge and probably people circulated (Ling et al. 2019; 2023). These networks are likely to have involved Denmark, which occupied a central geographical position between southern Sweden, Jutland, the North Sea and continental Europe.

The Pile hoard therefore provides crucial context for the intensified Sweden–Denmark interaction suggested by other archaeological evidence across the Late Neolithic–Early Bronze Age transition. These developments did not emerge in isolation. They intersected with established networks for the production and circulation of flint daggers across southern Scandinavia. Long-distance exchange networks across the Baltic Sea Region were already established during the Middle Neolithic, as demonstrated by the circulation of materials and objects associated with the Pitted Ware Culture, including slate objects and ceramic figurines (Iversen 2010; Fauvelle et al. 2025b; Lucenius et al. 2026). These interactions continued during the Late Neolithic. In this context, it is particularly interesting that a dagger made of southern Scandinavian flint, together with flint flakes, has been identified at the Kiukainen site of Myrsbacka on Åland (Strömberg & Anderberg 2010, 27). Apel's studies identify major centres of specialised dagger production in northern Jutland and in the eastern Danish islands–southern Swedish region, from which finished daggers circulated over considerable distances (Apel 2001, 2008, 2015), also reaching the eastern Baltic coast. The geographical distribution of these daggers demonstrates the extensive reach of these networks, connecting major production areas in southern Scandinavia with communities across the Scandinavian Peninsula, the Baltic region and parts of continental Europe (Fig. 6). Particularly significant is the distribution extending along the western Scandinavian coast and into inland western Sweden, indicating that these regions were already integrated into wider networks of exchange and interaction**.**

Their manufacture required highly specialised technological knowledge acquired through extensive practice, suggesting that these networks involved not only the exchange of objects but also the transmission of technological knowledge and skills (Apel 2008).

Evidence from Tuve 46 on Hisingen is relevant in this context. Apel (2015) interprets the assemblage as evidence that specialised flint knappers from flint-rich areas of southern Scandinavia, probably including Jutland, reached the Swedish west coast during LN I. Further evidence for connections between Jutland and western Sweden during LN I comes from the distribution of Bell Beaker-related artefacts, particularly arrowheads and Type I flint daggers, found in Jutland, Norway and western Sweden (Apel 2015; Blank in press). This predates the Sillvik individual from nearby Hisingen, who carried Eastern Scandinavian ancestry and has a reported radiocarbon age of 3895 BP (uncalibrated). Rather than representing the same demographic movement, the Tuve evidence suggests that the Hisingen–Göta älv

area was already integrated into cross-Kattegat networks before LN II. These established connections may subsequently have provided routes through which population movement from Sweden towards Denmark could develop.

This chronological sequence is particularly relevant because Hisingen lies at the mouth of the Göta älv, the principal waterway connecting the Kattegat coast with Lake Vänern and inland western Sweden. The earlier Tuve evidence and the later Sillvik individual therefore suggest that the Hisingen–Göta älv corridor participated in wider networks over an extended period. By LN II, this corridor may also have facilitated population movements between inland western Sweden, the Kattegat coast and Denmark. The transition towards increased metal use should not be understood as the creation of an entirely new system of long-distance interaction. Rather, metal circulation expanded and transformed existing networks through which flint, amber, technological knowledge and people were already moving. Vandkilde (2022) emphasises that from around 2000 BC these networks increasingly involved both intra-Scandinavian maritime traffic and longer-distance expeditions. For the present argument, this continuity is important: the maritime networks of LN II developed within an already connected social and technological landscape capable of supporting the movement of objects, knowledge and people.

3.4 Maritime connectivity: boats, rock art and seafaring traditions

Evidence for the maritime technology that sustained these networks is less direct but equally important. Early boat depictions of the Krabbestig/Nag tradition can be found along the western Scandinavian coast from Vestlandet in the north to Bohuslän in the south, separated by over 700 km of coastline and with shoreline chronology supporting a Late Neolithic date (Ling 2008, 2014; Melheim & Ling 2017). Several of the Bohuslän examples of this boat type display morphological features suggesting a boatbuilding tradition comparable to that of the c. 350 BC Hjortspring boat, a sewn plank-boat found in southeastern Jutland. Importantly, specific construction-related details depicted in Scandinavian rock art suggest that boats sharing key technological characteristics with the Hjortspring tradition may already have existed during the Late Neolithic, indicating a much longer history of this boatbuilding tradition than the surviving archaeological evidence alone would suggest (Kaul 1998; Crumlin-Pedersen 2003; Østmo 2005; Ling 2008; Fauvelle et al. 2025a; Bengtsson 2025). Simulations of past seafaring in the region, investigating the feasibility of direct open water crossings based on a close affinity in the archaeological material between e.g. western Norway and Jutland from around 2300 to 1500 BC, support the existence of large vessels seaworthy enough to ensure regular communication in the region at this time (Bengtsson et al. 2025).

The technological skills necessary for building such craft is evident from the repair of logboats dating from the late 6th or early 5th millennium BC. One example is the Askø boat from the Zealand region in Denmark, which had a series of holes drilled through the wood surrounding a crack in its side, through which thin cord was used to attach a patch subsequently caulked with pitch, but several pieces of t-shaped resin, interpreted as used for caulking between two pieces of wood – potentially a logboat or perhaps even an extended logboat, have been found at Huseby Klev in Bohuslän, a coastal settlement dated to the early 8th millennium BC (Nordqvist 2005; Ravn 2022). Both examples suggest the technology behind sewn plank-boats might go far back in time in the region (Bengtsson 2025; Fauvelle et al. 2024). Other boat-building traditions, including skin-boats and bark-boats, may also have

Mesolithic or Early Neolithic roots in Scandinavia, but evidence for such craft is fragmentary (Fauvelle et al. 2024; von Arbin and Lindberg 2017).

The possibility of increasingly complex watercraft should also be considered within the wider north-western European context. The earliest archaeological evidence of sewn plank-boats comes from the British Isles and is contemporary with emergent maritime links between this region and Scandinavia from around 2100 BC (Vandkilde 2017; Nørgaard et al. 2021). One of the best preserved of the British boats is Ferriby 1, a nearly 16 m long and 2.5 m wide boat dated to c. 1880–1680 cal. BC, which clearly demonstrates the existence at this time of sophisticated boats capable of carrying substantial cargo (Wright 2015; Bengtsson 2025). The combination of early Scandinavian imagery of potential plank-boats, contemporary British plank-boats and the later exceptionally sophisticated local boatbuilding tradition exemplified through the Hjortspring boat therefore suggests a long development of sewn plank-boats, even though the intermediate archaeological record remains incomplete.

The geographical distribution of maritime rock art is equally significant. The Krabbestig/Nag boat types, concentrated along the western Scandinavian seaboard, appear to give way around 1700 BC to a new type of boat, commonly referred to as the Rørby type, named after the incised boat depicted on a sword dated to c. 1700–1600 BC (Kaul 1998; Ling 2014). Significantly, this new boat type is not confined to western Scandinavia but also occurs in coastal regions along the eastern seaboard, including Uppland. The Rørby type thus appears to represent a more broadly shared, pan-southern Scandinavian maritime tradition.

Examples of this new boat type can be found in abundance in the region of Kville in Bohuslän (Fig. 7). Two nearly identical such early boat depictions also appear on a small stone deposited in a grave at Truehøjgård in Himmerland, northern Jutland (Kaul 1998). The similarities between these boats (Fig. 7) provide a striking iconographic connection across the Kattegat and add to the evidence for sustained maritime interaction between western Sweden and Jutland, which, in light of the availability of bedrock to carve upon in Bohuslän with none in Jutland, might even indicate interaction coming from the direction of Bohuslän rather than the other way around (Kristiansen 2002).

4. Maritime infrastructure and two potential vectors of population movement

The archaeological and genomic evidence discussed above points towards population movement from Sweden into Denmark during the Late Neolithic, but it does not in itself identify the routes through which this movement occurred. To address this problem, we model the riverine and maritime infrastructure connecting inland western Sweden with the Danish regions in which Eastern Scandinavian ancestry subsequently appears, and propose two potential vectors of population movement (Figs. 2b and 8)

This infrastructure should not be understood in terms of formal harbours or permanent maritime installations. It consisted instead of boats, navigational knowledge, river and lake systems, sheltered landing places, coastal settlements and established corridors of communication. Its importance lay in the way these elements were connected. Inland and maritime mobility were therefore not separate

systems but successive components of the same transport landscape. This is particularly important for Västergötland and Falbygden. Although situated inland, these regions were connected through waterways and terrestrial corridors to the river Göta älv and from there to the Kattegat coast (Figs. 8-9).

On the basis of the combined genomic, archaeological and geographical evidence, we propose two potential maritime vectors for population movement from western Sweden towards Denmark during LN II. Both share an initial corridor from Västergötland and Falbygden, principally through the Göta älv river system, towards the Onsala Peninsula at the southern end of the west-coast archipelago. From there they diverge (Figs. 8-9). Vector I crosses the Kattegat towards Jutland, whereas Vector II continues southwards along the more exposed Halland coast towards Scania and through the Öresund to Sjælland and the Danish Isles. These should not be understood as fixed migration routes, but as potential corridors whose plausibility can be evaluated through the convergence of geographical, archaeological and genomic evidence.

In the following sections, we first reconstruct the shared western corridor and then examine each vector in relation to the archaeological and genomic evidence associated with it, including topography, river systems, settlement patterns, material connections and evidence for maritime communication. Their practical feasibility is subsequently evaluated through ocean-voyage modelling in Section 5.

4.1 Initial Corridor: Falbygden–Onsala

The importance of the river Göta älv as a communication corridor between Falbygden and the coast becomes apparent when considering the topography of western Sweden (Fig 9). Falköping is situated within Falbygden, a sedimentary landscape characterised by table mountains and three limestone plateaus forming an approximately 50 × 30 km triangular area between Lakes Vänern and Vättern (Fig. 9). Depressions between the plateaus contain wetlands. Together with forests, lakes rich in migratory birds and fertile soils, this landscape would have provided a diverse resource base. The relatively accessible terrain and connecting valleys may also have facilitated the movement of people and heavy goods towards Lake Vänern and the Göta älv system.

Göta älv offered several advantages compared with neighbouring river systems. The present elevation difference between Lake Vänern and the sea is only 44 m and would, due to post-glacial uplift, have been considerably lower during c. 2000–1700 BC. Only two of the three historical portages along the river would therefore have had to be bypassed: one at Vargön, with an elevation drop of approximately 3 m, and another at the Trollhättan rapids, with a drop of approximately 32 m (Fig. 9). In addition, the present flow rate averages around two knots and, although probably somewhat lower during the period considered here, would have facilitated downstream movement towards the coast.

Alternative routes connecting Falbygden with the coast may have combined terrestrial and riverine transport before joining Göta älv further downstream (Fig. 9:a). A series of hoards and single metal depositions dated to LN II may support a route following the smaller rivers Nosse and Säve through a series of lakes towards Göta älv and the sea (Vandkilde 2017). Further support for the importance of riverine communication networks comes from concentrations of flint daggers in Falbygden and areas to its west and southwest, which Weiler (1994: 79) noted occur near the headwaters of several rivers,

suggesting that river valleys served as important corridors for interaction. Another possible corridor is suggested by the distribution of gallery graves, stone cairns and rock-art boat imagery around Skepplanda further downstream along Göta älv. Although the boat imagery is somewhat later in date (Fig. 9a), its location may reflect the longer-term importance of this area for access to the river and for building, landing and launching boats used for onward transportation towards more open waters.

The potential duration of this journey further illustrates the accessibility of the corridor. From the outlet of Lake Vänern, followed by movement southwards along the Göta älv River to Sillvik and Hönö in the Gothenburg archipelago, may have taken approximately two days, including passage around the two portages (Fig. 9). Boats could have been dragged past the rapids overland on wooden rollers, potentially lubricated with the locally prevalent bluish-grey clay, while the downstream river journey itself, taking advantage of the natural flow, is estimated at c. 12 hours. From the island of Hönö, simulations indicate that paddled sea journeys through the sheltered archipelago to the Onsala Peninsula could have been completed in approximately 8–9 hours on average during the summer months (Bengtsson et al. 2025). Taken together, the topography, archaeological evidence and estimated travel times identify the Falbygden–Göta älv–Onsala corridor as a plausible connection between inland western Sweden and the maritime routes of the Kattegat.

4.2 Vector I: Onsala–Læsø–Jutland

The first potential vector represents a more direct maritime connection between western Sweden and Jutland. From the Onsala Peninsula, movement could proceed westwards across the Kattegat, potentially using Læsø or whichever sandbar system at that time lay above the waterline, as an intermediate stopping point before reaching northern Jutland (Bengtsson et al. 2025). This route affords seafarers with relatively shallow and sheltered waters and directly links up with the trans-Jutland Limfjord and any connected river systems (such as e.g. Voers or Rye rivers) as opposed to the more exposed route rounding the 'tip' of Jutland as proposed by e.g. Vandkilde (2017) (Fig.8,9).

The genomic evidence provides a reason to retain this western vector. Among the radiocarbon-dated individuals carrying Eastern Scandinavian ancestry in the dataset considered here, one individual (genome ID) occurs in Jutland, on the western side of the Kattegat. The proportion of Eastern Scandinavian ancestry in this individual is somewhat lower than in the mapped individuals from the Danish Isles, which could reflect admixture with local populations in preceding generations. However, a single individual cannot establish a regional demographic pattern, nor does its presence demonstrate that movement followed the specific route proposed here. It nevertheless establishes the presence of Eastern Scandinavian ancestry in Jutland at a location geographically compatible with movement across the Kattegat to the Limfjord and interconnected river systems**.** The current evidence is therefore sufficient to retain the western vector as a hypothesis to be tested, but not to assess the scale or relative importance of demographic movement into Jutland. In relation to Vector I, the genomic evidence for Eastern Scandinavian ancestry in northern Jutland is supported by several independent categories of archaeological evidence for sustained interaction across the Kattegat during the Late Neolithic. Gallery graves, flint daggers and metal circulation all connect western Sweden with Denmark, while Late Neolithic boat depictions of the Krabbestig/Nag tradition along the western Scandinavian

coast provide further evidence for the importance of maritime communication (Ling 2008, 2014; Melheim & Ling 2017). Flint daggers and metal objects also document repeated circulation across the Kattegat and participation in wider maritime exchange networks (Apel 2001). None of these archaeological categories constitutes a direct proxy for migration, but together they demonstrate an established social and maritime infrastructure through which population movement could have occurred. The genomic evidence from Jutland therefore gains significance when viewed within this broader archaeological context, supporting Vector I as a plausible corridor for movement across the Kattegat.

4.3 Vector II: Onsala–Halland–Scania–Öresund–Sjælland

The second vector continues southwards from Onsala along the Halland coast towards Scania and the Öresund, before crossing to Sjælland and the Danish Isles (Fig. 9). Along the relatively open Halland coast, which generally lacks protective islands, river mouths would have provided natural nodes, offering sheltered landing places, freshwater and access to inland waterways. Their significance is reinforced by the distribution of documented LN II settlements, including two-aisled houses and sunken-floor huts, within the coastal zone and along navigable rivers such as Nissan, Ätran, Viskan and Lagan (Fig. 11).

The radiocarbon-dated sunken-floor huts (Fig. 10) indicate a main phase of occupation between 1888 and 1520 BC, although this building type appears in Halland before the Late Neolithic and continues into Bronze Age Period I. They are particularly concentrated around the Ätran and Nissan river systems (numbered 5 and 6 in Fig. 10). The main phase of the two-aisled houses shown in Figure 10 falls between 1950 and 1600 BC, although the northernmost example, Värö 336, provides the latest radiocarbon date for a two-aisled building in the region (1508–1416 cal BC, 2σ; 3192±30 BP). Two-aisled houses occur both within the coastal zone and at inland locations connected to the major waterways. These building traditions correspond broadly with wider South Scandinavian architectural developments, including Fosie-type houses (Björhem & Säfvestad 1989). From around 1600 BC, three-aisled buildings begin to appear in the region (Nordvall in press).

Together, these settlements demonstrate that Vector II passed through an inhabited Late Neolithic coastal landscape. Their association with river mouths and navigable waterways provides an archaeological basis for identifying potential landing places and nodes along the proposed route, rather than selecting arbitrary geographical stopping points. The corridor could therefore have permitted movement in stages between occupied coastal and riverine locations, providing opportunities for landfall, provisioning and interaction with local communities. This is particularly relevant when considering demographic movement rather than specialised long-distance voyaging.

The significance of this corridor can also be considered in relation to the genomic evidence. Radiocarbon-dated individuals carrying Eastern Scandinavian ancestry are more numerous in southern and eastern Denmark and on the Danish Isles than in Jutland. This corresponds with the broader demographic pattern identified by McColl et al. (2026), in which Eastern Scandinavian ancestry appears first in Sweden and subsequently expands into the Danish Isles and Jutland. The distribution is therefore

geographically compatible with movement southwards along the Swedish west coast and through the Öresund.

The genomic evidence does not, by itself, demonstrate movement along this particular corridor. Rather, the argument rests on the convergence of independent datasets: the riverine and coastal geography provides a plausible route from western Sweden; the Halland settlements provide contemporary potential stopping and landing places; archaeological evidence from Scania and the Öresund indicates interaction between Sweden and Denmark; and the corridor leads towards areas where Eastern Scandinavian ancestry is documented outside Sweden.

The two vectors therefore represent alternative possibilities within the same broader model of westward and southward movement, and thus offer falsifiable hypotheses. Vector I provides a more direct Kattegat connection towards Jutland, whereas Vector II provides a more continuous coastal corridor through Halland and Scania towards the Öresund and the Danish Isles. Their relative maritime feasibility is tested in Section 5.

5. Testing the two vectors: ocean-voyage modelling

The archaeological and genomic evidence identifies two plausible geographical corridors, but it cannot establish whether they were equally practicable for repeated maritime movement. To investigate this question, we employ an ocean-voyaging tool developed within the Maritime Encounters project to evaluate the feasibility, seasonality and duration of prehistoric open-water and coastal routes (Bengtsson et al. 2025). The tool combines agent-based modelling with high-resolution boat-performance data and simulates daily departures towards specified destinations using 28 years of environmental data on wind speed and direction, currents and waves. Available daylight is used to define the period during which seafaring is considered safe. Vessel performance is calculated from polar diagrams incorporating the number of paddlers, paddling cadence and total displacement, including cargo.

The purpose of the simulations is not to reconstruct particular prehistoric journeys or to suggest that specific individuals followed precisely modelled routes. Rather, they provide an independent means of evaluating the feasibility of the two proposed vectors under realistic environmental conditions. In the present analysis, this is primarily tested using the performance characteristics of a plank built Hjortspriing type boat, but Vector I has also been tested using performance characteristics of a digital reconstruction of the Varpelev boat, a large Bronze Age logboat (Bengtsson et al. 2025, Bengtsson et al. in press). Due to their dates, neither of these boats should be treated as a direct model for vessels used around 2000 BC. Its relevance is methodological: the full-scale reconstruction provides experimentally verified performance data for a prehistoric paddled vessel. By relating simulated voyage duration to environmental conditions, including wind, currents and encountered wave heights, the model provides insight into the conditions that prehistoric paddled vessels would have needed to negotiate during repeated maritime travel.

This approach is important because geographical distance alone provides a poor measure of maritime accessibility. A relatively short open-water crossing may involve substantial exposure to winds, waves and currents, whereas a longer coastal route may provide repeated opportunities for shelter and landfall. The two vectors therefore represent not simply different routes, but different maritime strategies.

5.1 Testing Vector I: the Kattegat crossing

Vector I represents an open-water strategy (Fig 11.). During favourable summer conditions, the presence of land beyond the horizon may have been indicated by cloud formations over land, while the relatively shallow waters surrounding present-day Læsø, approximately 45 km from Onsala and only 20–25 km from the Jutland coast, were likely known to prehistoric seafarers. Pitted Ware artefacts have been recovered from the oldest part of the present island, which has been repeatedly reshaped by migrating sand spits since around 2900 BC (Becker 1951; Hansen et al. 2016; Bengtsson et al. 2025; Bengtsson et al. in). The area around Læsø may therefore have provided both a navigational reference point and relatively sheltered waters, as well as a potential stopover during crossings of the Kattegat.

Simulations using both Hjortspring- and Varpelev-type vessels indicate that the approximately 45 km passage between Onsala and Læsø constituted the more demanding part of this route. The Varpelev boat is a 13.5 × 0.84 × 0.5 m logboat from Sjælland dated to c. 1000 BC. A Hjortspring-type vessel could complete the crossing in approximately 11 hours, and in as little as seven hours in the opposite direction. A Varpelev-type vessel would require approximately 17 hours for the first 45 km westwards and around 11 hours eastwards, making a stopover around Læsø necessary unless travelling through the night (Bengtsson et al. in press).

During the summer months, suitable conditions occur on approximately 50% of days westwards and 75% eastwards for a Hjortspring-type vessel, compared with approximately 40% and 47%, respectively, for a Varpelev-type vessel (Bengtsson et al. in press). Vessel characteristics therefore had substantial consequences for both journey time and carrying capacity. The higher freeboard, larger crew and greater cargo capacity of the Hjortspring-type vessel provided greater resilience, whereas even a relatively large logboat such as Varpelev would have been limited to a crew of approximately five and around 170 kg of additional cargo under open-water conditions, while remaining particularly vulnerable to changes in weather.

These results indicate that direct Kattegat crossings were regularly feasible during summer, but strongly dependent upon vessel performance and environmental conditions. For a Hjortspring-type vessel, suitable conditions occurred on average every two to three days, with winds averaging around 5.5–6 m/s along the route. The relevant question is therefore not simply whether the Kattegat could be crossed, but under what conditions such crossings could be undertaken repeatedly and with sufficient reliability to facilitate demographic movement.

This distinction is important because population movement may have involved possessions, provisions and individuals of different ages, creating logistical requirements different from those of specialised

crews engaged primarily in exchange, raiding or other maritime activities. Vector I offered a relatively rapid connection between western Sweden and Jutland, but also involved greater exposure to changing maritime conditions and fewer opportunities for intermediate landfall. Læsø may therefore have been particularly important as an intermediate stopping point, reducing the risks and logistical constraints associated with the open-water crossing. The modelling thus evaluates the practical conditions under which repeated movement across the Kattegat could have occurred, rather than reducing the question to whether such crossings were simply possible or impossible.

5.2 Testing Vector II: the Halland coastal corridor

Vector II represents a contrasting coastal strategy. From the Onsala Peninsula, movement proceeds southwards along the Halland coast through a succession of potential landing places before reaching Scania and the Öresund. As discussed in Section 4.3, this route combines the maritime advantages offered by river mouths—including shelter, freshwater and access to inland waterways—with documented LN II settlements along the proposed corridor. The model for vector II uses the same experimental and environmental parameters discussed above for the Hjortspring boat. **Vector II** follows the Halland coast southwards, passing proposed maritime stopping points (1–8) before crossing the Öresund towards the Danish Isles (Fig 11). The model indicates approximately 27 hours of sailing from Onsala to Öresund, corresponding to around six days with overnight stops. Simulations using the ocean-voyaging tool for the period May–September indicate that the journey from the Onsala Peninsula to the Öresund would require approximately six days on the water. Individual stages between the major river mouths along the Halland coast could generally be completed within a day, while suitable conditions for such journeys occurred on average approximately every second day during the summer months, depending upon vessel performance (Fig 11.).

Vector II therefore represents a longer but more continuous coastal strategy, in which movement could proceed through a succession of relatively short maritime stages with repeated opportunities for landfall.

6. From mobility to migration: a model of maritime demographic expansion

The maritime vectors outlined above model routes through which the movement of people and goods from north to south could have taken place based on available archaeological data. But how do such vectors relate to the genomic evidence for the spread of Eastern Scandinavian ancestry discussed at the start of this paper? Mobility was a central component of prehistoric social life but should not automatically be equated with migration, a term that in archaeological use has narrowed to the wholesale movement populations. Exchange, seasonal movement, marriage, craft production, warfare and ritual activities could all generate substantial movement without producing permanent demographic change. The genomic evidence considered here is significant precisely because it indicates something more than episodic mobility: Eastern Scandinavian ancestry became established across large parts of southern Scandinavia and contributed to a longer-term transformation of regional population structure (McColl et al. 2026).

The problem is therefore to explain how repeated mobility could develop into demographic expansion. The maritime corridors reconstructed above provide one part of this explanation. They created pathways through which movement could be repeated, but infrastructure alone does not explain why groups moved or why some movements resulted in permanent settlement. These processes must be considered within the demographic, economic and social transformations occurring around and after 2000 BC. The population increase identified in southern Sweden around 2250–2000 BC provides a crucial starting point. Population growth, settlement expansion and agricultural intensification potentially created pressures for access to land and resources while simultaneously generating the surpluses necessary to support increased mobility (Winther Johannsen et al. 2024). Winther Johannsen et al. (2024) explicitly raise the possibility that demographic expansion in southern Sweden contributed to movement towards the west. This demographic context overlaps chronologically with increasing mobility documented isotopically in western Sweden (Blank et al. 2021) and with the wider archaeological transformations discussed above.

Population growth need not have produced migration mechanically. Its effects would have been mediated through social institutions. New households might seek land elsewhere; marriage networks could connect communities across increasingly large areas; younger members of kin groups could establish new settlements; and competition between groups might encourage the extension of alliances and exchange networks. Maritime mobility offered one mechanism through which these strategies could be pursued (Kristiansen 2022). In line with archaeological and anthropological models of migration and demographic expansion, kinship may therefore have played an important role in structuring population movement during the Late Neolithic and Bronze Age (Haak et al. 2015; Goldberg et al. 2017; Kristiansen et al. 2017).

The spread of Eastern Scandinavian ancestry may have involved socially structured forms of maritime migration, in which kin-based groups established new communities while maintaining social networks across the Kattegat and Danish straits. Archaeological evidence, including the widespread circulation of flint daggers, early metalwork and amber, together with the distribution of gallery graves, indicates that extensive networks of exchange and communication were already established across southern Scandinavia before and during the demographic expansion considered here (Apel 2001; Frieman 2012; Kristiansen 2016). These material distributions cannot in themselves demonstrate kinship, but they may reflect enduring social relationships through which people, objects and knowledge circulated. Thus, the migratory process need not have created entirely new connections, but may instead have developed through pre-existing networks of social relationships, exchange and maritime mobility.

Potentially relevant to this interpretation is the association between Scandinavian ancestry clusters and particular Y-chromosome lineages identified by McColl et al. (2026). Since Y-chromosome lineages are transmitted through the paternal line, this pattern could, in theory, be consistent with male-biased migration and an important role for paternal kinship in the demographic processes involved. However, the Y-chromosome evidence alone cannot demonstrate either male-biased migration or patrilineal social organisation. Considered together with archaeological evidence for the pre-existing networks described above, with evidence for large-scale and sex-biased prehistoric migration (Haak et al. 2015;

Goldberg et al. 2017) and archaeological models of socially and kin-structured mobility (Kristiansen et al. 2017), the genomic pattern raises the possibility that kinship, and potentially male-biased forms of mobility, played a role in establishing maritime demographic expansion. We therefore treat this as a hypothesis to be explored through the combined genomic and archaeological evidence rather than as a conclusion derived from the Y-chromosome evidence alone.

7. Push and pull factors

To understand what may have driven this demographic expansion, we need to consider both the pressures that encouraged people to leave established communities and the opportunities that attracted them towards particular regions. Push factors may help explain why population movement occurred, whereas pull factors may help explain why it took particular geographical directions and became sustained over time. In this sense, demographic expansion can be approached as the outcome of an interaction between conditions in the areas of origin and opportunities available within the regions and maritime networks towards which people moved. Denmark and the southern Scandinavian maritime zone offered access not only to resources but also to established networks of exchange, communication and social relations. High-quality flint remained economically and socially important during the Late Neolithic, and the widespread circulation of flint daggers connected communities across southern Scandinavia (Fig. 12). Frieman (2012) has emphasised that such daggers could function as *boundary objects*, bridging social boundaries and facilitating communication and exchange between communities. Amber constituted another important element within these networks, with its distribution in western Sweden providing evidence for long-distance contacts and exchange (Blank et al. 2021; Blank 2022, Vandkilde et al 2024). At the same time, southern Scandinavia became increasingly integrated into European metal networks. Access to copper and bronze, and to the social relationships through which these materials circulated, may therefore have provided important incentives for participation in expanding maritime networks (Earle et al. 2015; Nørgaard et al. 2019, 2021; Vandkilde 2022; Vandkilde et al. 2024).

Crucially, many of these networks had already been established before, or were developing during, the demographic expansion considered here. The circulation of flint daggers, ceramics, slate, amber and early metalwork indicates repeated contacts across southern Scandinavia, while the distribution of gallery graves points to another dimension of shared practices and connectivity (Zvelebil 2006; Iversen 2010, 2015; Blank et al. 2020, 2021; Fauvelle et al. 2024, 2025b). The Pile hoard in Scania provides particularly important evidence for the growing scale of these connections around 2000 BC, demonstrating that communities in southern Sweden were already participating in long-distance metal networks at the Late Neolithic–Early Bronze Age transition (Vandkilde 2017, 2022, see also Fig .13). These networks involved more than the movement of objects: metal circulation required knowledge of suppliers and routes, repeated contacts, mechanisms of trust and exchange, and the transmission of technological knowledge. Population movement may therefore have followed and expanded pre-existing networks of exchange and social relationships rather than creating entirely new connections. The same maritime networks that carried trade goods and technological knowledge could also have

facilitated the movement of people. As our vector models have shown, the Öresund and Danish Isles occupied particularly advantageous positions within these systems, providing a maritime gateway between southern Sweden and wider European networks (Ling et al. in press;). Communities established in eastern Denmark could participate in networks extending towards Jutland, northern Germany, the western Baltic and the North Sea (Vandkilde 2017, see also Fig. 13). From this perspective, demographic expansion into eastern Denmark need not simply have reflected a search for new agricultural land. Access to established maritime routes, exchange partners, resources and strategically positioned coastal communities may itself have constituted an important pull factor. The combination of demographic and economic pressures in Sweden with opportunities presented by these maritime networks therefore provides a plausible framework for understanding how repeated mobility could develop into sustained demographic expansion.

The expansion can therefore be considered through interacting *push and pull factors*, rather than through a single causal explanation. Potential push factors within southern and western Sweden include population growth, demographic expansion, agricultural intensification and increasing social competition (Kristiansen 2015; Winther Johannsen et al. 2024). Greater population density may have encouraged the establishment of new settlements, while intensified agricultural production could both support larger populations and provide resources for more extensive movement. The increasing importance of exchange and alliance networks may likewise have encouraged groups to extend their social relationships beyond established local territories.

These push and pull factors may also help explain why demographic expansion could have followed more than one maritime vector. The two routes reconstructed above provided access to partly different resource zones and exchange networks. **Vector I**, across the Kattegat towards Jutland, connected western Sweden with regions in which flint and amber formed important components of Late Neolithic exchange, while Jutland's position between the Kattegat and North Sea provided access to networks extending into north-western Europe. **Vector II**, following the Swedish west coast through the Öresund towards Sjælland and the Danish Isles, provided access to a different but overlapping maritime sphere. The Öresund and Danish Isles occupied a strategic position between the Baltic and routes extending southwards towards northern Germany and continental Europe, including the expanding networks through which copper and bronze circulated. The two vectors should therefore not be understood simply as alternative geographical routes between Sweden and Denmark, but as corridors providing access to partly different combinations of resources, exchange partners and wider maritime networks.

Demographic growth, agricultural expansion and increasing social competition in Sweden would have encouraged outward movement, while access to resources and exchange networks provided opportunities that differed between the two vectors. In both cases, however, sustained movement depended upon the capacity to mobilise boats, crews, provisions, navigational knowledge and social relationships. The interaction between these push and pull factors and the maritime capacity required to act upon them provides the point of departure for the following discussion of the Maritime Mode of Production.

8. Maritime demographic expansion and the formation of the Nordic Bronze Age

The push and pull factors above can be understood within the broader framework of the Maritime Mode of Production (MMP) (Ling et al. 2018; Horn et al. 2024; Fauvelle & Ling 2025). Central to the MMP is the social and economic investment required to create and reproduce maritime capacity (Fig. 13). Boats had to be constructed and maintained, crews organised, navigational knowledge acquired and transmitted, and voyages provisioned. Agricultural production and surplus could provide the labour and resources required to sustain these investments, while repeated maritime practice accumulated knowledge, experience and social relationships (Ling et al.2018). Maritime capacity was therefore not simply technological, but socially and economically produced and reproduced over generations.

Such maritime capacity operated within socially connected maritime landscapes. Established coastal communities could provide landing places, provisions, information and social connections, allowing movement to proceed in stages rather than requiring direct movement between an area of origin and a final destination. This resembles what Needham (2009; see also Ling et al. 2026) conceptualises as *maritories*: maritime spaces in which routes, coastal places and communities formed parts of the same interaction system. The coastal and riverine vectors reconstructed above could therefore have provided both the physical and social infrastructure through which repeated mobility developed into demographic expansion.

Crucially, this process could become cumulative. Repeated movement could progressively lower the social and practical costs of subsequent movement**.** Successful voyages generated experience, navigational knowledge and social relationships, while newly established communities created additional nodes from which further mobility could develop. Previous mobility thus helped create the organisational conditions for future mobility. Within an MMP framework, demographic expansion and maritime organisation could consequently become mutually reinforcing: maritime networks facilitated the establishment of new communities, while these communities extended the networks through which further movement could take place (Ling et al. 2018; Austvoll et al. 2025; Ling 2025; Fauvelle & Ling 2025; Ling et al. 2026).

The MMP also helps explain why the archaeological transformations associated with LN II do not form a single homogeneous package. House traditions, burial practices, flint technologies, metalworking and genetic ancestry need not have moved together or at precisely the same time. Rather, they could have circulated through partially overlapping networks generated by the same broader processes of demographic and maritime expansion (Blank et al. 2020, 2021; Winther Johannsen et al. 2024). Maritime demographic expansion therefore does not require a one-to-one correspondence between particular archaeological traits and particular ancestry groups**.** Our approach instead emphasizes the convergence of independent evidence. Genomics identifies demographic change; archaeology identifies contemporary networks, material connections and inhabited landscapes; and ocean-voyage modelling evaluates whether the proposed maritime corridors were practicable (McColl et al. 2026; Bengtsson et al. 2025). Together, these datasets allow us to move beyond abstract arrows between sampling points towards a socially and geographically situated model of population movement.

Maritime demographic expansion should therefore be distinguished from migration that merely happened to take place by boat. We use the term to describe a cumulative process in which demographic growth, productive surplus, social relationships and maritime organisation interacted, allowing repeated mobility to produce lasting changes in population structure. Maritime networks were not simply channels through which migrating groups moved; they constituted an infrastructure through which movement could be organised, sustained and reproduced.

8.1 Linguistic dimensions of maritime demographic expansion

If the demographic expansion reconstructed above involved sustained population movement between Sweden, Denmark and Norway, it also raises the question of whether languages may have travelled through the same maritime networks. This possibility remains more difficult to evaluate than the demographic and archaeological processes discussed above and should be treated as a potential consequence of the model rather than as independent evidence for it**.** McColl et al. (2026) identified the expansion of Eastern Scandinavian ancestry as a potential demographic factor at the spread of Palaeo-Germanic, the reconstructed Pre-Iron Age predecessor of the Germanic languages. This new model situates this potential linguistic expansion considerably later than traditional scenarios associating early Germanic directly with the early third-millennium Corded Ware expansions.

The maritime reconstruction developed here is theoretically compatible with such a scenario. If populations carrying Eastern Scandinavian ancestry diffused from Sweden towards the Danish Isles, Jutland and Norway through the networks described above, this demographic process could have contributed to linguistic spread. Maritime corridors would have connected communities over precisely the geographical area in which Germanic developed and from which it expanded during the Iron Age.

Linguistic reconstruction does not contradict such a scenario. The reconstructed lexicon of Proto-Germanic, the Early Iron Age ancestor of the Germanic languages, is rich in vocabulary related to seafaring and boat technology (Fig. 15). Some of these terms are known to be inherited from Proto-Indo-European, including words for ‘ship’ and ‘to row’, demonstrating they have a linguistic history of several thousands of years, spanning also the Late Neolithic. However, unlike archaeology, linguistic reconstruction does not have direct dating methods, such as C14-dating, making that the age of the majority of the inherited Germanic nautical terms cannot be dated with certainty beyond the Iron Age.

As a result, linguistic evidence cannot resolve the question whether Palaeo-Germanic was indeed transmitted from Sweden to Denmark through Late Neolithic maritime corridors. While suggested by genomic and archaeological evidence, this model must remain hypothetical. More generally, genetic ancestry does not equal linguistic affiliation, and populations can adopt new languages without substantial demographic replacement. Conversely, migrating groups may adopt the language of communities among which they settle. The archaeological and modelling evidence presented here, while offering new prerequisites for the potential of linguistic transmission, therefore does not definitively demonstrate that groups moving through these maritime corridors spoke an early form of Germanic.

8.2 Implications for the formation of the Nordic Bronze Age

Irrespective of whether this demographic expansion was associated with the spread of Palaeo-Germanic, the model has broader implications for our understanding of the processes leading to the Nordic Bronze Age. Traditional approaches have often placed Denmark, particularly Jutland, in an advantageous position because of its proximity to continental Europe and its role in the transmission of metals, technologies and social practices northwards (Kristiansen & Larsson 2005; Vandkilde 1996, 2017). The importance of these connections is not in question. The evidence considered here, however, suggests that the transformations leading to the Nordic Bronze Age cannot be understood solely as a south-to-north process.

The demographic evidence instead indicates movement operating in several directions. Eastern Scandinavian ancestry appears to have formed through connections involving the north-eastern Baltic sphere before becoming established in Sweden and subsequently expanding towards Denmark, Norway and Jutland (McColl et al. 2026). At approximately the same time, archaeological evidence indicates population growth in southern Sweden, increasing individual mobility in western Sweden and movements of particular architectural, burial and technological traditions from the Swedish Peninsula towards eastern Denmark (Blank et al. 2020, 2021; Winther Johannsen et al. 2024).

These patterns do not allow us simply to reverse the traditional model and replace Denmark with Sweden as the principal centre of innovation. A more meaningful interpretation is multidirectional. Southern Scandinavia was becoming increasingly integrated through intersecting networks linking the Baltic, the Swedish interior, the western Scandinavian coast, the Danish Isles, Jutland, the North Sea and continental Europe (Kristiansen & Larsson 2005; Vandkilde 2017, 2022). Different regions contributed different resources, technologies, knowledge and populations to this developing system. Recent research on Nordic Bronze Age economies similarly emphasises regional diversity within an interconnected system rather than a uniform economic or political structure (Horn et al. 2024; Austvoll et al. 2025; Ling 2025; Ling et al. 2026).

This perspective also helps to reinterpret the central position of Denmark and the Danish Isles. Rather than functioning primarily as a source from which innovations spread northwards, these regions occupied a strategic position at the intersection of routes linking the Baltic and southern Sweden with Jutland, northern Germany and the North Sea (Needham 2009; Vandkilde 2022; Ling et al. 2026). Their importance within the emerging Nordic Bronze Age may therefore have derived partly from their position within an increasingly interconnected maritime system.

The growing importance of metals added an important economic dimension to this integration. Scandinavia depended heavily upon imported copper and tin to sustain its expanding Bronze Age metal economy, making participation in European metal networks dependent upon long-distance connections (Earle et al. 2015; Ling et al. 2014; Melheim et al. 2018; Nørgaard et al. 2019, 2021; Vandkilde 2017, 2022). Communities capable of mobilising boats, crews, provisions, navigational knowledge and alliances consequently occupied advantageous positions within these networks . Maritime capacity was therefore not simply a means of transportation, but increasingly a form of economic and political capacity, enabling communities to participate in and potentially exercise influence over flows of people, metals and other resources (Ling 2025; Ling et al. 2026, see also Fig 15).

Such connectivity did not require political uniformity. Communities in Denmark, Scania, western Sweden and Norway could draw upon different combinations of agricultural and maritime resources while remaining connected through exchange, mobility and alliance networks (Horn et al. 2024; Austvoll et al. 2025; Ling 2025). This corresponds closely to the MMP model (Fig. 13), in which long-distance interaction can connect dispersed and relatively low-density communities without requiring urbanisation or centralised state organisation (Ling et al. 2018). The demographic movements reconstructed here add an important dimension to this process: maritime networks circulated not only objects, technologies and knowledge, but also people, establishing new social relationships across regional boundaries.

The processes identified here may therefore represent part of the foundations upon which the later Nordic Bronze Age maritime system developed. This does not mean projecting the political organisation of the developed Bronze Age backwards into LN II. Rather, some of the capacities on which the later system depended—repeated maritime movement, accumulated navigational knowledge, interregional social relationships and the ability to mobilise people and resources for voyaging—were already developing before 1700 BC. The formation of the Nordic Bronze Age can thus be approached as a progressive and multidirectional integration of populations and regional economies through maritime networks, rather than simply as the northward diffusion of a Bronze Age cultural package.

9. Conclusion

Since the pioneering work of Oskar Montelius (1905), Denmark has occupied a central position in explanations of the developments that transformed southern Scandinavia during the Late Neolithic and eventually led to the formation of the Nordic Bronze Age. In this perspective, Denmark, and particularly Jutland, has largely been regarded as the stepping stone through which continental innovations, metals, technologies and social practices reached the Scandinavian Peninsula (Kristiansen & Larsson 2005; Vandkilde 1996). However, the new archaeogenetic evidence presented by McColl et al. (2026), together with recent archaeological research, calls for a reconsideration of this predominantly south-to-north model. Based on these new data, we argue that parts of Sweden were not merely recipients of impulses transmitted through Denmark, but may themselves have played an important role in the demographic and social developments that preceded the Nordic Bronze Age.

The identification and subsequent spread of Eastern Scandinavian ancestry is particularly significant in this respect (Allentoft et al. 2024; McColl et al. 2026). We have distinguished three broad phases in this demographic development. The first, c. 2200–2000 BC, concerns the possible formation or arrival of this ancestry through connections across the Baltic or its northeastern coastline. The second involves its establishment in Sweden around 2000 BC, with Västergötland and Falköping prominent in the available genomic record. The third concerns its subsequent expansion into the Danish Isles, Norway and Jutland during the Late Neolithic and Bronze Age. Although neither the precise geographical origin of this ancestry nor the mechanisms of its initial arrival can yet be established, its subsequent distribution provides new grounds for considering demographic movements from the Swedish Peninsula towards Denmark.

This development occurred against a background of substantial population growth and agricultural intensification in southern Sweden during the later third millennium BC (Winther Johannsen et al. 2024). The archaeological evidence points to expanding settlements, changing house traditions, new agricultural practices and increasingly extensive networks of exchange. The distribution of gallery graves, isotopic evidence for mobility, flint sickles and daggers, and the circulation of early metals further suggest connections between western and southern Sweden and Denmark (Apel 2001; Blank et al. 2020, 2021; Vandkilde 2017, 2022). Some of these developments also indicate influences moving from the Swedish Peninsula towards the Danish Isles. They cannot be treated as direct archaeological markers of Eastern Scandinavian ancestry, but their chronology and distribution are compatible with the demographic changes identified by McColl et al. (2026).

A central question addressed in this study is how these population movements could have taken place. The maritime geography of southern Scandinavia provides an important starting point. The Kattegat, Skagerrak and Öresund are often represented as geographical boundaries between archaeological regions, although they also constituted important corridors of communication. The concentration of early individuals carrying Eastern Scandinavian ancestry in Västergötland makes the connections between Falbygden, Lake Vänern, Göta älv and the Kattegat coast particularly relevant. This system of inland waterways, portages and coastal routes could have connected densely settled agricultural landscapes with maritime networks extending towards Denmark and the North Sea.

We have explored two possible vectors of demographic movement from western Sweden towards Denmark. Vector I follows the Göta älv corridor towards the Onsala Peninsula and continues across the Kattegat towards northern Jutland, potentially via Læsø. This route is supported by archaeological evidence for longstanding connections across the Kattegat, including flint exchange, metal circulation and parallels in maritime imagery (Apel 2001; Ling 2014; Melheim & Ling 2017). The ocean-voyage simulations indicate that such crossings were feasible during favourable summer conditions, although the results also demonstrate the importance of vessel performance, weather conditions and opportunities for intermediate landfall (Bengtsson et al. 2025; Bengtsson et al. in press a). The presence of Eastern Scandinavian ancestry in Jutland is compatible with movement along this corridor, but the limited number of individuals presently available prevents a more precise assessment of its demographic significance.

Vector II follows a different maritime strategy. From Onsala, movement continued southwards along the Halland coast towards Scania and through the Öresund to Sjælland and the Danish Isles. Although considerably longer, this corridor offered repeated opportunities for landfall, particularly around the mouths of the major Halland rivers, including Viskan, Ätran, Nissan and Lagan. The distribution of radiocarbon-dated Late Neolithic settlements, including two-aisled houses and sunken-floor huts, indicates that this was an inhabited coastal landscape with connections between the shoreline and inland communities (Nordvall in press). The modelling suggests that the passage towards the Öresund could be undertaken through successive daily stages, with approximately six days of travel on the water under suitable conditions (Bengtsson et al. 2025). Such a route may have been especially relevant for demographic movement involving households, provisions and possessions, where the possibility of stopping, establishing contacts and obtaining support would have been important.

The geographical distribution of Eastern Scandinavian ancestry, with a stronger representation on the Danish Isles than in Jutland, makes Vector II particularly interesting (McColl et al. 2026). We therefore suggest that the Halland–Scania–Öresund corridor may have been especially important for the demographic expansion considered here, while the direct Kattegat crossing provided a complementary connection towards Jutland. Both routes probably formed parts of a wider maritime interaction system rather than separate or mutually exclusive pathways. The simulations cannot demonstrate that migration followed either vector, but they establish that the proposed movements were practicable within the environmental and technological conditions considered.

Taken together, the genomic, archaeological and ocean-voyage modelling results allow us to return to the three analytical dimensions outlined at the beginning of this study: mobility, connectivity and directionality. Mobility is demonstrated by the genomic evidence for population dispersal and independently supported by isotopic and archaeological evidence for movement between regions (Blank et al. 2021; McColl et al. 2026). Connectivity is reflected in the distribution of burial traditions, settlements, flint technologies, metal circulation and maritime imagery, which indicate established networks linking Sweden and Denmark (Apel 2001; Blank et al. 2020; Vandkilde 2022). Directionality emerges from the chronological and geographical distribution of Eastern Scandinavian ancestry and from archaeological developments suggesting movement and influence from the Swedish Peninsula towards Denmark (Winther Johannsen et al. 2024; McColl et al. 2026). Ocean-voyage modelling provides a means of evaluating how these movements could have been undertaken. The strength of the argument lies in the convergence of these independent datasets, rather than in any single category of evidence.

The reasons behind such movements must be considered in relation to broader demographic and economic developments. Population growth, agricultural intensification and increasing social competition may have encouraged groups to seek new land and opportunities beyond their established territories (Kristiansen 2015; Winther Johannsen et al. 2024). At the same time, access to flint, amber, metals and expanding exchange networks could have attracted people towards different parts of Denmark and the wider North Sea–Baltic region (Vandkilde 2022). Kinship relations, marriage alliances and existing exchange partnerships may have provided the social connections through which migration could be organised and new settlements established. The two maritime vectors also offered access to partly different resource zones and networks, suggesting that demographic expansion need not have followed a single route or been driven by a single cause.

These population movements may also have implications for the formation of the prehistoric linguistic landscape. As suggested by McColl et al. (2026), the spread of Eastern Scandinavian ancestry offers a possible alternative demographic context for the diffusion of Palaeo-Germanic, rather than associating this development exclusively with the earlier Corded Ware expansions. The maritime routes discussed here provide plausible geographical connections between the regions subsequently associated with Germanic. The reconstructed Proto-Germanic vocabulary also contains a substantial body of terminology relating to boats, seafaring and maritime environments. However, neither the linguistic evidence nor the genomic data establishes a direct relationship between ancestry and language. This remains a hypothesis requiring further investigation.

The Maritime Mode of Production (MMP) offers a framework for understanding how these demographic, economic and social developments could have interacted (Ling et al. 2018; Horn et al. 2024; Fauvelle & Ling 2025). Agricultural intensification and population growth could generate the surplus and labour required for the construction and maintenance of boats, the organisation of crews, provisioning and the transmission of maritime knowledge. These investments made repeated maritime movement possible, while established coastal communities provided landing places, resources and social relationships that facilitated further movement. In this sense, maritime demographic expansion should not be understood simply as migration undertaken by boat. It represents a potentially cumulative process in which demographic growth, productive surplus and maritime organisation reinforced one another. Migration was not external to the networks through which metals and other resources circulated; it was also one of the processes through which those networks expanded and acquired new social foundations.

The implications extend beyond the identification of particular migration routes. We do not suggest that the traditional Denmark-centred model should simply be replaced by an equally one-directional model originating in Sweden. Rather, the evidence points towards a more complex development in which demographic movements, technological innovations, economic interests and social relationships connected different parts of southern Scandinavia. Denmark remained central to these developments, but Sweden may have played a more significant role than previously recognised. The formation of the Nordic Bronze Age should therefore be approached as the outcome of interacting demographic, economic and social processes operating across an increasingly connected maritime landscape.

The sea was not merely a space across which these transformations occurred. Through the organisation of boats, crews, exchange and settlement, maritime connections became part of the processes that shaped societies on both sides of the Kattegat and the Danish straits. In this perspective, the expansion of Eastern Scandinavian ancestry represents one demographic dimension of a wider transformation in which the movement of people contributed to the making of Bronze Age Scandinavia.

List of Figures

Figure 1. Distribution of gallery graves and Kiukainen/Third Type pottery sites in southern Scandinavia and the Baltic region during the Middle and Late Neolithic (c. 2200–1700 BC). The map illustrates archaeological connections across the Baltic during this period. Archaeological data from Riksantikvarieämbetet; river data from the Copernicus Land Monitoring Service.

Figure 2a–b. Geographical and chronological distribution of selected individuals with Eastern Scandinavian ancestry in southern Scandinavia during the Late Neolithic (c. 2000–1700 BC). (a) Locations and radiocarbon dates (^{14}C) of sampled individuals; (b) proposed phases of demographic development and dispersal based on archaeogenetic evidence. Based on Allentoft et al. (2024), McColl et al. (2026), and additional datasets listed in the accompanying table 1.

Figure 3. Schematic model of changing house sizes and settlement patterns in southern Scandinavia from the Late Neolithic to the end of the Bronze Age, in relation to changes in metal supply and land

use. After Kristiansen (2006, Fig. 50).

Figure 4. Radiocarbon-based demographic modelling of population development in southern Scandinavia during the Middle and Late Neolithic, indicating substantial population growth culminating around 2100 BC. Reproduced from Winther Johannsen et al. (2024, Fig. 6), under the Creative Commons Attribution 4.0 International License (CC BY 4.0).

Figure 5. Distribution of gallery graves in southern Scandinavia, highlighting their concentration in southwestern Sweden, particularly Västergötland. Yellow dots indicate gallery graves, while red dots represent gallery graves with port-holes (*gavelhål*). The distribution illustrates the geographical connections between inland western Sweden, the coastal regions and Denmark during the Late Neolithic.Data retrieved from Riksantikvarieämbetet open data for cultural remains and from Blank (2021, figs-8-9). Modern rivers were generated using European Union's Copernicus Land Monitoring Service information; https://doi.org/10.2909/393359a7-7ebd-4a52-80ac-1a18d5f3db9c.

Figure 6. Distribution of Late Neolithic Scandinavian flint daggers across northern Europe, showing their principal production areas, natural sources of high-quality flint, general distribution, and isolated finds beyond southern Scandinavia. The distribution illustrates extensive exchange networks connecting Jutland, the Danish Isles, southern Sweden, and more distant regions during the Late Neolithic. Based on Apel (2008), redrawn by Malou Blank.

Figure 7. Early Bronze Age boat depictions from Kville in Bohuslän, western Sweden, and Truehøjgård in Jutland, Denmark, illustrating striking iconographic similarities across the Kattegat. The boats share characteristic prow and stern shapes and hollowed-out hull representations. Two examples also display ten crew lines and a rope attached to a steering oar at the stern. Redrawn by Boel Bengtsson after Fredsjö (1981) and Kristiansen (2002).

Figure 8. Map illustrating two proposed vectors of population movement from inland western Sweden towards Denmark during the Late Neolithic II (c. 2000–1700 BC). Both originate in the Falbygden region of Västergötland and follow potential riverine and terrestrial corridors towards the Kattegat coast. Vector I crosses the Kattegat towards Jutland, potentially via Læsø, while Vector II follows the Swedish west coast southwards through Halland and Scania before crossing the Öresund towards the Danish Isles. The proposed vectors are based on combined archaeological, genomic, and geographical evidence. The palaeogeographical reconstruction is based on shoreline displacement data from the Geological Survey of Sweden (SGU), representing conditions around 3800 BP. Modern river networks are derived from the EU-Hydro River Network (Copernicus Land Monitoring Service), while land and waterbody vectors are from Natural Earth. Map produced using the SWEREF99 TM coordinate system.

Figure 9. Topographical and palaeogeographical reconstruction of the Falbygden–Göta älv corridor connecting inland western Sweden with the Kattegat coast during the Late Neolithic II (c. 2000–1700 BC). **(a)** Palaeogeographical reconstruction of Göta älv, highlighting the two principal obstacles to riverine navigation: the rapids at Vargön, near the outlet of Lake Vänern, and Trollhättan, where boats would have required overland portage. The map also indicates the Göta älv estuary and connections

towards the Gothenburg archipelago. Rock art from Skepplanda 56:1 illustrates the region's maritime traditions. **(b)** Topographical map showing Falbygden, the principal waterways and potential transport corridors towards the west coast, including alternative connections via the Nosse and Säve river systems. Stars indicate river mouths and proposed maritime stopping points along the Halland coast. Figure by Boel Bengtsson, incorporating topographical data from topographic-map.com, shoreline displacement data from the Geological Survey of Sweden (SGU), and archaeological information from Fornsök.

Figure 10. Distribution of radiocarbon-dated sunken-floor huts (1888–1520 BC) and two-aisled houses (1950–1600 BC) in Halland and adjacent areas. The settlements occur along coastal and inland waterways, with sunken-floor huts particularly concentrated around the Ätran and Nissan river systems (5 and 6). Based on Nordvall (in press).

Figure 11. Results of ocean-voyage modelling of two potential maritime vectors of population movement from Falbygden in western Sweden towards Denmark during the Late Neolithic II (c. 2000–1700 BC). Both vectors connect inland western Sweden with the Kattegat coast via the Lake Vänern–Göta älv corridor and alternative inland waterways. **Vector I** crosses the Kattegat from Onsala towards Jutland, with an estimated sailing time of approximately 11 hours (one day). **Vector II** follows the Halland coast southwards, passing proposed maritime stopping points (1–8) before crossing the Öresund towards the Danish Isles. The model indicates approximately 27 hours of sailing from Onsala to Öresund, corresponding to around six days with overnight stops. Dashed arrows indicate potential inland connections, pink lines represent modelled maritime routes, and stars mark river mouths and proposed maritime stopping points. Estimated travel times depend on the modelled sailing conditions. Figure by Boel Bengtsson, incorporating topographical data from topographic-map.com, shoreline displacement data from the Geological Survey of Sweden (SGU), and archaeological information from Fornsök.

Figure 12. Distribution of flint and amber sources in southern Scandinavia, illustrating access to important raw materials within Late Neolithic and Early Bronze Age exchange networks. Map after Horn et al. (2024), redrawn by Ashely Green.

Figure 13. Schematic map of northern Europe showing interactions between resource production and consumption areas during Late Neolithic II and Nordic Bronze Age Period I. Major resources include copper, tin, and amber. Southern Scandinavia is shown in relation to wider exchange networks connecting continental Europe, the British Isles, and the Nordic region. Redrawn by Ashely Green after Vandkilde (2022).

Fig. 14. Conceptual model of the Maritime Mode of Production (MMP), illustrating the interdependence between the land-based domestic economy and the maritime political economy. Agricultural surplus provided the labour, resources, and provisions necessary to sustain maritime activities, while maritime ventures generated goods, social relationships, and political power. Maritime capacity was thus socially and economically produced and reproduced over generations. Reproduced from Horn et al. (2024).

Figure 15: The reconstructed development of selected nautical terminology from Proto-Indo-European through Proto-Germanic to the earliest attested Germanic languages. Linguistically reconstructed forms are indicated by an asterisk (*).

Figure 16.. Rock art boats from Kville, western Sweden, dated to the Nordic Early Bronze Age (c. 1700–1500 BC). The composition, featuring a large vessel surrounded by numerous smaller boats, may represent a collective maritime event, potentially associated with population movement or migration. Orthophoto (SfM) of L1969:5872 by Tanums Hällristningsmuseum Underslös (2022), Swedish Rock Art Research Archives (SHFA), accessed 3 November 2026: https://shfa.dh.gu.se/image/133411.

References

Allentoft, M. E., Sikora, M., Sjögren, K.-G., et al. (2015). Population genomics of Bronze Age Eurasia. Nature 522: 167–172. https://doi.org/10.1038/nature14507

Allentoft, M. E., Sikora, M., Refoyo-Martínez, A., et al. (2024). Population genomics of post-glacial western Eurasia. Nature 625: 301–311. https://doi.org/10.1038/s41586-023-06865-0

Apel, J. (2001). Daggers, Knowledge and Power: The Social Aspects of Flint-Dagger Technology in Scandinavia 2350–1500 cal BC, Uppsala University, Uppsala.

Apel, J. (2008). Knowledge, know-how and raw material: The production of Late Neolithic flint daggers in Scandinavia. Journal of Archaeological Method and Theory 15(1): 91–111. https://doi.org/10.1007/s10816-007-9044-2

Apel, J. (2015). Specialiserat flinthantverk på Hisingen. In Situ Archaeologica 11: 55–67.

Artursson, M. (2009). Bebyggelse och samhällsstruktur: Södra och mellersta Skandinavien under senneolitikum och bronsålder 2300–500 f.Kr., Riksantikvarieämbetet, Göteborg.

Austvoll, K. I., Fauvelle, M., and Ling, J. (2025). Contrasting strategies: Social organization and interaction in the Early Bronze Age of northwestern Scandinavia. Journal of Anthropological Archaeology 79: 101708. https://doi.org/10.1016/j.jaa.2025.101708

Bengtsson, B. (2025). Using direct and indirect evidence of boats and boatbuilding for understanding the nature of seafaring in Atlantic Europe c. 5000–500 BC. In Koch, J. T., Fauvelle, M., Cunliffe, B., and Ling, J. (eds.), Presenting Counterpoints to the Dominant Terrestrial Narrative of European Prehistory: Maritime Encounters I, Oxbow Books, Oxford, pp. 49–93.

Bengtsson, B., Montenegro, A., Green, A., Tomasini, M., Prince, M., Wåhlstrand Skärström, V., Austvoll, K. I., Ling, J., and Lindhé, C. (2025). Seafaring and navigation in the Nordic Bronze Age: The application of an ocean voyage tool and boat performance data for comparing direct open-water crossings with sheltered coastal routes. PLoS ONE 20(4): e0320791. https://doi.org/10.1371/journal.pone.0320791

Bengtsson, B., Prince, M., Montenegro, A. & Tomasini, M. (in press). Testing the Digital Reconstruction of the Varpelev Boat, in Ravn, M. & Kastholm, O. T. (eds.), The Varpelev Boat: A Scandinavian Bronze

Age Logboat in its Archaeological and Maritime Context, Ships and Boats of the North, Vol. 10, Viking Ship Museum, Roskilde, pp. 101–127.

Björhem, N. & Säfvestad, U. 1989. Fosie IV. Byggnadstradition och bosättningsmönster under senneolitikum. Malmöfynd 5. Malmö.

Blank, M. (2021). Mobility, Subsistence and Mortuary Practices: An Interdisciplinary Study of Neolithic and Early Bronze Age Megalithic Populations of Southwestern Sweden, University of Gothenburg, Gothenburg.

Blank, M. (2022). Flint daggers and related artefacts in megalithic tombs of south-western Sweden. In Tornberg, A., Svensson, A., and Apel, J. (eds.), Life and Afterlife in the Nordic Bronze Age: Proceedings of the 15th Nordic Bronze Age Symposium Held in Lund, Sweden, June 11–15, 2019, Lund University, Lund, pp. 73–98.

Blank, M. In press. Human mobility and exchange networks in southwestern Sweden during the Neolithic and Early Bronze Age. In Brinkmann J, Schaefer-Di Maida S and Nørgaard HW (eds.) People, objects, connections. Mobility and exchange in the Late Neolithic and Bronze Age – Raw materials, networks, innovations. Session at the Kiel Conference. Scales of Social, Environmental & Cultural Change in Past Societies, 13–17 March 2023, Kiel University.

Blank, M., Sjögren, K.-G., and Storå, J. (2020). Old bones or early graves? Megalithic burial sequences in southern Sweden based on 14C datings. Archaeological and Anthropological Sciences 12: 89. https://doi.org/10.1007/s12520-020-01039-9

Blank, M., Sjögren, K.-G., Knipper, C., Frei, K. M., Malmström, H., Fraser, M., Svensson, E. M., Günther, T., Yngve, H., Jakobsson, M., Götherström, A., and Storå, J. (2021). Mobility patterns in inland southwestern Sweden during the Neolithic and Early Bronze Age. Archaeological and Anthropological Sciences 13: 64. https://doi.org/10.1007/s12520-021-01294-4

Becker, C. J. (1951). Den grubekeramiske kultur i Danmark. Aarbøger for nordisk Oldkyndighed og Historie 1950: 153–274.

Brink, K. (2013). Houses and hierarchies: Economic and social relations in the Late Neolithic and Early Bronze Age of southernmost Scandinavia. European Journal of Archaeology 16: 433–458. https://doi.org/10.1179/1461957113Y.0000000033

Birkhan, H. (1970). Germanen und Kelten bis zum Ausgang der Römerzeit: Der Aussagewert von Wörtern und Sachen für die frühesten keltisch-germanischen Kulturbeziehungen, Sitzungsberichte der Österreichischen Akademie der Wissenschaften, Philosophisch-Historische Klasse 272, Böhlau, Vienna.

Brorsson, T., J. Lucenius & N. Stenbäck (2021). Changing perspectives. Thin section and ICP analysis of Neolithic pottery from the Åland Islands. In: Mannermaa, K., Manninen, M. A., Pesonen, P. & Seppänen, L. (eds.). Helsinki Harvest. Proceedings of the 11th Nordic Conference on the Application of Scientific Methods in Archaeology, Archaeological Society of Finland. Helsinki, pp. 48–71.

Childe, V. G. (1926). The Aryans: A Study of Indo-European Origins, Kegan Paul, London.

Crumlin-Pedersen (2003). The Hjortspring boat in a ship-archaeological context. In: Crumlin-Pedersen, O. and Trakadas, A., (eds.), Hjortspring. A Pre-Roman Iron-Age Warship in Context. Ships and boats of the North. Volume 5. Roskilde, pp. 209–233.

Earle, T. K., Ling, J., Uhnér, C., Stos-Gale, Z., and Melheim, L. (2015). The political economy and metal trade in Bronze Age Europe: Understanding regional variability in terms of comparative advantages and articulations. European Journal of Archaeology 18(4): 633–657.

Fauvelle, M., and Ling, J. (2025). Larger boats, longer voyages, and powerful leaders: Comparing Maritime Modes of Production in Scandinavia and California. In Koch, J. T., Fauvelle, M., Cunliffe, B., and Ling, J. (eds.), Presenting Counterpoints to the Dominant Terrestrial Narrative of European Prehistory: Maritime Encounters I, Oxbow Books, Oxford, pp. 95–108.

Fauvelle, M., Bengtsson, B., Pipping, O., Hollmann, M., Mortensen, M. N., Toft, P., Ganji, S., Green, A., Horn, C., Hall, S., Kaul, F., and Ling, J. (2025a). New investigations of the Hjortspring boat: Dating and analysis of the cordage and caulking materials used in a pre-Roman iron age plank boat. PLoS ONE 20(12): e0336965. https://doi.org/10.1371/journal.pone.0336965

Fauvelle, M., Brorsson, T., Artursson, M., Björck, N., and Horn, C. (2025b). Maritime exchange during the Middle Neolithic: Evidence of trade in ceramic figurines at the Pitted Ware Culture site of Tråsättra. Journal of Archaeological Science: Reports 66: 105342. https://doi.org/10.1016/j.jasrep.2025.105342

Fauvelle, M., Horn, C., Alvå, J., and Artursson, M. (2024). Skin boats in Scandinavia? Evaluating the maritime technologies of the Neolithic Pitted Ware Culture. Journal of Maritime Archaeology 19: 489–515. https://doi.org/10.1007/s11457-024-09408-4

Forssander, J. E. (1933). Die schwedische Bootaxtkultur und ihre kontinentaleuropäischen Voraussetzungen, C. W. K. Gleerup, Lund.

Fredsjö, J. (1981). Hällristningar. Kville härad, Kville socken, Nordbladh, J. & Rosvall, J. (eds.), Studier i nordisk arkeologi, 14/15, Göteborg.

Frieman, C. J. (2012). Flint daggers, copper daggers, and technological innovation in Late Neolithic Scandinavia. European Journal of Archaeology 15(3): 440–464. https://doi.org/10.1179/1461957112Y.0000000014

Glob, P. V. (1945). Studier over den jyske Enkeltgravskultur, Det Kongelige Nordiske Oldskriftselskab, Copenhagen.

Goldberg, A., Günther, T., Rosenberg, N. A., and Jakobsson, M. (2017). Ancient X chromosomes reveal contrasting sex bias in Neolithic and Bronze Age Eurasian migrations. Proceedings of the National Academy of Sciences 114(10): 2657–2662. https://doi.org/10.1073/pnas.1616392114

Güntert, H. (1934). Der Ursprung der Germanen, Kultur und Sprache 9, Carl Winter, Heidelberg.

Haak, W., Lazaridis, I., Patterson, N., et al. (2015). Massive migration from the steppe was a source for Indo-European languages in Europe. Nature 522: 207–211. https://doi.org/10.1038/nature14317

Hansen, J. M., Aagaard, T., Stockmarr, J., Møller, I., Nielsen, L., Binderup, M., Larsen, J. H., and Larsen, B. (2016). Continuous record of Holocene sea-level changes and coastal development of the Kattegat island

Læsø (4900 years BP to present). Bulletin of the Geological Society of Denmark 64: 1–55. https://doi.org/10.37570/bgsd-2016-64-01

Hinsch, E. (1956). Yngre steinalders stridsøkskulturer i Norge. Bergen Museums Årbok 1954, Historisk-Antikvarisk Rekke 1: 1–237.

Holm, L. (2003). Contacts in the Bothnian region – The Neolithic site Hedningahällan in regional and interregional context. In Samuelsson, C. & N. Ytterberg (eds.), Uniting Sea: Stone Age Societies in the Baltic Sea Region. Proceedings from the First Uniting Sea Workshop at Uppsala University, Sweden, January 26-27, 2002, Wikströms, Uppsala, pp. 89–102.

Horn, C., Austvoll, K. I., Artursson, M., and Ling, J. (2024). Nordic Bronze Age Economies, Cambridge University Press, Cambridge. https://doi.org/10.1017/9781009421416

Iversen, R. (2010). In a world of worlds: The Pitted Ware complex in a large-scale perspective. Acta Archaeologica 81: 5–43. https://doi.org/10.1111/j.1600-0390.2010.00242.x

Iversen, R. (2015). The Transformation of Neolithic Societies: An Eastern Danish Perspective on the 3rd Millennium BC, Jutland Archaeological Society, Højbjerg.

Iversen, R. (2017). Big-men and small chiefs: The creation of Bronze Age societies. Open Archaeology 3: 361–375. https://doi.org/10.1515/opar-2017-0023

Iversen, R., and Kroonen, G. (2017). Talking Neolithic: Linguistic and archaeological perspectives on how Indo-European was implemented in southern Scandinavia. American Journal of Archaeology 121(4): 511–525. https://doi.org/10.3764/aja.121.4.0511

Kallio, P. (2012). The prehistoric Germanic loanword strata in Finnic. In Grünthal, R., and Kallio, P. (eds.), A Linguistic Map of Prehistoric Northern Europe, Société Finno-Ougrienne, Helsinki, pp. 225–238.

Karsten, T. E. (1928). Die Germanen: Eine Einführung in die Geschichte ihrer Sprache und Kultur, Grundriss der germanischen Philologie 9, Walter de Gruyter, Berlin and Leipzig.

Kaul, F. (1998). Ships on Bronzes: A Study in Bronze Age Religion and Iconography, National Museum of Denmark, Copenhagen.

Koch, J. T. (2020). Celto-Germanic: Later Prehistory and Post-Proto-Indo-European Vocabulary in the North and West, University of Wales Centre for Advanced Welsh and Celtic Studies, Aberystwyth.

Koch, J. T., Fauvelle, M., Cunliffe, B., and Ling, J. (eds.) (2025). Presenting Counterpoints to the Dominant Terrestrial Narrative of European Prehistory: Maritime Encounters I, Oxbow Books, Oxford.

Kristiansen, K. (1989). Prehistoric migrations: The case of the Single Grave and Corded Ware cultures. Journal of Danish Archaeology 8: 211–226. https://doi.org/10.1080/0108464X.1989.10590029

Kristiansen, K. (1998). Europe before History, New Studies in Archaeology, Cambridge University Press, Cambridge.

Kristiansen, K. (2002). Langfærder og helleristninger. In Situ 2000–2002: 67–80.

Kristiansen, K. (2006). Cosmology, economy and long-term change in the Bronze Age of Northern Europe. In K.-G. Sjögren (ed.), Ecology and Economy in Stone Age and Bronze Age Scania. Skånska spor – arkeologi längs Västkustbanan, Riksantikvarieämbetet, Stockholm, pp. 171–218.

Kristiansen, K. (2015). The Decline of the Neolithic and the Rise of Bronze Age Society, in Fowler, C., Harding, J. & Hofmann, D. (eds.), The Oxford Handbook of Neolithic Europe, Oxford University Press, Oxford. https://doi.org/10.1093/oxfordhb/9780199545841.013.057

Kristiansen, K. (2016). Interpreting Bronze Age trade and migration. In Kiriatzi, E., and Knappett, C. (eds.), Human Mobility and Technological Transfer in the Prehistoric Mediterranean, Cambridge University Press, Cambridge, pp. 154–180.

Kristiansen, K. (2022). Bronze Age globalisation in numbers: Volumes of trade and its organisation. In Hofmann, D., Nikulka, F., and Schumann, R. (eds.), The Baltic in the Bronze Age: Regional Patterns, Interactions and Boundaries, Sidestone Press, Leiden, pp. 1–20.

Kristiansen, K., and Larsson, T. B. (2005). The Rise of Bronze Age Society: Travels, Transmissions and Transformations, Cambridge University Press, Cambridge.

Kristiansen, K., Allentoft, M. E., Frei, K. M., Iversen, R., Johannsen, N. N., Kroonen, G., Pospieszny, Ł., Price, T. D., Rasmussen, S., Sjögren, K.-G., Sikora, M., and Willerslev, E. (2017). Re-theorising mobility and the formation of culture and language among the Corded Ware Culture in Europe. Antiquity 91(356): 334–347. https://doi.org/10.15184/aqy.2017.17

Larsson, Å. M. (2009). Breaking and Making Bodies and Pots: Material and Ritual Practices in Sweden in the Third Millennium BC, Uppsala University, Uppsala.

Lazaridis, I., Patterson, N., Anthony, D., et al. (2025). The genetic origin of the Indo-Europeans. Nature 639: 132–142. https://doi.org/10.1038/s41586-024-08531-5

Ling, J. (2014). Elevated Rock Art: Towards a Maritime Understanding of Bronze Age Rock Art in Northern Bohuslän, Sweden, Oxbow Books, Oxford.

Ling, J., Earle, T., and Kristiansen, K. (2018). Maritime Mode of Production: Raiding and trading in seafaring chiefdoms. Current Anthropology 59(5): 488–524. https://doi.org/10.1086/699613

Ling, J., Hjärthner-Holdar, E., Grandin, L., Stos-Gale, Z., Kristiansen, K., Melheim, A. L., Artioli, G., Angelini, I., Krause, R. & Canovaro, C. (2019). Moving metals IV: Swords, metal sources and trade networks in Bronze Age Europe, Journal of Archaeological Science: Reports, 26, 101837. https://doi.org/10.1016/j.jasrep.2019.05.002

Ling, J., Grandin, L., Hjärthner-Holdar, E., Melheim, L., Stos-Gale, Z., Vicze, M. & Tarbay, J. G. (2023). Moving metals V: The question of shared copper sources between Scandinavia and Hungary 1700–1500 BC, Journal of Archaeological Science: Reports, 51, 104198. https://doi.org/10.1016/j.jasrep.2023.104198

Ling, J. (2025). The Maritime Mode of Production in relation to self-sufficiency, reciprocity, and comparative advantages. In Koch, J. T., Fauvelle, M., Cunliffe, B., and Ling, J. (eds.), Presenting

Counterpoints to the Dominant Terrestrial Narrative of European Prehistory: Maritime Encounters I, Oxbow Books, Oxford, pp. 109–114.

Ling, J., Bengtsson, B., Fauvelle, M. & Horn, C. (2026). The social organisation of metal trade: Assessing the resources and logistical structures behind the movement and exchange of Great Orme copper and Cornish tin to Scandinavia, c. 1600–1400 BC. In J. T. Koch, M. Fauvelle, B. Cunliffe & J. Ling (eds.), Moving Metals by Sea: Great Orme and the Bronze Age World, pp. 273–290. Oxford: Oxbow Books.

Ling, J., Bengtsson, B., Fauvelle, M., Horn, C., Austvoll, K. I. & Artursson, M. (in press). Anchoring Power: The Danish Region as a Maritime Hub in the Metal Exchange System during the Nordic Bronze Age, in Ravn, M. & Kastholm, O. T. (eds.), The Varpelev Boat: A Scandinavian Bronze Age Logboat in its Archaeological and Maritime Context, Ships and Boats of the North, Vol. 10, Viking Ship Museum, Roskilde, pp.177-200.

Lucenius, J., Brorsson, T. & Stenbäck, N. (2026). Faces in Places: Portable Clay Figurines from Åland and South-Western Finland in the Light of Chemical and Petrographic Analysis, European Journal of Archaeology, 29(2), 139–161. https://doi.org/10.1017/eaa.2026.10033

Malmström, H., T. Günther, E.M. Svensson, A. Juras, M. Fraser, A.R. Munters, Ł. Pospieszny, M. Tõrv, J. Lindström, A. Götherström, J. Storå, M. Jakobsson (2019). The genomic ancestry of the Scandinavian Battle Axe Culture people and their relation to the broader Corded Ware horizon. Proc. R. Soc. B 286 (1912): 20191528. https://doi.org/10.1098/rspb.2019.1528

Margaryan, A., Lawson, D.J., Sikora, M. et al. (2020). Population genomics of the Viking world. Nature 585, 390–396. https://doi.org/10.1038/s41586-020-2688-8

McColl, H., Kroonen, G., Moreno-Mayar, J.V. et al. (2026). Tracing the spread of Germanic languages using ancient genomics. Nature (2026). https://doi.org/10.1038/s41586-025-09064-1

Melheim, L., and Ling, J. (2017). Taking the stranger on board: The two maritime legacies of Bronze Age rock art. In Skoglund, P., Ling, J., and Bertilsson, U. (eds.), North Meets South: Theoretical Aspects on the Northern and Southern Rock Art Traditions in Scandinavia, Oxbow Books, Oxford, pp. 59–86.

Melheim, L., Grandin, L., Persson, P.-O., Billström, K., Stos-Gale, Z., Ling, J., Williams, A., Angelini, I., Canovaro, C., Hjärthner-Holdar, E., and Kristiansen, K. (2018). Moving metals III: Possible origins for copper in Bronze Age Denmark based on lead isotopes and geochemistry. Journal of Archaeological Science 96: 85–105. https://doi.org/10.1016/j.jas.2018.04.003

Montelius, O. (1905). Om lifvet i Sverige under hednatiden, 3rd revised ed., P. A. Norstedt & Söner, Stockholm.

Müller, S. 1913. Sønderjyllands Stenalder. Aarboger for Nordisk Oldkyndighed og Historie Ser. 3 3, pp. 169–322.

Müller, S., and Vandkilde, H. (2021). The Nordic Bronze Age rose from Copper Age diversity: Contrasts in the Cimbrian Peninsula. In Austvoll, K. I., et al. (eds.), Contrasts in the Nordic Bronze Age: Essays in Honour of Christopher Prescott, Brepols, Turnhout, pp. 29–48.

Needham, S. (2009). Encompassing the sea: “Maritories” and Bronze Age maritime interactions. In Clark, P. (ed.), Bronze Age Connections: Cultural Contact in Prehistoric Europe, Oxbow Books, Oxford, pp. 12–37.

Nielsen, P. O. (2019). The development of the two-aisled longhouse in the Neolithic and Early Bronze Age, in Lotte Reedtz Sparrevohn, Ole Thirup Kastholm & Poul Otto Nielsen (eds.), Houses for the Living (Nordiske Fortidsminder 31:1), The Royal Society of Northern Antiquaries, Copenhagen, pp. 9–50.

Nielsen, H. F. (2000). The Early Runic Language of Scandinavia: Studies in Germanic Dialect Geography, Winter, Heidelberg.

Nordvall, L. (in press). Architecture and building practices in Late Neolithic and Bronze Age West Sweden.

Nordqvist, B. (2005). Huseby Klev, UV Väst Rapport 2005:2, Riksantikvarieämbetet.

Nørgaard, H. W., Pernicka, E., and Vandkilde, H. (2019). On the trail of Scandinavia’s early metallurgy: Provenance, transfer and mixing. PLoS ONE 14(7): e0219574. https://doi.org/10.1371/journal.pone.0219574

Nørgaard, H. W., Pernicka, E., and Vandkilde, H. (2021). Shifting networks and mixing metals: Changing metal trade routes to Scandinavia correlate with Neolithic and Bronze Age transformations. PLoS ONE 16(6): e0252376. https://doi.org/10.1371/journal.pone.0252376

Polomé, E. C. (1985). Methodological approaches to the ethno- and glottogenesis of the Germanic people. In Ureland, P. S. (ed.), Entstehung von Sprachen und Völkern: Glotto- und ethnogenetische Aspekte europäischer Sprachen, Max Niemeyer, Tübingen, pp. 45–70.

Price, T. D. (2015). Ancient Scandinavia: An Archaeological History from the First Humans to the Vikings, Oxford University Press, Oxford.

Prieto-Martínez, M. P. (2008). Bell Beaker communities in Thy: The first Bronze Age society in Denmark. Norwegian Archaeological Review 41(2): 115–158. https://doi.org/10.1080/00293650802517027

Ravn, M. (2022). Skibe og søfart i Danmarks oldtid, Turbine Forlaget, Aarhus.

Ringe, D. (2017). From Proto-Indo-European to Proto-Germanic, 2nd ed., Oxford University Press, Oxford.

Sarauw, T. (2006). Bejsebakken: Late Neolithic Houses and Settlement Structure, Nordiske Fortidsminder, Series C, Copenhagen.

Schmidt, K. H. (1991). The Celts and the ethnogenesis of the Germanic people. Historische Sprachforschung / Historical Linguistics 104(1): 129–152.

Schwantes, G. (1950). Die Jastorf-Zivilisation. In Behrens, G., and Werner, J. (eds.), Reinecke-Festschrift: Zum 75. Geburtstag von Paul Reinecke am 25. September 1947, Mainz, pp. 119–130.

Simonsen, J. (2017). Daily Life at the Turn of the Neolithic: A Comparative Study of Longhouses with Sunken Floors at Resengaard and Nine Other Settlements in the Limfjord Region, South Scandinavia, Jysk Arkæologisk Selskabs Skrifter 98, Jysk Arkæologisk Selskab, Aarhus.

Sjögren, K.-G. (2003). “Mångfalldige uhrminnes grafvar…” Megalitgravar och samhälle i Västsverige, Göteborg University, Göteborg.

Sprockhoff, E. (1936). Sonnenwagen und Hakenkreuz im nordischen Kreis. Germania 20: 1–9.

Strömberg, A. & D. Anderberg (2010). A Research Overview and Discussion of the Late Neolithic and the Bronze Age on Åland. In H. Martinsson-Wallin (ed.), Baltic prehistoric interactions and transformations: The Neolithic to the Bronze Age, Gotland University Press, Visby, 23–37.

Tallavaara M, P. Pesonen & M. Oinonen (2010). Prehistoric population history in eastern Fennoscandia. Journal of Archaeological Science 37: 251–260. https://doi.org/10.1016/j.jas.2009.09.035.

Tornberg, A. (2018). Stature and the Neolithic transition: Skeletal evidence from southern Sweden. Journal of Archaeological Science: Reports 17: 58–67.

van Sluis, P., Jørgensen, A. R., and Kroonen, G. (2023). European prehistory between Celtic and Germanic: The Celto-Germanic isoglosses revisited. In Kristiansen, K., Kroonen, G., and Willerslev, E. (eds.), The Indo-European Puzzle Revisited: Integrating Archaeology, Genetics, and Linguistics, Cambridge University Press, Cambridge, pp. 193–244.

Vandkilde, H. (1996). From Stone to Bronze: The Metalwork of the Late Neolithic and Earliest Bronze Age in Denmark, Aarhus University Press, Aarhus.

Vandkilde, H. (2017). The Metal Hoard from Pile in Scania, Sweden: Place, Things, Time, Metals and Worlds around 2000 BCE, Swedish History Museum Studies 29, Aarhus University Press, Aarhus.

Vandkilde, H. (2022). Entrepreneurs, metals and change: Scandinavia meets its neighbours in the earliest Bronze Age. In Ling, J., Chacon, R. J., and Kristiansen, K. (eds.), Trade before Civilization: Long-Distance Exchange and the Rise of Social Complexity, Cambridge University Press, Cambridge, pp. 309–333.

Vandkilde, H., Stephansen, C. F., Suchowska-Ducke, P., Bjørnevad-Ahlqvist, L. E., Andersen, C. S., Felding, L., Bjørnevad-Ahlqvist, M., Czebreszuk, J., and Nørgaard, H. W. (2024). Metal-for-amber in the European Bronze Age. Prähistorische Zeitschrift 99(1): 280–338. https://doi.org/10.1515/pz-2024-2003

von Arbin, S., and Lindberg, M. (2017). News on the Byslätt bark “canoe.” In Litwin, J. (ed.), Baltic and Beyond: Change and Continuity in Shipbuilding. Proceedings of the Fourteenth International Symposium on Boat and Ship Archaeology, National Maritime Museum, Gdańsk.

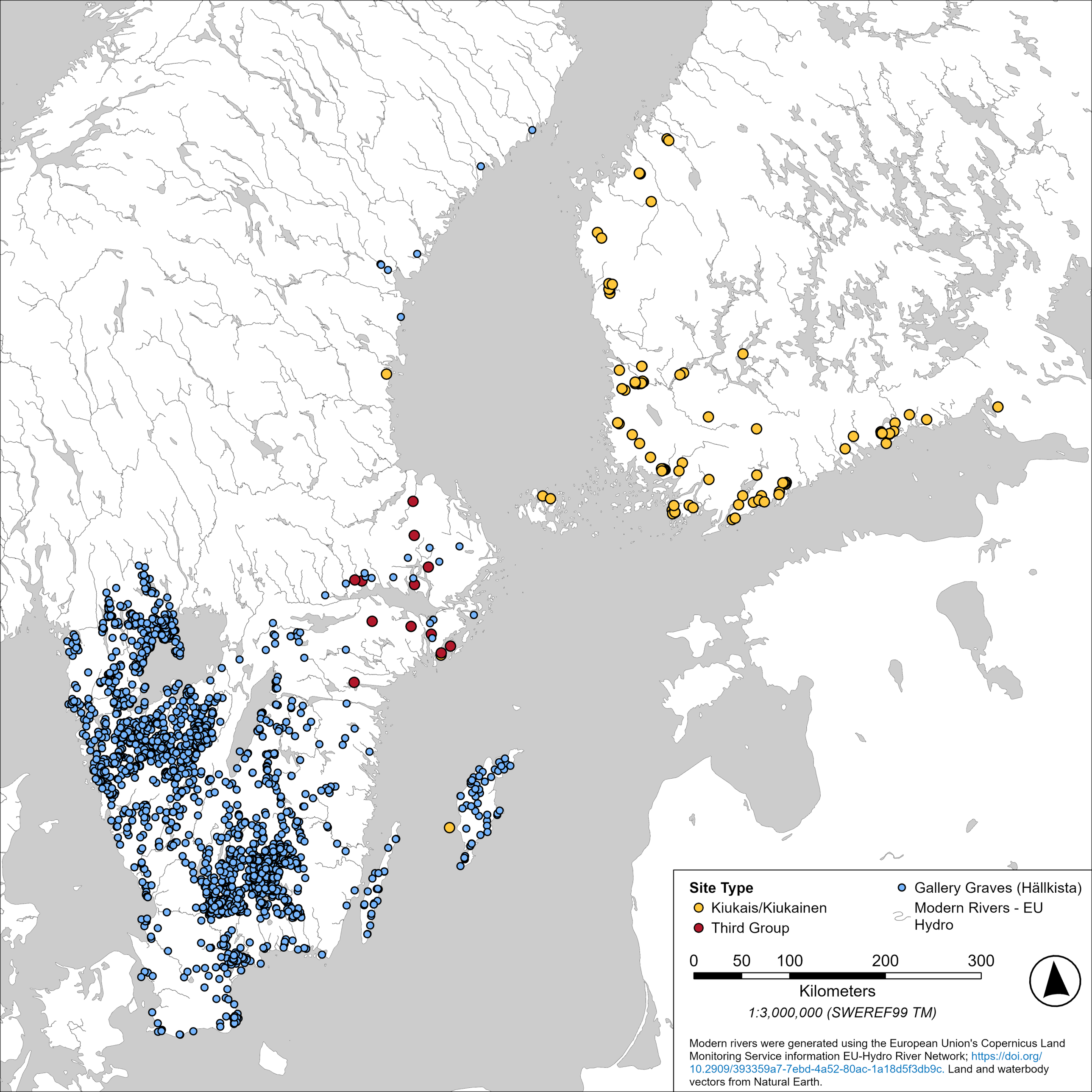
Weiler, E. (1994). Innovationsmiljöer i bronsålderns samhälle och idévärld: Kring ny teknologi och begravningsritual i Västergötland, Studia Archaeologica Universitatis Umensis 5, Umeå universitet, Umeå.

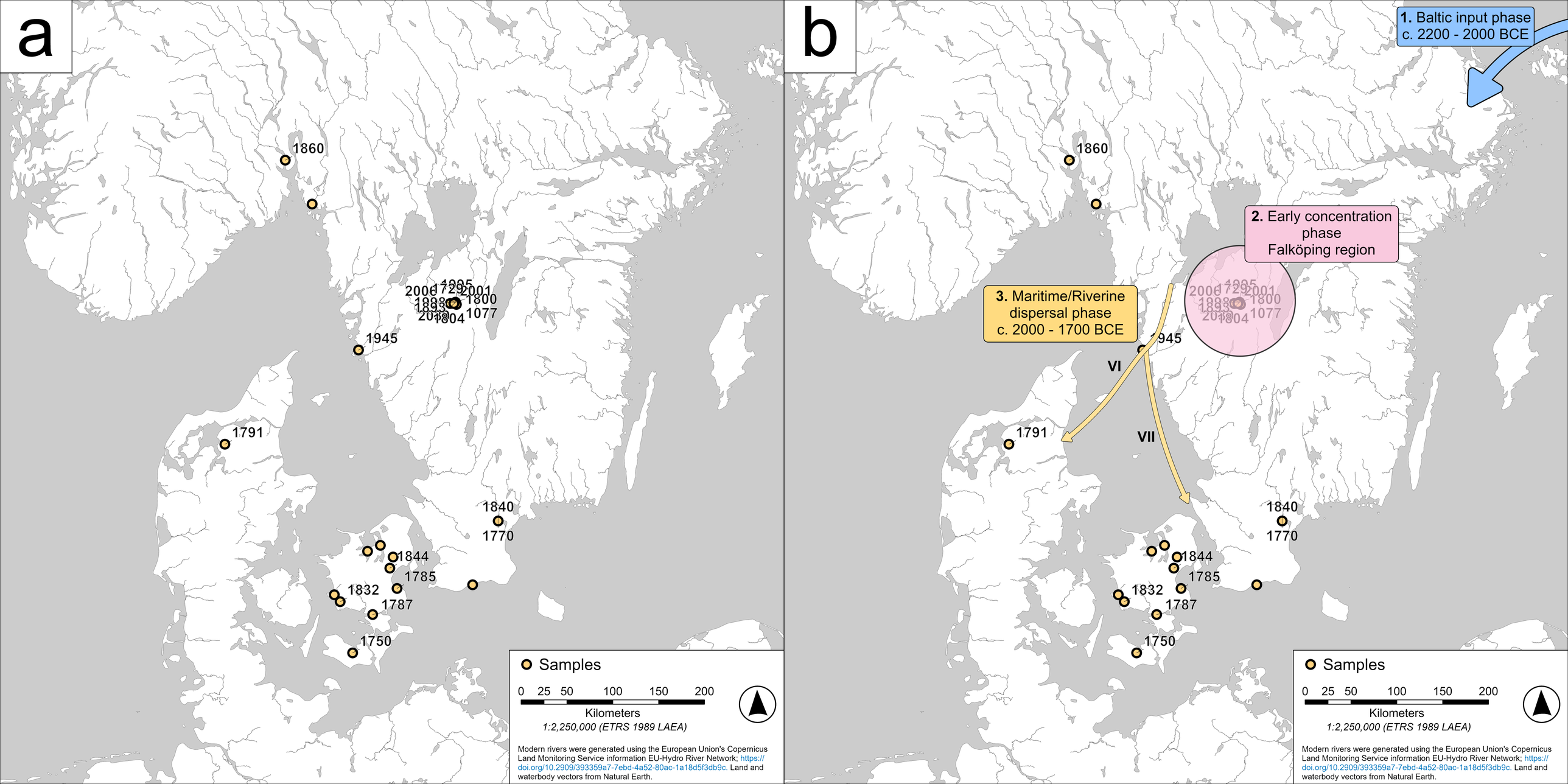
Winther Johannsen, J., Laabs, J., Bunbury, M. M. E., and Mortensen, M. F. (2024). Subsistence and population development from the Middle Neolithic B (2800–2350 BCE) to the Late Neolithic (2350–1700 BCE) in Southern Scandinavia. PLoS ONE 19(10): e0301938. https://doi.org/10.1371/journal.pone.0301938

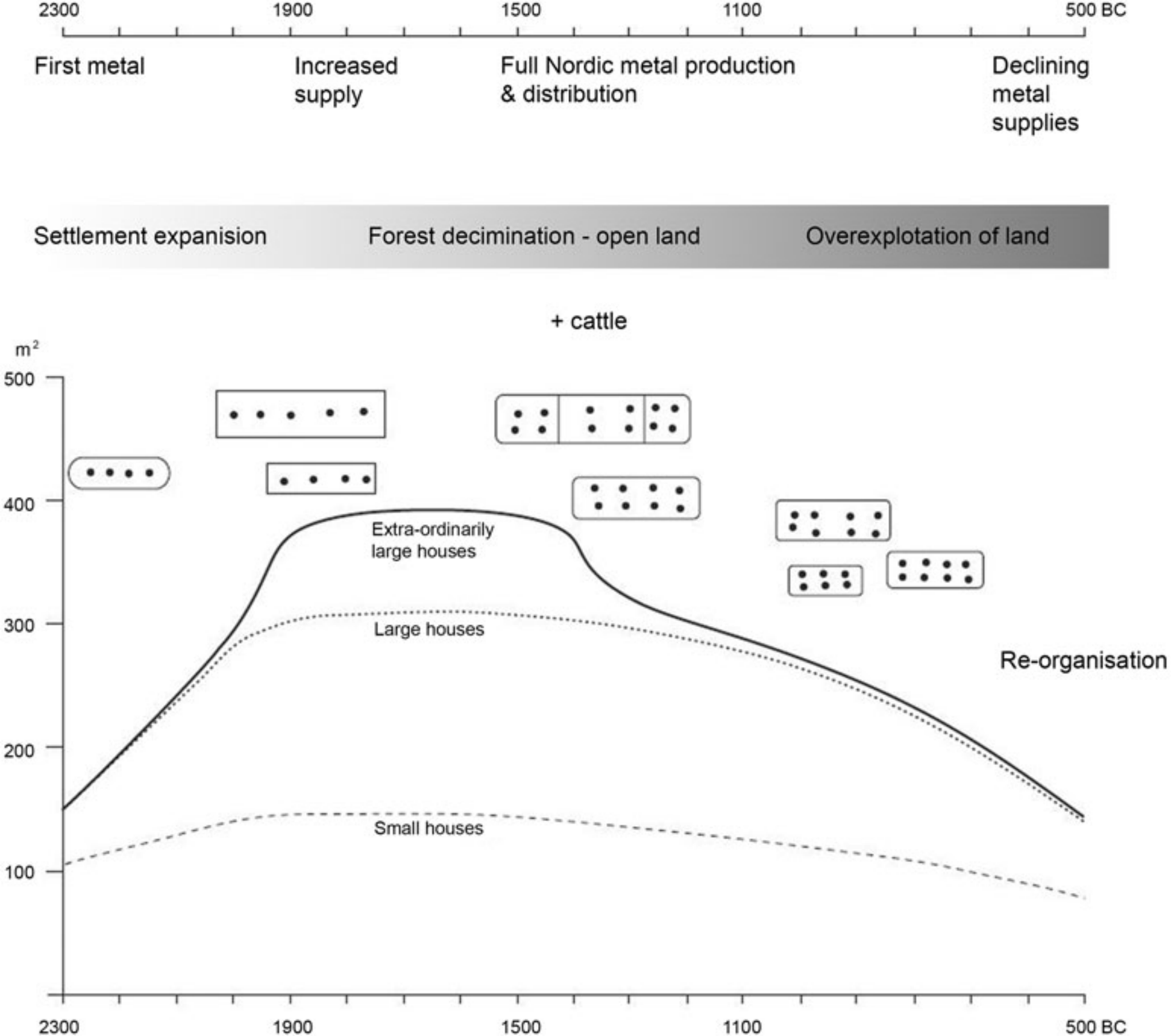
Wright, E. (2015 [1990]). The Ferriby Boats: Seacraft of the Bronze Age, Routledge Library Editions: Archaeology 55, Routledge, London.

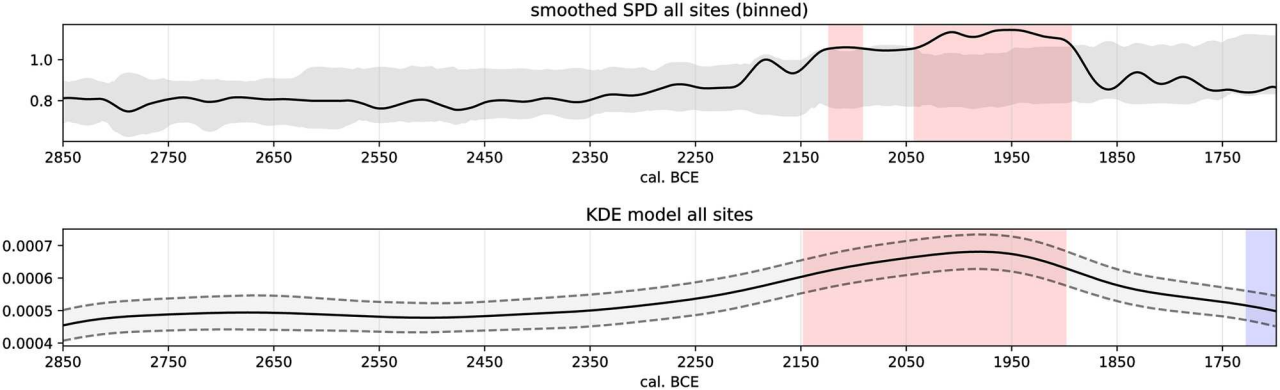
Zvelebil, M. (2006). Mobility, contact, and exchange in the Baltic Sea basin 6000–2000 BC. Journal of Anthropological Archaeology 25(2): 178–192. https://doi.org/10.1016/j.jaa.2005.11.003

Østmo, E. (2005). Over Skagerak i steinalderen. Noen refleksjoner om oppfinnelsen av havgående fartøyer i Norden, Viking, 68, 55–82.


Site Type
Kiukais/Kiukainen
Third Group
Gallery Graves (Hällkista)
Modern Rivers - EU Hydro
0
50
100
200
300
Kilometers
1:3,000,000 (SWEREF99 TM)
Modern rivers were generated using the European Union's Copernicus Land Monitoring Service information EU-Hydro River Network; https://doi.org/10.2909/393359a7-7ebd-4a52-80ac-1a18d5f3db9c. Land and waterbody vectors from Natural Earth.


a
1860
1945
1791
1840
1770
1844
1785
1832
1787
1750
Samples
0 25 50 100 150 200
Kilometers
1:2,250,000 (ETRS 1989 LAEA)
Modern rivers were generated using the European Union's Copernicus Land Monitoring Service information EU-Hydro River Network; https://doi.org/10.2909/393359a7-7ebd-4a52-80ac-1a18d5f3db9c. Land and waterbody vectors from Natural Earth.
b
1. Baltic input phase
c. 2200 - 2000 BCE
2. Early concentration phase
Falköping region
3. Maritime/Riverine dispersal phase
c. 2000 - 1700 BCE
VI
VII
1860
1945
1791
1840
1770
1844
1785
1832
1787
1750
Samples
0 25 50 100 150 200
Kilometers
1:2,250,000 (ETRS 1989 LAEA)
Modern rivers were generated using the European Union's Copernicus Land Monitoring Service information EU-Hydro River Network; https://doi.org/10.2909/393359a7-7ebd-4a52-80ac-1a18d5f3db9c. Land and waterbody vectors from Natural Earth.


2300
1900
1500
1100
500 BC
First metal
Increased supply
Full Nordic metal production & distribution
Declining metal supplies
Settlement expanision
Forest decimination - open land
Overexplotation of land
+ cattle
m²
500
400
300
200
100
Extra-ordinarily large houses
Large houses
Small houses
Re-organisation
2300
1900
1500
1100
500 BC


smoothed SPD all sites (binned)
1.0
0.8
2850
2750
2650
2550
2450
2350
2250
2150
2050
1950
1850
1750
cal. BCE
KDE model all sites
0.0007
0.0006
0.0005
0.0004
2850
2750
2650
2550
2450
2350
2250
2150
2050
1950
1850
1750
cal. BCE

Gallery Grave (Hällkista)

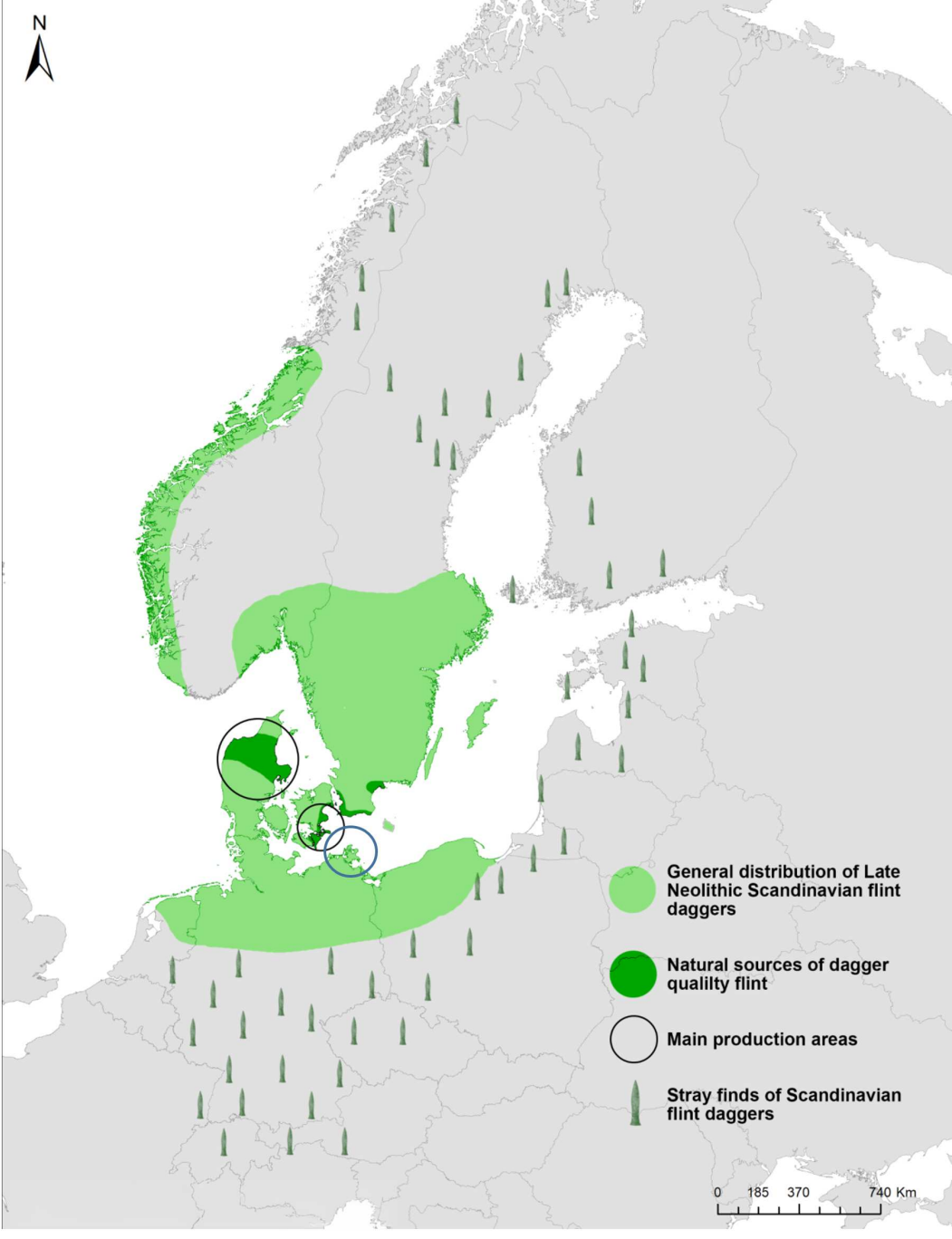
Gallery grave with port hole

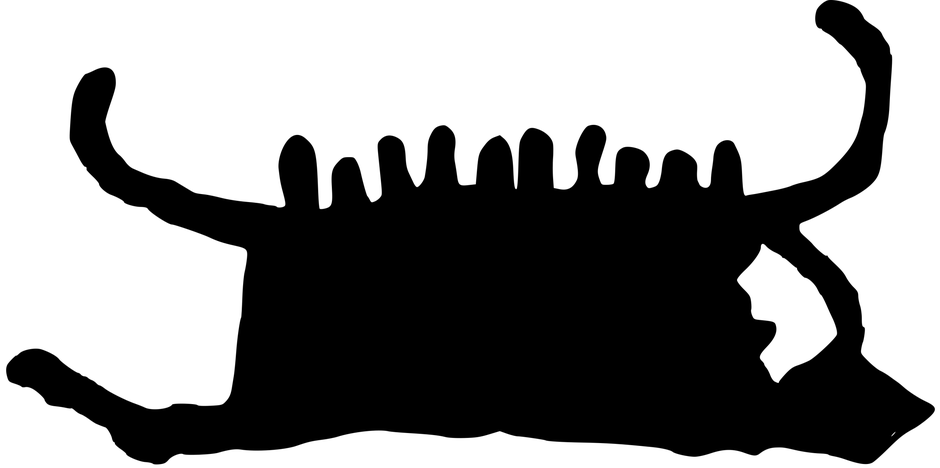
0 40 80 160 240

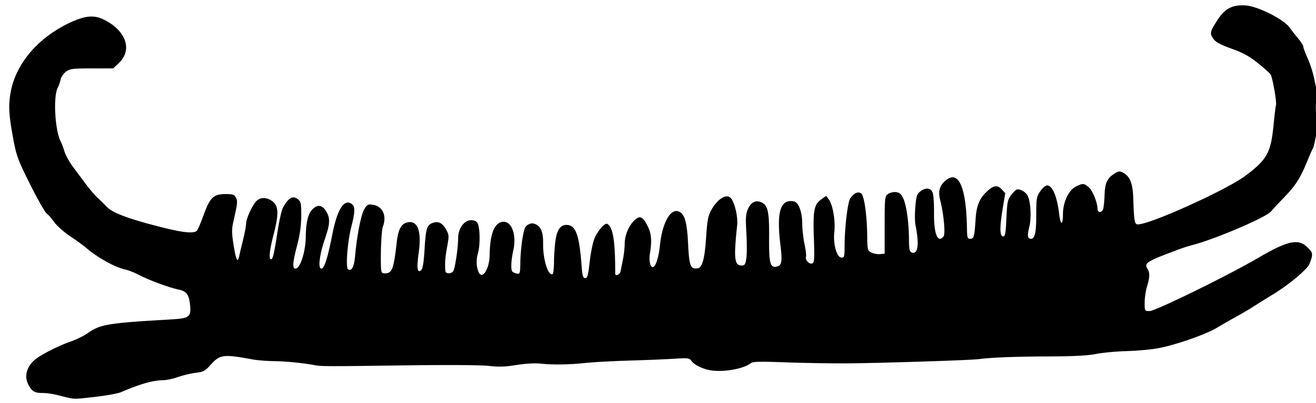
Kilometers

1:2 500 000 (SWEREF99 TM)

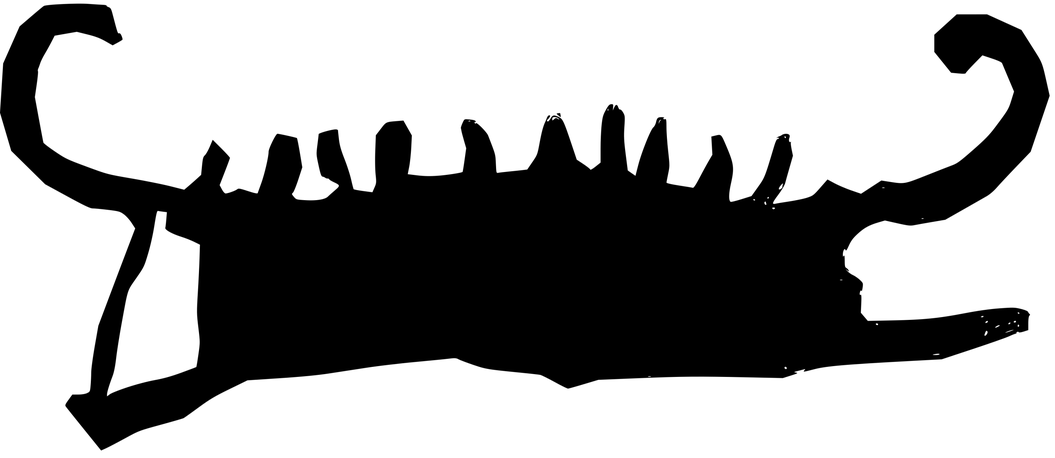
Modern rivers were generated using the European Union's Copernicus Land Monitoring Service information EU-Hydro River Network; https://doi.org/10.2909/393359a7-7ebd-4a52-80ac-1a18d5f3db9c. Land and waterbody vectors from Natural Earth.

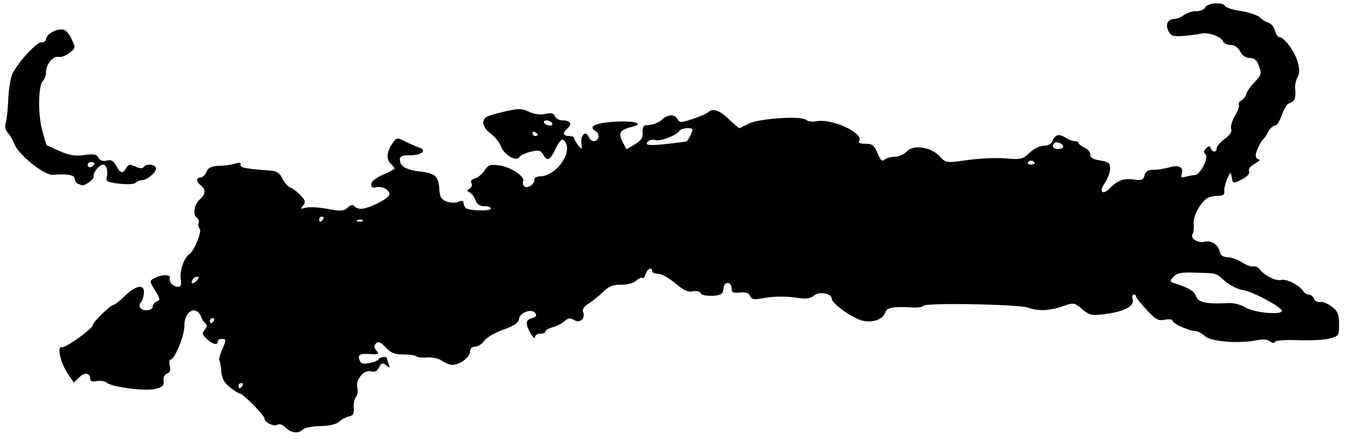

N
General distribution of Late Neolithic Scandinavian flint daggers
Natural sources of dagger qualilty flint
Main production areas
Stray finds of Scandinavian flint daggers
0 185 370 740 Km





Kville, Bohuslän





Truehøjgård, Jutland

Skagerrak

Falbygden

VI

VII

Kattegat

SGU Shoreline 3800BP

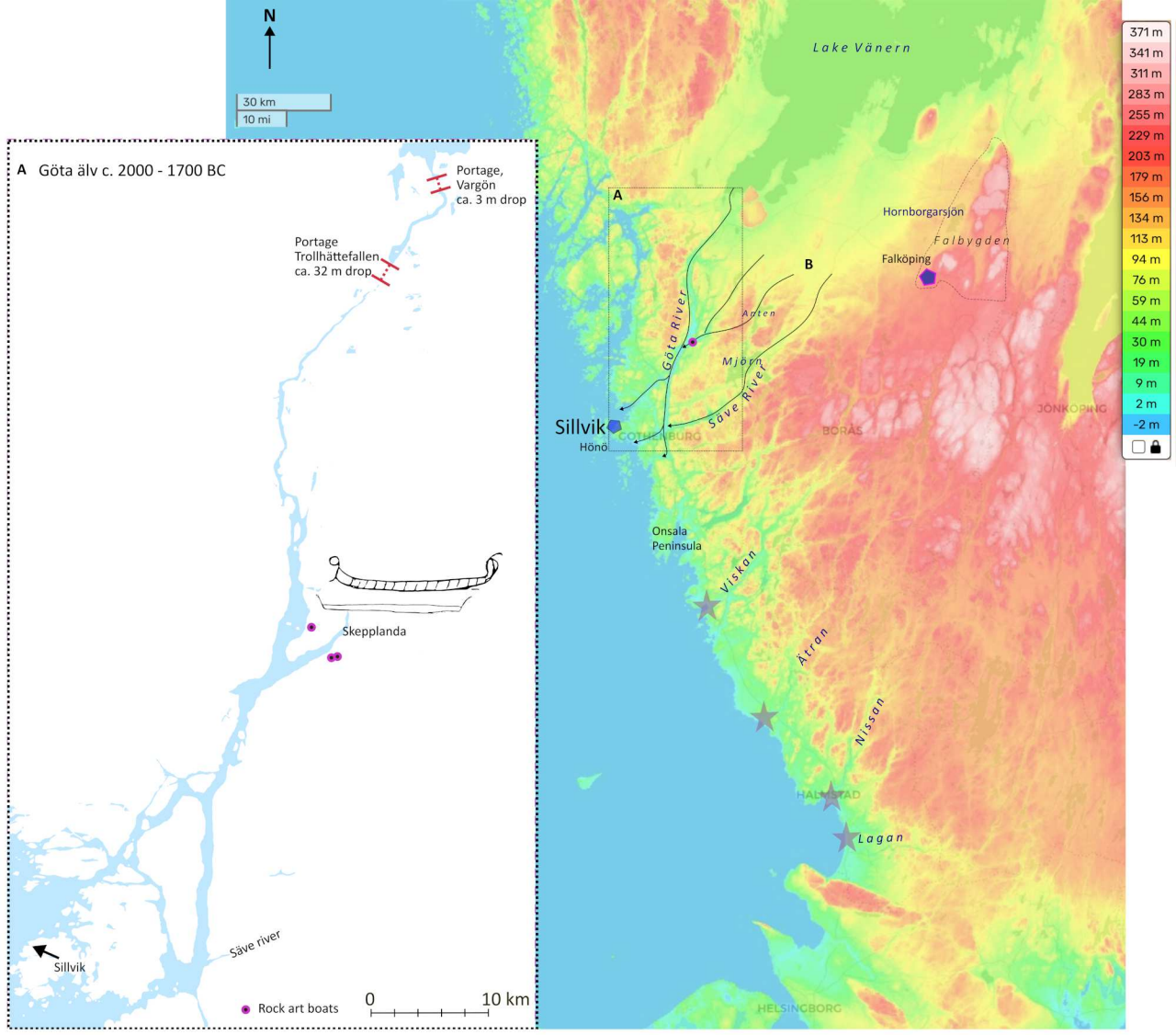
Modern Rivers - EU Hydro

0 15 30 60 90

Kilometers

1:1,000,000 (SWEREF99 TM)

Modern rivers were generated using the European Union's Copernicus Land Monitoring Service information EU-Hydro River Network; https://doi.org/10.2909/393359a7-7ebd-4a52-80ac-1a18d5f3db9c. Land and waterbody vectors from Natural Earth.


N
30 km
10 mi
Lake Vänern
371 m
341 m
311 m
283 m
255 m
229 m
203 m
179 m
156 m
134 m
113 m
94 m
76 m
59 m
44 m
30 m
19 m
9 m
2 m
-2 m
A
B
Göta River
Säve River
Åsen
Mjörn
Sillvik
Hönö
Hornborgarsjön
Falbygden
Falköping
Onsala Peninsula
Viskan
Åtran
Nissan
Lagan
GOTHENBURG
BORÅS
JÖNKÖPING
HALMSTAD
HELSINGBORG
A Göta älv c. 2000 - 1700 BC
Portage, Vargön ca. 3 m drop
Portage Trollhättefallen ca. 32 m drop
Skepplanda
Säve river
Sillvik
Rock art boats
0
10 km

Sunken-floor Hut
Two-aisled House
Modern Rivers - EU Hydro
SGU Shoreline 3700BP

0 5 10 20 30
Kilometers

1:300,000 (SWEREF99 TM)

Modern rivers were generated using the European Union's Copernicus Land Monitoring Service information EU-Hydro River Network; https://doi.org/10.2909/393359a7-7ebd-4a52-80ac-1a18d5f3db9c. Land and waterbody vectors from Natural Earth.

N

Lake Vänern

Lake Vänern - Hönö
c. 12 h, 2 days

? Falbygden

?

Lake Vättern

Sillvik

1.

2.

Fjärås

c. 1 day

3.

c. 1 day

4.

c. 1 day

5.

c. 1 day

6.

7.

c. 2 days

8.

9.

Onsala - Jylland
c. 11 h/1 day

Onsala - Öresund
c. 27 h or c. 6 on-water days

0 50 100 150 200 km

Natural Resources

Amber

Flint

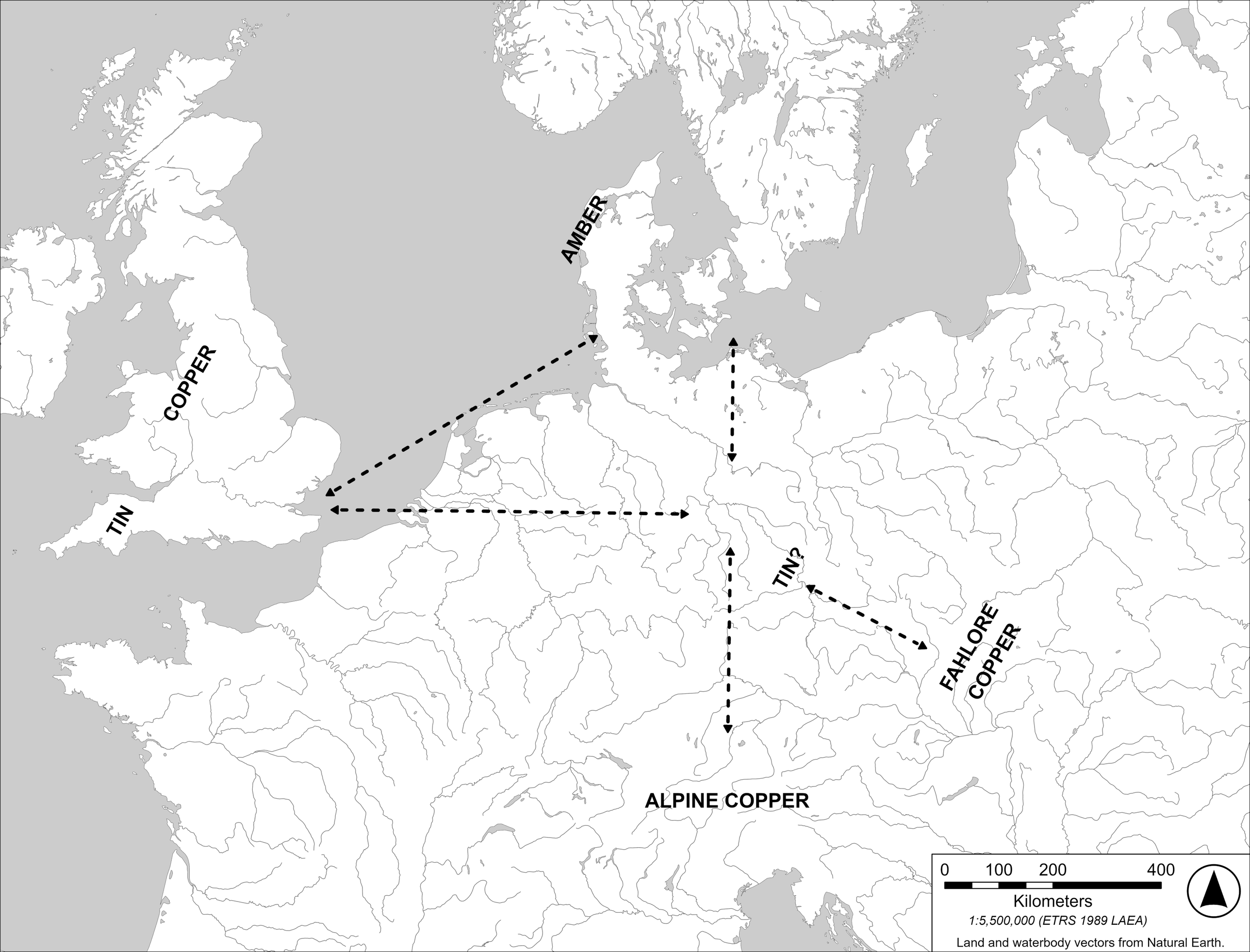
Flint Mine

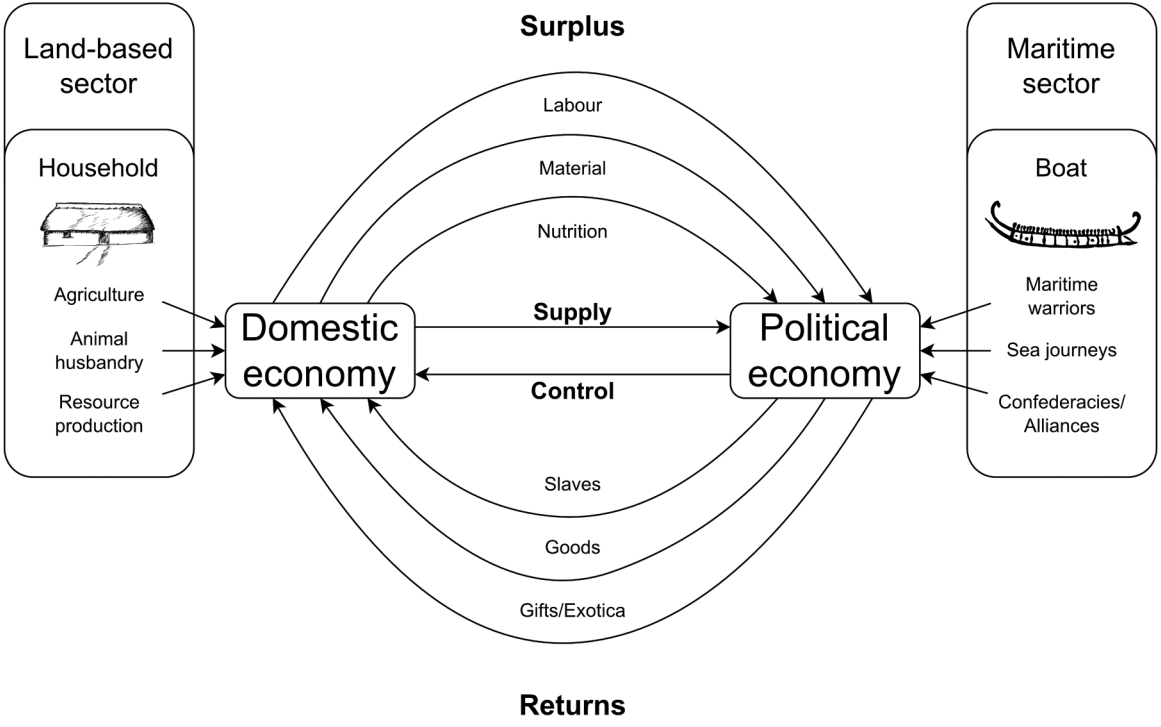
0 35 70 140 210

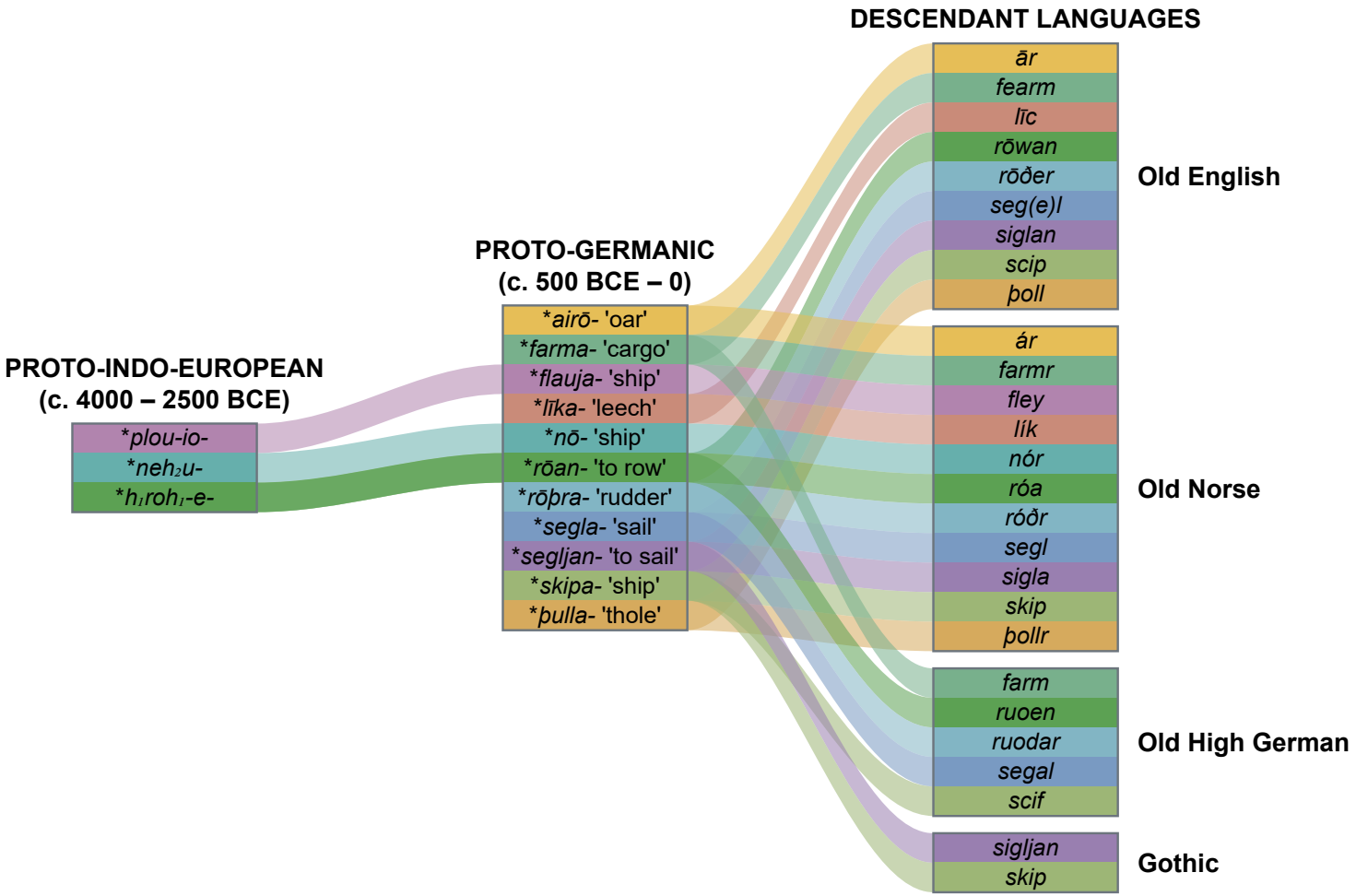
Kilometers

1:2,000,000 (ETRS 1989 LAEA)

Modern rivers were generated using the European Union's Copernicus Land Monitoring Service information EU-Hydro River Network; https://doi.org/10.2909/393359a7-7ebd-4a52-80ac-1a18d5f3db9c. Land and waterbody vectors from Natural Earth.


AMBER
COPPER
TIN
TIN?
FAHLORE
COPPER
ALPINE COPPER
0
100
200
400
Kilometers
1:5,500,000 (ETRS 1989 LAEA)
Land and waterbody vectors from Natural Earth.


Land-based sector
Household
Agriculture
Animal husbandry
Resource production
Surplus
Labour
Material
Nutrition
Domestic economy
Supply
Control
Political economy
Slaves
Goods
Gifts/Exotica
Returns
Maritime sector
Boat
Maritime warriors
Sea journeys
Confederacies/ Alliances


DESCENDANT LANGUAGES
PROTO-INDO-EUROPEAN
(c. 4000 – 2500 BCE)
*plou-io-
*neh₂u-
*h₁roh₁-e-
PROTO-GERMANIC
(c. 500 BCE – 0)
*airō- 'oar'
*farma- 'cargo'
*flauja- 'ship'
*līka- 'leech'
*nō- 'ship'
*rōan- 'to row'
*rōþra- 'rudder'
*segla- 'sail'
*segljan- 'to sail'
*skipa- 'ship'
*þulla- 'thole'
ār
fearm
līc
rōwan
rōðer
seg(e)l
siglan
scip
þoll
Old English
ár
farmr
fley
lík
nór
róa
róðr
segl
sigla
skip
þollr
Old Norse
farm
ruoen
ruodar
segal
scif
Old High German
sigljan
skip
Gothic



Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SouthwardsbySeaTable1.docx