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Creating Order or Revealing Disorder? Some Preliminary Results Using Multiple Correspondence Analysis (MCA) in Studying Archaeological Boat Finds from Norway (AD 1050–1700)

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Abstract

This article discusses the use of statistical methods for systematising 96 archaeological ship finds, mainly from the southern and south-eastern coast of Norway. It draws on an article published in 2009 by Jan Bill, where he did a similar investigation of material from the Danish area. The method of multiple correspondence analysis (MCA) provides a way to summarise categorical data in a reduced number of dimensions. The results are presented in a geographical space, a plot, that can be used for making interpretations and assumptions of cohesions and divergences in the material. It is a way of analysing continuity and change in boatbuilding techniques that avoids using arbitrary and ambiguous concepts of historical (ship) types. Instead, the building techniques, the ways of 'doing things', make the premises for classification. The results in this article can be considered preliminary, its primary function being a discussion on methodology.

Keywords

archaeological ship finds – statistical methods – ship-building technology

1 Introduction

This article presents some preliminary results from an ongoing research project at Stockholm University.[1] The project discusses technical variables in the archaeological boat- and ship material from the early medieval period to 1700 in the historical region of Viken[2] (Figs. 1 and 2).[3] This period involved rapid and slow societal changes on many levels (e.g. economy and trade, science, state formations, religion, identity, and social relations). Most relevant for the perspectives in this article is that the changes also influenced craft practices (Adams 2003; 2013; Bill 1997; Varenius 1992) both on an everyday basis and initiatives from the growing apparatus connected to the Crown. Also, craft practices contributed to societal changes in a complex network of causes and effects as an outcome of people's practices and ways of doing things.

1 The results discussed here derive from Tori Falck's ongoing PhD-project at Stockholm University, Department of Archaeology and Classical Studies.
2 The geographical term Viken is here defined loosely as the counties in the Oslofjord and Agder coastal regions. In the PhD project, the Bohuslän region in Western Sweden will also be included. This means that more vessels will be included in the statistics (in total, 112). Historically, the concept of Viken has contained varying meanings, but the primary purpose of applying it in this project is to connect the regions of Oslofjord and Skagerrak on both sides of the modern borders of Sweden and Norway.
3 A comprehensive list will be published in T. Falck's PhD Thesis.

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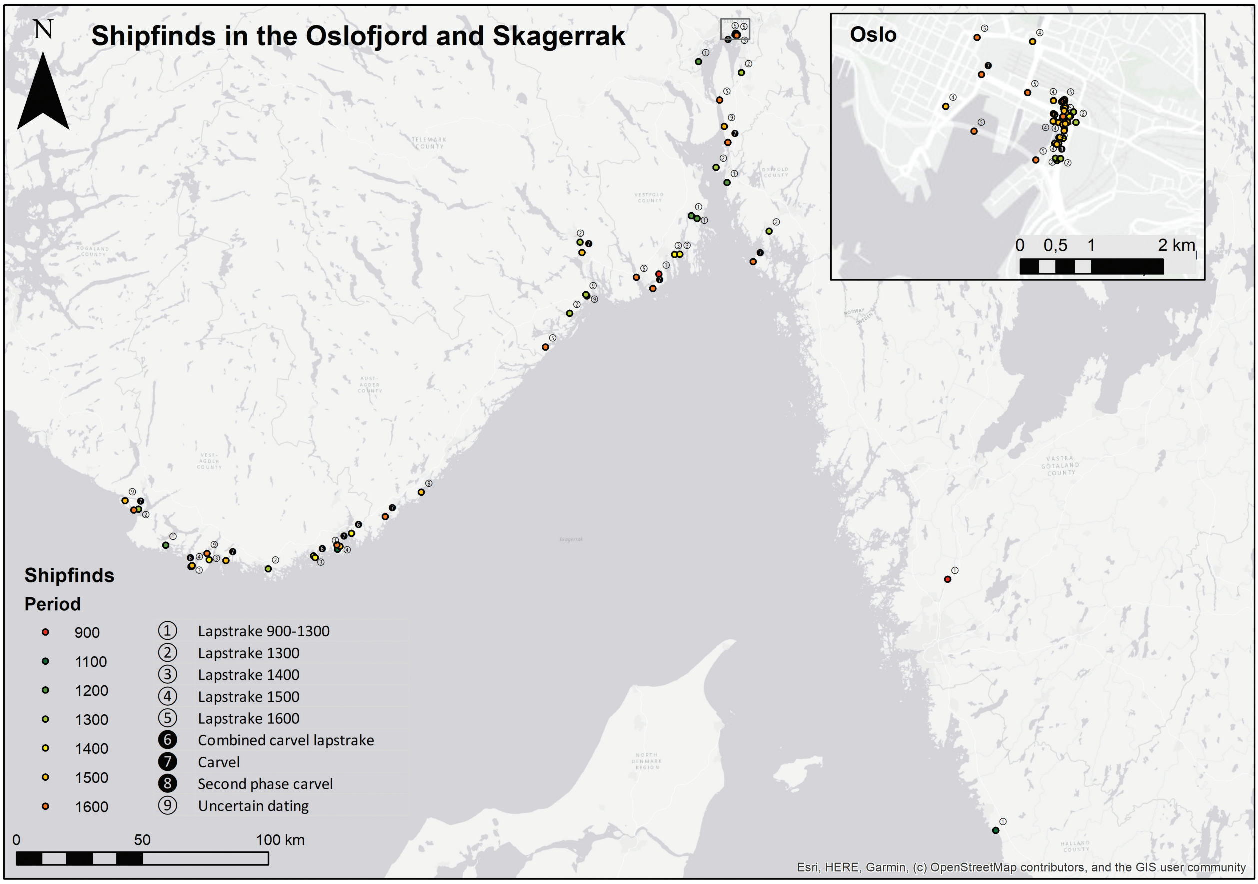

FIGURE 1 Map of the ship finds systematised and run statistically using MCA in R Studio. The ship finds are labelled by colour according to date (century) and dominant building technique (number in circle). Two finds are from Western Sweden, while 94 are from the Oslofjord and Agder regions in Norway. The two included finds from the 10th century are dated approximately around AD 1000.
MAP: MORTEN REITAN, NORWEGIAN MARITIME MUSEUM

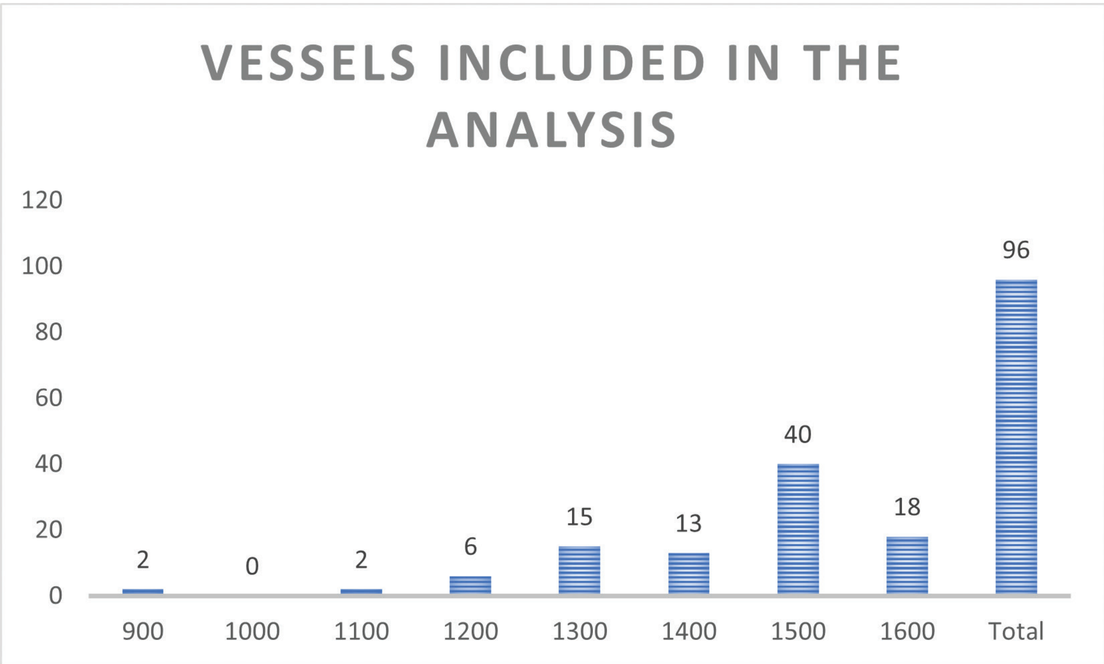

FIGURE 2 Diagram of 96 vessels included in the analysis and sorted by date. Note that the dating of the vessels is restricted to a century in the diagram. The two earliest vessels attributed to the 10th century are from approximately AD 1000.

A vital motivation in the research project is to contextualise the changes in craft practices. The contextualisation considers aspects of theoretical perspectives on craft and craft performances, including human relations with things and materials and their changing manifestations over time. This article will discuss a possible methodological path to get there, where the goal is to understand continuity and change in techniques based on an often-fragmented archaeological material. In 2009, Jan Bill published an article where the Danish ship archaeological material was systematised according to various technical properties and examined using multiple correspondence analysis (MCA) (Bill 2009). The present article attempts a similar approach to the Norwegian material and can be considered a regional expansion of Bill's methodological pursuit. Some preliminary results will be presented and discussed, but considering the early stages of this work, the results will primarily provide a base for evaluating the method.

2 Material and Method

The idea of using statistics to examine the ship finds in southern and south-eastern Norway grew as it became evident that the complex nature of the material itself demanded a rigorous methodological approach to systematisation. There was a need to build a better understanding of the technical characteristics that archaeologists are trained to identify and what these properties represent when activating them in an analysis of the material over time. This approach might also present an opportunity to activate the rich database on ship technology built up over years of meticulous studies, adding new research perspectives and explanations to it (Adams 2013, 1). Not least, it offers a methodology that facilitates a comparative perspective over regional distances, not limited by modern national borders.

Ships and boats are complex technological structures (Adams 2001, 300). This insight can be maintained without any deeper knowledge of the quality and character of these features. It might also explain a techno-bias in maritime archaeology or a claimed tendency to fail to make the technical descriptions of a steadily growing wreck database relevant to a broader societal context (Eriksson 2014, 33). But, as Dobres clarifies, the study of prehistoric technology has a long and privileged place in archaeology as such, and *the study of techniques and innovations through time and across space is central to practically any understanding of the human career* (Dobres 2000, 10). This implies that it is more a question of how, and not why, maritime archaeologists should work with technology, or preferably, crafts. The limited length of this article gives little room for theoretical reflection, but this section is added to underline the potential for maritime archaeology to investigate the more 'messy sides of technology' (Dobres 2000, 10), where the social aspects of craft performances (Hocker 2013; Ravn 2020), and complex relationships between people, things and materials are as interesting as ship types, sailing and cargo capacities, and even ships as symbols.

3 The Find Corpus

The data consists of archaeological ships and boats dating from AD 1050 to 1700, with some exceptions. As in Bill's (2009, 430) analysis, they are incorporated regardless of the provenance of timbers, and the finds are dated by dendrochronology or context, not by typology. Exceptions from this are vessels that are dated with $^{14}C^{-}$ method, which makes them less accurate. Two earlier overview reports have been made concerning ship finds in the region, where the first involved the medieval finds only (Nævestad 1999), and the second is an unpublished report of all the known finds in the region (Falck & Kvalø 2015, unpublished). Here, we have only concentrated on the coastal finds because of the general lack of inshore crafts. The lapstrake-built boats are the main interest for discussion, but the carvel-built vessels are also included in the statistics. The main difference in the selection compared to Nævestad (1999) is that the material also consists of vessels from the period after the Protestant Reformation (1536/37). This is also where the main increase of new finds in the region has been added.

Out of about 150 finds in the national database for the region, 96 are included in the statistical analysis. The exclusion of 1/3 concerns the insufficient degree of information connected to these. From some sites, the information is restricted to a geographical position, probable dating, and a classification of primary building method (i.e. lapstrake or carvel). For a vessel to be methodologically suitable for statistical analysis, a minimum of information on its technical properties must be available, but we will elaborate on this later. The 96 vessels comprise a broad functional range from vernacular rowing boats to carvel-built ships. The early period, from 1050–1300, is poorly represented in the material. For this reason, two vessels from circa 1000 are incorporated in the analysis, namely the *Klåstad* (Christensen & Leiro 1976; Christensen 1978) and the *Äskekärr* (Humbla 1934; Borg et al. 2000) ships. For a similar reason, the *Galtabäck 2* ship from the Swedish region of Halland (Enqvist 1929, 36), dating from 1100–1150 (Björck 2005), is included. Indirectly, this choice also concerns how Bill defined his list of properties for the publication in 2009. He incorporated finds from 900–1600, and many of the properties were fit to illuminate the significant changes in boatbuilding techniques from the Viking period and through the early parts of the medieval.

The provenance could be inferred for 56 of the 96 finds. Reading the dendrochronological reports for the early ships (until 1400), the provenances are ambiguous, and few point towards timbers that with certainty have grown in the region. The identified timbers are located in western and southern Sweden, Denmark, Poland, Germany, and the Netherlands. It is not unlikely, however, that some of the vessels *without* suggested provenance are from the area of investigation. Five of the 13 finds from the 15th century have timbers with identified provenance. They are located in southern Scandinavia/southern Baltic, southern Norway/and southern or eastern Baltic, southern Sweden, and south-western Sweden/Zealand, respectively. The situation changed dramatically in the 16th century. A minimum of 29 of the 40 finds from the 1500s is provenanced to southern Norway, western Sweden, or a combination of both. This trend continued through the 17th century. A comparison with the Danish material makes it clear that the situation has differences that must be addressed. Bill commented on the Danish material like this:

> The provenanced finds indicate that the record of ship-finds until ca. 1355 is dominated by ships from medieval Denmark or adjacent Scandinavian waters, while it for the remaining two and a half century is more internationally composed, although timber trade may obscure the picture. (Bill 2009, 430)

The early provenances in Norway are dominated by Swedish and Danish origin ('adjacent Scandinavian waters') and timbers from the Southern Baltic and the North Sea region. If one is to take this result literally, the material does not reflect a tradition of building on local/regional timbers in the Oslofjord and Agder regions. Bearing in mind that (parts of) western Sweden should be viewed administratively together with Norway in large parts of the medieval period, nuances this picture. Still, it is striking that the results before the 16th century suggest that most vessels that ended their endeavours in the region are built on timbers from 'elsewhere' (i.e. Sweden, Denmark, or the Continent). Interestingly, the 1500s were dominated by timbers from western Sweden and/or southern Norway. This coincides with the expansion of the Norwegian timber trade in the 16th century and the introduction of the water-powered saw, which came into common use in the first half of the century (Moseng et al. 2020, 404ff.)

There are also other essential clarifications from the numbers in Figure 2 that help shed some light on what has just been discussed. The most important is the bias towards finds from the town of Oslo. Extensive, ongoing excavations in the harbour of Oslo have brought forth the majority of finds from the 14th century onwards. Of the 15 finds from the 14th century, six are found in the medieval harbour of Oslo. *Sørenga 1* (1300) (Christensen 1973; Eriksen 1994a), *Sørenga 3* (1320) (Paasche et al. 1995; Eriksen 1993, 1994b) and *Nordenga 1* (1330–40) (Brandstrup 2013; Paasche et al. 2020) are the oldest of these, all from the first half of the 1300s. Five of the 13 finds from the 15th century are also found in Oslo. The Oslo-dominated pattern becomes even more distinct in the 16th century, where 33 out of 40 finds from the century are found in Oslo (Vangstad et al. 2020), and only seven are found in the rest of the Oslo fjord and Agder region. Eight of 18 finds from the 17th century are also from Oslo and illustrate the situation just commented well. The Oslo finds are linked to an urban and partly international context and cannot be taken to represent local building traditions without further contextualisation. Due to excavation and post-excavation documentation, Oslo is not only dominant in the sheer number of vessels but also the degree of knowledge we have from them. The difference in the quality of the information we have from the fully excavated finds and the ones only known from surveys is immense and echoes all aspects, from dating and provenance to technical details.[4]

4 Systematisation – Choice of Properties

Collecting the data from the ship finds first involved working through Bill's list of properties and then systematise the relevant material accordingly. The 49

4 Since knowledge of the pre-defined technical properties of the ship finds is a criterion for being accepted for the statistical analyses, this adds to the Oslo bias. Most of the Oslo vessels are excavated and have undergone post-excavation documentation (Falck et al. 2013; Falck 2014). This means that many of the excluded vessels are from other parts of the region.

properties in Bill's analysis included conversion method for the planking, type of fasteners, plank scarf types, choice of caulking material, the absence or presence of decorations, framing design and distance between frames, keel and keelson design, joint types for joints in the keel, stems, keelson and stringers, and fastening methods for the keelson (Bill 2009, 430). A slightly different approach was chosen concerning the main building methods, as they were included in the analysis. In line with Bill's motivation to not have *types* as a starting point, these were defined as *lapstrake*, *carvel* and *carvel/lapstrake*. The last of these three referred to ships with a flat flush laid bottom and lapstrake-built sides, i.e. cogs. Lapstrake-built vessels with a secondary layer of carvel were noted as present with both properties. These converted boats are particularly interesting to the investigation since they combine 'old and novel' techniques (Nielsen 2010). No half-carvels (Eriksson 2010) were identified in the material. Also, *confirmed building phase* was included to capture the biographies of finds that had been rebuilt significantly during their life span. The property was not activated in the statistics but was kept as a substantial observation. The decision not to activate the property in the statistics was mainly taken because it did not meet the need for methodical stringency. Additional properties concerning the vessel's stem- and stern constructions were also added, primarily because of the introduction of the transom as a significant new property during the last half of the 16th century in the Oslo material. As a result, the total number of properties was expanded from 49 to 60 (Table 1).

5 The MCA: Collect, Project, Interpret

Bill was dissatisfied with the use of an elaborate nomenclature of historically known ship types to understand an imperfect archaeological material. By defining and systematising the available technical information from the fragmented archaeological material, he intended to reveal possible underlying technical concepts or traditions (Bill 2009, 429; see also Maarleveld 1995). This is precisely what MCA is created to do. Correspondence analysis provides a way to summarise categorical data in a reduced number of dimensions. The goals of correspondence analysis can be described as a method that a) summarises the information you find in a presence/absence table, b) provides a graphical projection of this information, and c) facilitates the interpretation of the essential structures in the data material that the table contains (Hjellbrekke 1999, 8). Its strength is that

TABLE 1 List of 60 properties that have been used to systematise the 96 vessels. The properties are organised according to 11 categories (first column). The last four properties (category stem/stern shape) are not included.

Categories	Properties	Active or passive
0	Period	Not included
0 Dating, provenance, length*	Building date	Not included
0	Provenance	Not included
0	Overall length	Not included
1	Confirmed building phases	Passive
2 Main building method	Lapstrake	Active
3	Carvel	Active
4	Carvel/lapstrake	Active
5	planks_radially_split	Active
6 Conversion	planks_tangentially_split	Active
7	planks_sawn	Active
8	round_rivet_shanks	Active
9	square_rivet_shanks	Active
10 Joining of strakes	rivet_rove	Active
11	doublehooked_nails	Active
12	treenails	Active
13	caulking_hair	Active
14	caulking_plant	Active
15	caulking_inlaid	Active
16	caulking_with_laths	Active
17	short_plank_scarfs	Active
18 Strake scarfs	long_plank_scarfs: 50–100% of plank w.	Active
19	end_to_end_joints	Active
20	multiprofiles	Active
21 Profiles	singleprofiles	Active
22	no_profiles	Active
23	framing_distance_<35	Active
24	framing_distance_35–44cm	Active
25	framing_distance_45–54cm	Active
26 Framing distance	framing_distance_55–64cm	Active
27	framing_distace_65–74cm	Active
28	framing_distance_75–84cm	Active
29	framing_distance_>85cm	Active
30	biti_construction	Active
31	grown_stanchion	Active
32	stanchion_board	Active

TABLE 1 List of 60 properties (*cont.*)

Categories	Properties	Active or passive
33	keelson_chock	Active
34	other_connections_ between-keelson_and_*biti*	Passive
35 Transverse strenghtening techniques	scarfed_frame	Active
36	protruding_beamheads	Active
37	side_timbers	Active
38	parallel_sided	Active
39	vertical-knees/buttresses/ keelson-riders	Passive
40	horizontal_knees	Passive
41	keel_plank	Active
42	keel_T	Active
43	keel_Y	Active
44	keel_U	Active
45	stringers_joggled	Active
46 Longitudinal strengthening techniques	stringers_plankshaped	Active
47	direct_tree_or_iron_nails	Active
48	keelson_joggled_over_ frames	Active
49	keelson_cut_into_frames	Active
50	beamshaped_keelson	Active
51	plankshaped_keelson	Active
52	maststep_in_frame	Active
53	hooks_in_major_joints	Active
54 Joining of timbers	through_scarfs_in_ major_joints	Active
55	stopped_scarfs_in_ major_joints	Active
56	mortise_and_tenon_in_ major_joints	Active
57	Double_ended	Active
58	Transom	Active
59	Straight_stern	Active
60 Stem/stern shape	Curved_stern	Active
0	Flat_sides	Not included**
0	Single_rebate	Not included**
0	Individual_recess	Not included**
0	Covering_base	Not included**

*Basic information for use in discussion
** Will be included in the main study

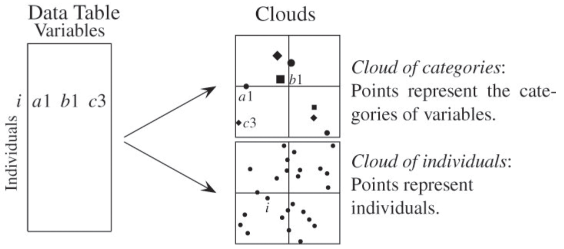

FIGURE 3 Input and output. Data table (absence/presence table) and the two clouds of points generated by MCA.
AFTER LE ROUX & ROUANET 2010

it can simultaneously contain attributes of different sorts based on their presence or absence. The graphical representation is visualised in a form similar to that of Figure 3.

In the study of archaeological boats and ships, the variables are the pre-defined technical properties one has chosen to systematise the finds according to, while the individuals are the ship finds. MCA projects and visualises the categorical data so that the distance between any two individuals reflects their similarity. The same holds for variables (properties). In statistical terms, the variability measure is referred to as inertia, a concept that captures the combination of the point's distance from origin and its weight (or mass) (Hjellbrekke 1999). Weight or mass refers to each point's influence on the spatial distribution of points. Simply put, a space with high variance will form objects far from origin, while in spaces with low variance, the groups will collect themselves close to origin. Material with a high degree of similarities will tend to group themselves in clusters. The most famous user of MCA in the social sciences is the French sociologist Pierre Bourdieu, and the method was prominent in his book *Distinction* (Hjellbrekke 2018, 56), where he investigates taste and lifestyle in social classes. Bourdieu was not very instructive on how he used MCA methodologically (Duval 2018, 513), but one can find reflections on the method and statistical data in the book's appendix (Bourdieu 2010, 503ff). Several explanatory textbooks help educate on the use of the method (e.g. Carlson 2017; Hjellbrekke 1999; 2018; Le Roux & Rouanet 2010).

The data has been processed in the software R (version 4.2.2 2022-10-31).[5] The most challenging methodological concerns when creating these first plots have been how to mitigate the effects of the unavailable (NA) data in the tables (Carlson 2017, 144f). As a rule of thumb, the more data is available, the stronger the statistics, but in any

5 The original choice of the statistical package in Bill's analysis was XL Stat from Addinsoft (Bill 1999, 431).

investigation, some data will always be missing. It will affect the results and needs to be mitigated. An evaluation has been conducted on the Norwegian data, and it shows that 35.5% of the total information is missing. 36 of the 96 vessels are within 80–100 % of the total value (containing 48–60 of the properties observed). When all observations are put together, the average is 39 properties observed. There is no room for an in-depth evaluation of the effect of the NAs here. Still, with the amount of missing data in the Danish material, the Norwegian data is apparently statistically stronger (Bill 2009, 431f). Within MCA, missing values' effects were mitigated by creating a new category (level) for them, combined with giving individuals with many missing values less weight. This is shown in the results below.

6 Preliminary Results

> … to construct a space is never 'only' a statistical challenge, but is also a task that involves making a series of historically informed theoretical, methodological, statistical and empirical decisions. (Hjellbrekke 2018, 92–93)

The biplot below projects the first results from the plotting, showing both properties and individuals (Fig. 4). The distance between any point measures their similarity (or dissimilarity). Extracting only the properties, one can start to look for patterns or clusters (Fig. 5). The third plot shows all the vessels (individuals), with names for identification, dating, and basic technical construction (Fig. 6).

An evaluation of the three plots together gives a few directions for further investigation. The inclusion of two older finds (*Äskekärr* and *Klåstad*) has made a distinction between finds of an older and younger date visible (Fig. 5, large green circle). Interestingly, the *Sjøvollen* ship (AD1280) (Bonde 2005; Christensen 1968) places itself in this category with older vessels and properties. Below these three ships, some vessels also with an early dating are placed, consisting of small cargo ships from the 14th century, but also small, vernacular boats covering the whole period of investigation, with the boat from *Portør*

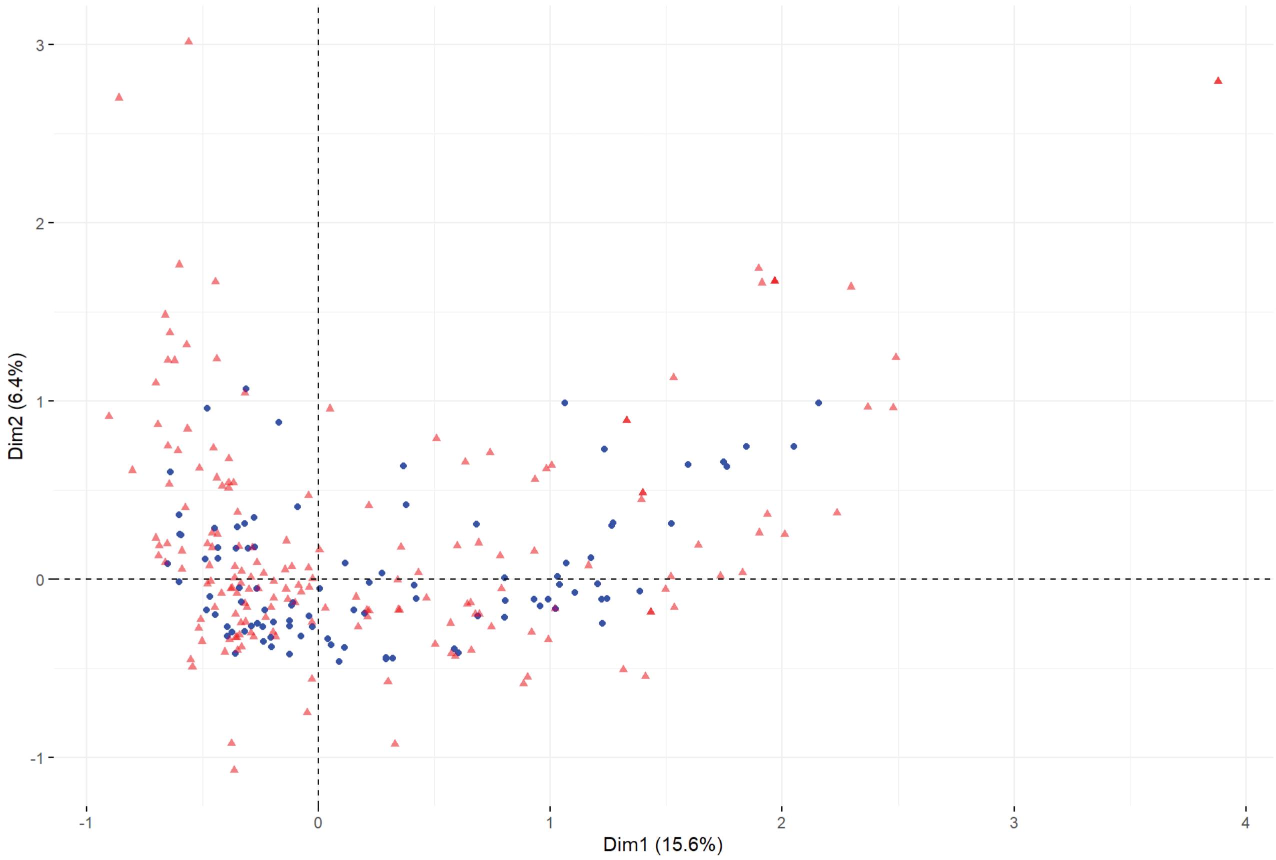

FIGURE 4 MCA biplot showing properties (red triangles) and individuals or ship finds (blue dots). The distance between any point gives a measure of their similarity or dissimilarity. Points with similar profiles are close on the map, and finds containing the most frequent features are close to origin. The missing data are visible as a separate level (towards the right, upper part of the plot).

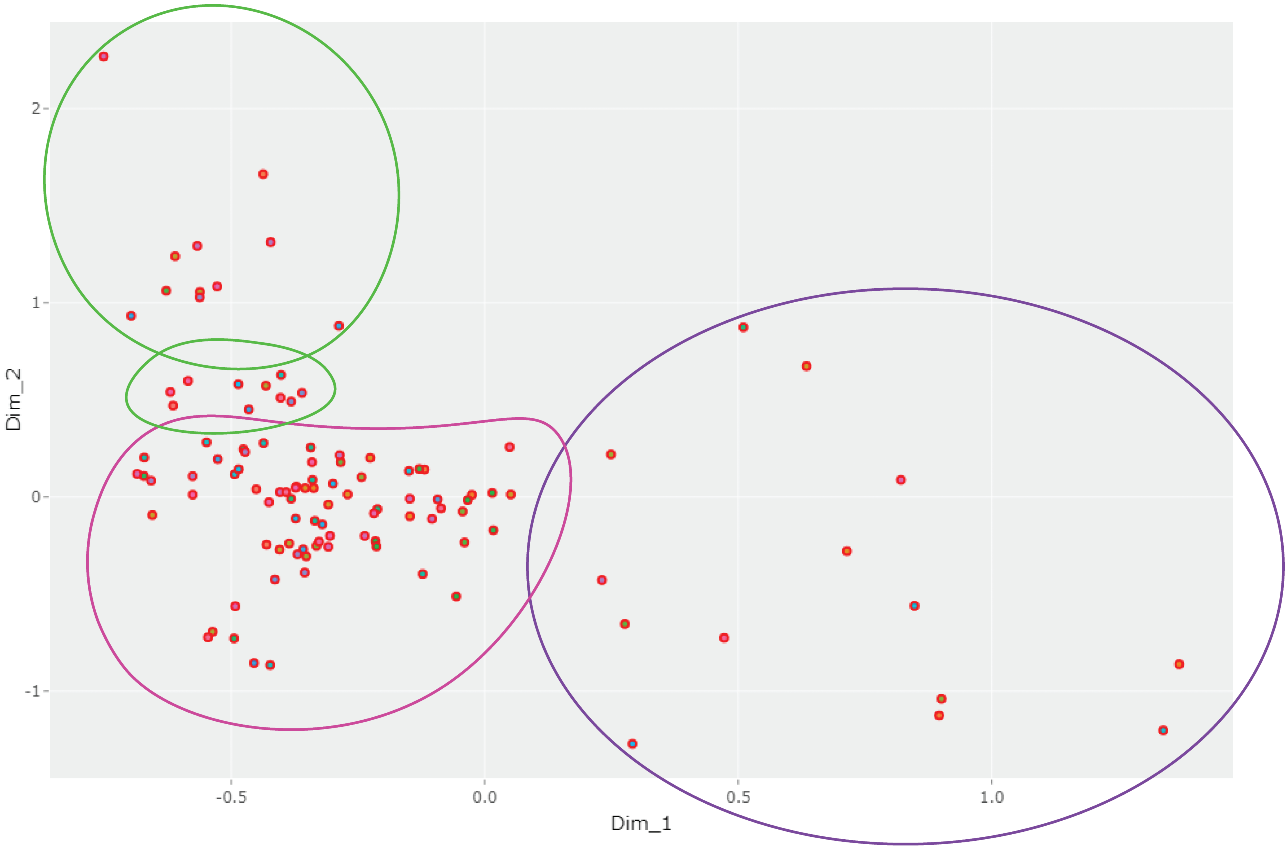

FIGURE 5 Biplot showing only properties, excluding the missing data category (NA). Green, pink and purple circles mark apparent clusters of related ship finds.

as the youngest (mid-17th century) (Christensen 1985; Daly 2013) (Fig. 5, small green circle). This is noteworthy because it suggests that the small boats, some only for rowing and some with a small sail, share properties with each other across time, but also with the oldest vessels in the investigation. Put simply, there are signs of stronger technical continuity ('traditional way of building') within the smaller vessels than the vessels that are constructed for heavier cargo and with sail as the main propulsion.[6] Below this group, the bulk of the material is congested together, showing a large collection of mainly small cargo ships dating from the 15th to 17th centuries (Fig. 5, pink circle). To be able to interpret this complex cluster of vessels will require a more thorough investigation than we are able to provide here. The preliminary suggestion is that within this large group, technical variation is to be found, meaning that the appearance of the group as 'uniform' is considered superficial and dependent on the conceptual level of your analysis. It is a great advantage that most of the vessels in this group are well-documented and, therefore, statistically viable. The following observation in the plot concerns the introduction of carvel-built ships in the Norwegian material, with the *Bispevika 8* (Fawsitt et al. in prep.) and the *Paléhaven* ship (Daly 2014; Borvik et al. 2015). The introduction of the carvel technique (flush-laid planks) in Scandinavian ship construction is widely accepted as an 'event' that brings in new craft practices that are not immediately conceptually compatible with the lapstrake tradition (Lemée 2006, 37). It can be compared to an academic versus vernacular way of building (Eriksson 2010, 78). This comparison is complicated by how early techniques of carvel building in Northern Europe are referred to as bottom-based or bottom-first techniques, similar to the building sequence of lapstrake-built vessels (Hocker 1991; 2004, 65ff; Lemée 2006, 39ff; Maarleveld 1992). This implies that there are essential conceptual similarities between lapstrake-building and early carvel-building techniques. Still, there is no doubt that the carvel practice is a novelty and represents new manners of doing things. As mentioned earlier, this makes the vessels with

6 This effect is similar to what Bill showed when experimentally adding a traditional Norwegian åttring from Misvær, Northern Norway, built between 1750 and 1800 (Bill 2009, 436), along with his material from the Danish region.

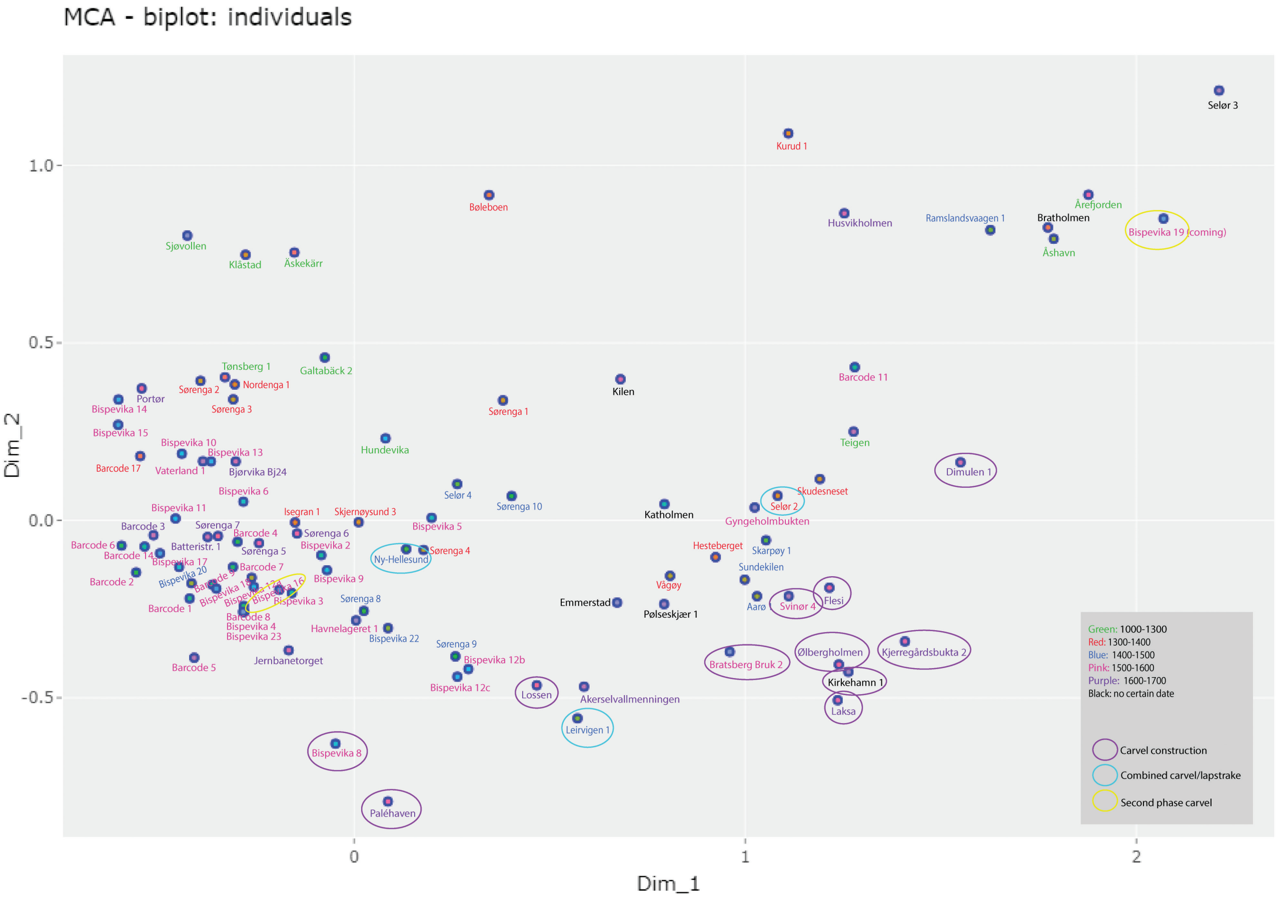

FIGURE 6 Biplot showing individuals, with names of each find. The names are colour-coded: green for vessels from pre-1300, red for 1300–1400, blue for 1400–1500, pink for 1500–1600, and purple for 1600–1700. Vessels with no specific date are indicated in black. Carvel-constructed vessels are marked with a purple circle, combined carvel-lapstrake construction – with a turquoise circle, and lapstrake vessels showing a second phase applying carvel construction are marked with a yellow circle.

a second phase of carvel construction on the outside, an interesting conceptual phenomenon (e.g. *Bispevika 16*, 1589–1603, Fig. 7) (Daly 2019; Rodum in prep.), that will be discussed properly upon completion of the research project. The situation on the right side of the plots shows a mix of vessels of carvel and lapstrake construction, but where the carvel-built vessels are dominant. It must also be noted that the consequence of the missing data is visible towards the upper right side of the plot (Fig. 6) and that the situation here is less statistically viable and should be ignored.

7 Discussion and Conclusion: Creating Order or Revealing Disorder?

The statistical space has created order by visualising some trends linked to technical variances and change and continuity over time. It has also revealed disorders with patterns that are not easily interpreted and that call for more attention. Regarding Bill's analysis of the Danish material, where he could identify both a traditional and a more modern way of building in Denmark (Bill 2009, 432ff), the result of the Norwegian material appears more ambivalent.

At this point, five aspects have been identified from the plots that will be explored further in the main work. Hopefully, including more material from Western Sweden will strengthen the picture and even raise new questions.

1. The presence of older traits in the *Sjøvollen* cargo ship (1280) shows similarities with the late Viking period vessels *Klåstad* and *Äskekärr* (circa 1000). Comparative analysis based on the Danish material.
2. The possible continuity of older properties within the smaller, vernacular vessels than the concurrent cargo carriers. This can be characterised as a more 'traditional way of building'.

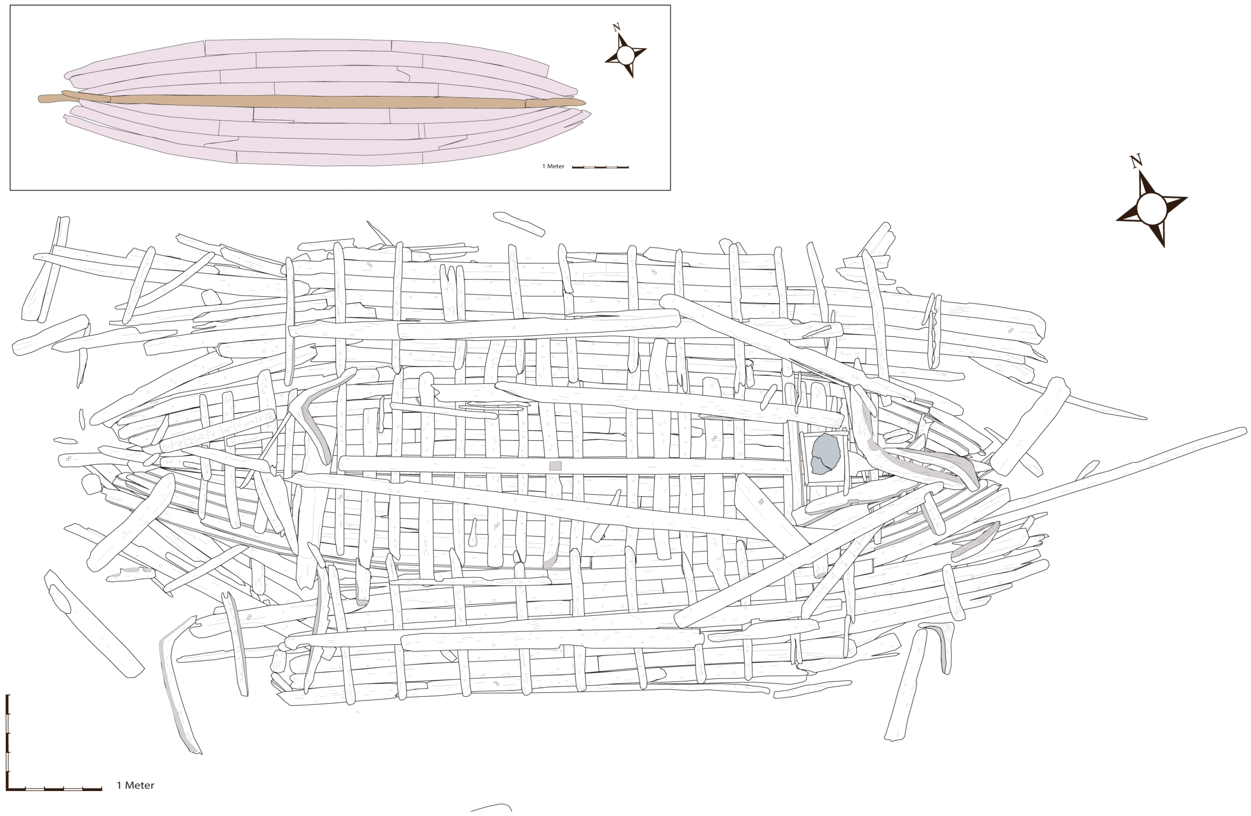

FIGURE 7 Drawing of the ship remains of Bispevika 16 excavated in Oslo harbour. The plan is showing the framing system, keelson and lapstrake hull. Inserted drawing to the top left: the four flush-laid strakes (pink colour) that have been added to the lapstrake hull.
PLAN: SJOERD VAN RIEL, PROJECT B8A/NMM

3. The technical variation between lapstrake-built vessels within the main cluster of finds. Identifying patterns of variation in a group with many similarities.
4. The introduction of carvel-built ships in the 16th-century Norwegian ship-building, with regards to understanding the influence on techniques of building and organisation of communities of practice.
5. The phenomenon of converted lapstrake-built vessels to which have been added an additional layer of carvel on the outside (*Bispevika 16*) or similar features of double planking.

Many of these questions are directly or indirectly influenced by the need for a better understanding of the consistency of the dates and provenances that are the basis for interpreting regional differences. Visual representations and statistical plots are useful to 'think with'. Handling almost 100 vessels, each with the absence or presence of 60 technical properties, simultaneously is not an easy task, while picturing them in a plot provides a guide for further reasoning. This is how the statistics have been used in this article, and that has led to a series of questions to investigate, contextualise, and discuss.

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