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14 Sources and methods for the reconstruction of medieval and early modern sea routes in northern Europe

> We think of paths as existing only on land, but the sea has its paths too, though water refuses to take and hold marks. (. . .) Sea roads are dissolving paths whose passage leaves no trace beyond a wake, a brief turbulence astern. They survive as convention, tradition, as a sequence of coordinates, as a series of waymarks, as dotted lines on charts, and as stories and songs.[1]

14.1 Introduction

Premodern travel has always been hard to grasp in historical research, as the precise routes taken by travellers and the time required for their travels often remains obscure in the sources. Moreover, the absence of any centralised road system, as well as the heightened influence of weather circumstances on travel time compared to the modern age, complicate the estimation of premodern travel times. In the last decade, digital tools and projects have been developed to improve the modelling of premodern travel, first and foremost for the Roman Empire.[2] For late medieval and early modern northern Europe (1350–1650), the Viabundus project provides digital data for land routes and navigable inland waterways for many regions – this is freely available in the form of an online street map and as downloadable GIS data.[3] A similar resource for the Early Middle Ages is currently lacking, and the conception of such a project for early medieval northern Europe is highly problematic due to the limited number of available sources and the absence of a prior Roman infrastructure, which remained in place and use in many parts of southern Europe. For these reasons, this paper will use the Viabundus dataset to discuss the potential of the methods and sources used for the study of early medieval mobility.

Moreover, a third main mode of transport, namely seafaring, is not covered in the Viabundus dataset. This becomes ever more problematic as the dataset grows to encompass regions that were predominantly connected via the sea – for example the

1 *Macfarlane*, The Old Ways (2012), 88.

2 E.g. ORBIS: The Stanford Geospatial Network Model of the Roman World (2012): orbis.stanford.edu; Digital Atlas of the Roman Empire (DARE) (2019): dg.gu.se./dare; and the current projects Itiner-e: itinere.recerca.iec.cat; Simulation of Transport between the Adriatic Sea and the Danube (STRADA): strada.uni-trier.de.

3 Viabundus.eu. See *Holterman* et al., Viabundus (2022).

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countries along the shores of the Baltic Sea or regions with many islands, such as the Dutch province of Zeeland and eastern Denmark. Of course, it would be possible to draw general lines across the water connecting the ports, such as is often done in overview maps of Hanseatic trade,[4] for instance, but it is questionable whether this is historically very accurate.

The problem with sea routes is that they are even harder to trace than land routes, as the sea theoretically allows one to sail anywhere as long as enough water depth is maintained for the draught of the vessel. Even more than land routes, the actual course taken by a ship in the "Age of Sail" depended heavily on changing factors, such as wind speed and direction, as well as tides. The problem of traceability for sea routes means that it is difficult to present them as a line on a map, as one would do with a land road, which is a prerequisite for creating a network model of routes that can be used as a basis for route calculations. However, although sea routes are not as fixed in the landscape as rivers or land roads, they are far from arbitrary. To express it in Robert Macfarlane's words:

> There are optimal routes to sail across open sea, as there are optimal routes to walk across open land. Sea roads are determined by the shape of the coastline (they bend out to avoid headlands, they dip towards significant ports, archipelagos and skerry guards) as well as by marine phenomena. Surface currents, tidal streams and prevailing winds all offer opportunities for sea travel between certain places.[5]

This means that if these factors are known, it could very well be possible to represent sea routes with lines on a map, or with more sophisticated mapping and modelling techniques, in a way that closely reflects historical nautical practices. This article will explore the historical sources that could provide the data for mapping sea routes in the late Middle Ages and the Early Modern period, as well as the digital methods that could be employed to model them. In doing so, it will discuss the broader potential of these methods and sources for the study of the Early Middle Ages. It will primarily focus on the northern European regions also covered by the Viabundus dataset, i.e. the North and Baltic Sea. For reasons of comparison, it will start with a short introduction of the sources and methods usually employed in researching the historical course of roads.

Compared to sea routes, there is a huge amount of literature that focuses on the reconstruction of premodern roads, all of which use a more or less similar approach.[6] The biggest challenge here is that the visual representation of geographical space on a map as we know it today is a development of the early modern period, meaning that reliable and detailed road maps only appear in the eighteenth century. Before this

4 E.g. *Dollinger*, Die Hanse (2012), map 3.

5 *Macfarlane*, The Old Ways (2012), 89.

6 For example *Bruns/Weczerka*, Hansische Handelsstraßen (1962); *Denecke*, Methodische Untersuchungen (1969).

period, we have to rely on written sources about (actually) undertaken travels, such as itineraries and town accounts including expenses for messengers, or information about important points along the route, such as toll stations, inns, bridges, ferries, etc. However, these written sources provide the points along a route rather than the actual route itself. The latter is reconstructed by retracing the route with the help of the oldest available large-scale topographic surveys (*Landesaufnahmen*) of the eighteenth and nineteenth century, which represent the situation before the many changes in the landscape due to industrialisation, canalisation, railway and highway construction, urban sprawl and mining activities.

Additional evidence is supplied by archaeological finds and other traces in the landscape, although these are often scattered and hard to date and interpret.[7] In recent years, the process has been greatly helped by digital techniques – particularly the digitisation of historical geographical surveys made available in a georeferenced form – and the availability of aerial imagery and LiDAR laser scan data of the landscape, which can help identify traces of disappeared infrastructure in the form of changes in vegetation and hollow ways.[8] However, the difficulty of dating traces in the landscape as well as interpretational problems and missing information still challenge the reliable reconstruction of routes. In some areas, the reconstruction of old routes simply comes down to making educated guesses, especially where many different tracks run more or less parallel to each other – as is the case in areas where it was possible to drive next to the road when the old track had become unusable. The resulting track bundles remind us that land routes are not as fixed in the landscape as they may appear to be and that routes sometimes resemble corridors of probability rather than lines in the landscape – making them perhaps not so different from sea routes after all.

14.2 Sources for the reconstruction of historical sea routes

Any attempt to adapt the method described above to the reconstruction of sea routes, however, leads to a number of additional problems. In terms of density of information, many of the sources relied upon for the reconstruction of land routes are even scarcer when it comes to sea routes. However, this does not mean that they are absent altogether.

For sea routes, we have to rely on similar sources as for land routes, starting with itineraries. The oldest known reports of sea journeys in northern Europe can be

7 See also the articles of Pierre Fütterer and Irmela Herzog in this volume.

8 See also the articles of Wouter Verschoof-van der Vaart and Anna Swieder in this volume.

found in the Old English translation of Orosius's *Historiae adversum paganos*, created in the late ninth century for King Alfred the Great of Wessex. Inserted into the translation are two journeys from the same period: one, taken by the Norwegian seafarer Ottar/Ohthere, who travelled along the Norwegian coast to the White Sea; another, taken by the merchant Wulfstan, who travelled from Haithabu in northern Germany to the early medieval trading place Truso, near modern Elbląg in Poland. These descriptions, however, are lacking further details and are hardly usable for a reconstruction of the routes taken.[9] A more detailed itinerary is found only centuries later with the so-called *King Waldemar's Itinerary*, thought to have been compiled between 1215 and 1300. The Latin itinerary consists of a list of isles and other places along the Swedish and Finnish coastline (with some notes about their distance), which together form a route from southern Sweden to Estonia. The route runs mostly in between the many skerries along the Swedish coast, avoiding the open sea as much as possible. In some parts the itinerary even describes an inner and outer route, whereby the inner route would have been suitable only for small vessels that could be rowed owing to the narrow channels between the islands.[10] It is often questioned whether this text would really have served as a general route description, not just because of its being written in Latin, but because the route would have been troublesome for a larger sailing vessel – the close vicinity of the islets requires very accurate manoeuvring.[11]

However, the choice for sheltered routes that avoided open water is not exceptional and is attested in more cases. One is the preferred sailing route for Hanseatic ships to Bergen in Norway, the so-called *Bergens led*, which followed a course between the many islands and skerries along the western Norwegian coast for as long as possible.[12] In the county of Holland, the many inland waterways can be considered an extension of the sea routes which allowed shortcuts of the dangerous route along the North Sea coast. The *gecostumeerde route binnendunen* was the obligatory sailing route through the county, which connected the Zuiderzee via the river IJ at Spaarndam and a system of rivers and canals with the delta of the Rhine, Meuse and Scheldt rivers. Sources show that the route was used by merchant ships from the Hanseatic towns, among others, on their way to Bruges in the late fourteenth century.[13] However, this was only possible for ships that were small enough to pass the bottleneck in the system, the very narrow lock in the city centre of Gouda.[14] Using such sheltered routes was thus only viable for small ships that could be manoeuvred easily. For larger sailing ships that needed more space to manoeuvre, a course at a greater dis-

9 *Sauer*, Seebuch (1996), 64–65; *Indruszewski/Barton*, Simulating Sea Surfaces (2007), 475–477; Cf. *Urbańczyk*, Reliability (2009); *Englert*, Ohthere's voyages (2007).
10 *Zwick*, Lineare nautische Netzwerke (2012), 99–101, 110.
11 *Sauer*, Seebuch (1996), 65–67.
12 *Burkhardt*, Hansische Bergenhandel, 148–150.
13 *Vogel*, Binnenfahrt durch Holland (1909), 13–15.
14 *Ibelings*, Scuren ende diepen (2001), 3.

tance from the coast was recommended due to the imminent danger of being pressed on the lee shore by the wind.[15]

Although there are some other itineraries from this period for northern Europe, they are limited in number, especially compared to the southern European sources. For example, the *Incanto* system was in place in the Venetian Republic from 1315 onwards, by which galleys were employed by the Venetian senate on fixed sailing routes, which could be chartered by merchants via auction. The structured nature of the system permitted the reconstruction of the main axes of the Venetian maritime network.[16] Similarly, there exist many itineraries for pilgrimages to Jerusalem. These were produced in increasing numbers in the late Middle Ages and usually involved a maritime journey from Venice to Palestine, allowing detailed insights into the sea routes taken through the eastern Mediterranean.[17]

Ship logbooks, as testimonies of actually completed voyages, are of little use for reconstructing the sea routes within northern European waters. These only came into play in the Early Modern period and increase in number towards the Age of Steam. Logbooks have been included in multiple digital projects such as the CLIWOC database (1750–1854)[18] and the Global Sea Routes project.[19] However, they usually record the intercontinental travels of ocean-going merchantmen and explorers and are therefore of limited use for reconstructing sea traffic routes in the local waters of northern Europe. The same goes for letters and accounts of well-recorded voyages, such as the documents surrounding the voyages of the *Peter von Danzig*, a former French caravel deployed as warship by the city council of Gdańsk during the war against England (1471–1473).[20] Although the many documents surrounding the ship's voyage make it possible to reconstruct its whereabouts at various times, the information provided by them is too thin to reliably estimate the precise sailing routes. Moreover, the fact that it was employed as a warship with the aim of disturbing English shipping makes the information of little value for a good understanding of the routes commonly taken by merchant ships. The *Peter von Danzig* is also an extremely well-documented case, which means that there is only little comparable material available, especially for the Middle Ages. Finally, combining various sources such as toll records and port books to trace the movement of single ships, for instance in the *Navigocorpus* project for French shipping in 1787, would hardly be possible for earlier periods due to the scarcity of sources and problems of interpretation.[21]

15 *Sauer*, Seebuch (1996), 108–115; *Zwick*, Lineare nautische Netzwerke (2012), 110.
16 *Fournier*, Venetian maritime supremacy (2016).
17 *Mai*, Reisebedingungen (2020), 220–222.
18 See *García-Herrera* et al., CLIWOC (2005) and other articles in the same volume.
19 Gsr.nodegoat.net.
20 *Możejko*, Peter von Danzig (2020), especially 122–173.
21 *Marzagalli*, Navigocorpus (2016), 92–96.

Next to textual sources, we might turn to visual sources and maps in order to reconstruct sea routes, which look promising at first glance. Sea charts were created in the context of actual navigation, starting with the Mediterranean *portolan* charts of the thirteenth century, and became ever more numerous and precise throughout the centuries, including information such as depth measurements, currents and the location of buoys towards the end of the Early Modern period.[22] However, they come with one big disadvantage: they hardly ever display sailing routes and tend to present the sea as an open space, where one could sail anywhere, as long as obstacles are avoided. Only in exceptional cases do early modern European maps display sailing routes, and then often only single routes of notable voyages, such as the maps of northern Europe which include sailing routes taken by Willem Barentsz in search of the Northeast Passage (1594–1597); by Gerrit de Veer and Jan Huygen van Linschoten, around 1600;[23] and the world map of Battista Agnese, with the sailing route of Ferdinand Magellan's circumnavigation of the earth (1544).[24]

A very notable exception is a hand-drawn map of Sweden and the Baltic Sea, which was probably created by the Swedish bishop Hans Brask while living in exile in Gdańsk in 1533 (Figure 14.1).[25] It shows various large sailing ships with multiple masts on the sea, moving along narrow black lines that represent a network of sailing routes connecting the most significant ports along the Baltic Sea cost, including Gdańsk, Riga and Tallinn. Stockholm is situated prominently in the centre of the map, like a spider in its web, acting as a hub between the Baltic Sea and the towns of inland Sweden, which can be reached from Stockholm via the Mälaren lake. The map is drawn quite schematically and was obviously not intended for nautical purposes. Nevertheless, it contains some interesting details about seafaring and maritime networks in the early sixteenth century. There are a few mentions of sailing distances ("van Calmarn tho Stockhol 60 milen"), and it shows multiple alternative routes between two points. En route between the Øresund and Stockholm, for example, one has the choice of sailing around the island of Öland, or sailing closer to the coast of the Swedish mainland, between the many (brightly coloured) skerries. The latter course is reminiscent of the route from King Waldemar's Itinerary. At the very least, the map allows us to make the observation that the idea of a maritime network represented by lines drawn across the sea is not necessarily a modern one.

22 *Baumgärtner*, Portulan-Atlas (2017), 10–15; *Blake*, Sea Chart (2004), 8–20.

23 *Ehrensvärd*, Nordiska kartans historia (2006), 118–126; *Yandle*, Noordpoolgebied in kaarten (2019), 22.

24 *Baumgärtner*, Portulan-Atlas (2017), 118–119; *Blake*, Sea Chart (2004), 71. For other examples see *Shirley*, Mapping (1984), xxxiv–xxxv; *Wildeman*, Doordrijvers en dwarsliggers (2019), 33.

25 Universiteitsbibliotheek Leiden, COLLBN 002–03-021: hdl.handle.net/1887.1/item:3243570 (accessed: 07.07.2023). For the history of the map, see *Ehrensvärd*, Nordiska kartans historia (2006), 58–60; *Storms*, Kaarten (2022), 32–33.

Figure 14.1: Map of Sweden and the Baltic Sea, compiled by Hans Brask in 1533. Universiteitsbibliotheek Leiden, COLLBN 002–03-021. Image: CC BY.

Even in later centuries, when sea charts become increasingly accurate and useful as an aid in navigation, lines representing sea routes remain rare. Interestingly, when they do appear – usually in cases such as those appearing in King Waldemar's Itinerary or *Bergens led* – it is to mark routes between many small islands and skerries with little space for navigation. One example is attested by the map of the Orkney islands made by Murdoch Mackenzie in the mid-eighteenth century, which contains some major sailing routes between the isles ("The Common Way thro Petland Firth"; "The Way thro Petland Firth to Stromness &c. with Ebb Tide") next to information considered useful for fishermen or sailors ("Cod and Ling here"; "The Stream scarce sensible here").[26] Similarly, a 1748 map of the Finnish coast around Pellinge/Pellinki and Degerby/Loviisa by Jonas Hahn shows sailing routes ("leder") between the skerries, but not on the open sea,[27] as does the 1791 map *A New Chart of the Baltic or East*

26 National Library of Scotland, EMS.X.005, online: maps.nls.uk/coasts/chart/4142 (accessed 07.07.2023).
27 *Ehrensvärd*, Nordiska kartans historia (2006), 280–281.

Figure 14.2: Robert Sayer, A New Chart of the Baltic or East Sea (1791), detail of the waters around Stockholm. Source: gallica.bnf.fr/ark:/12148/Bibliothèque nationale de France.

Sea by Robert Sayer, which displays among others a route almost identical to King Waldemar's Itinerary (Figure 14.2).[28]

14.3 Early modern sailing instructions: a useful source?

Many of the sea charts from the early modern period were not produced as standalones, but accompanied so-called rutters or navigational instructions, books with detailed descriptions of sailing routes. Although they share a number of similarities with the itineraries mentioned above, they certainly do not belong to the same genre. Where itineraries usually only focus on a single route, rutters treat a system of sailing routes within a given region, with an explicit nautical function. The routes are defined by landmarks on the coast (mountains, church steeples, islands) as well as water depths measured with the sounding lead, distances and compass directions between the points, and additional information about tides, shallow waters and currents (Fig-

28 Included as supplement in *Meyer-Friese/Sauer*, Månssons Seebuch (2020).

ure 14.3). As they supply much practical information about sailing routes from a nautical perspective, which is often invisible on sea charts, they are a promising source for the reconstruction of premodern sea routes.

While navigational instructions are already known from the classical period in the Mediterranean (*periplus*), the first rutters in the post-classical sense are the southern European *portolani*, the oldest being the Italian *Compasso de navegare* from 1296, although its contents might be significantly older. It focuses on the Mediterranean, which is treated following the coast in a clockwise direction.[29] Sailing instructions for western and northern European waters, however, only appear much later. The portolan *Trattato di Nautica*, from the Venetian Pietro de Versi (1445), is the first to include a route around the Iberian peninsula through the English Channel to Bruges in Flanders.[30] Genuine northern European sailing instructions appear in the second half of the fifteenth century: the Low German book known as the *Seebuch* was compiled in c. 1470 and covers the Bay of Biscay, the English Channel, as well as the North and Baltic Seas; its contents were probably compiled from various (much) older sources.[31] The English sailing instructions for a circumnavigation of England and the route to the Strait of Gibraltar date from about the same period (1468–1483), although they are much shorter than the *Seebuch*.[32]

While the early rutters were handwritten and contained few details, the genre experienced a rapid development in the sixteenth and seventeenth century. The French *Routier de la mer* from 1502–1510 was the first rutter to be printed and was translated into English as the *Rutter of the See* in 1528. It covered the Bay of Biscay, the waters around England and the southern North Sea.[33] The *Grant Routtier et Pyllotage et encrage de la mer*, published by Pierre Garcie in Poitiers in 1520, was the first to include depictions of the coastline with landmarks as a supplement to the textual information.[34] Later in the period, new and improved sailing manuals were predominantly produced in the Netherlands, starting with the *Kaert vander zee* from 1532, which shows much overlap with the *Seebuch*, but in an extended version.[35] Later, Dutch sailing instructions were printed in many editions, translated into various languages and increasingly complemented by maps. Lucas Janszoon Waghenaer's *Spieghel der Zeevaerdt* from 1584/5 became one of the most famous of these sailing instructions, not least because it included almost fifty sea charts in high detail with indications of water depths and the positions of buoys and beacons, which appeared

29 *Sauer*, Seebuch (1996), 72–73; *Waters*, Rutters (1967), 9–10.
30 *Sauer*, Seebuch (1996), 73.
31 Ibid.
32 *Rose*, Rutters, Courses and Voyages (2023), 7–9; *Sauer*, Seebuch, 82–83; *Meyer-Friese/Sauer*, Månssons Seebuch (2020), 13.
33 *Waters*, Rutters (1967).
34 Ibid., 11–39.
35 *Meyer–Friese/Sauer*, Månssons Seebuch (2020), 14–15.

in luxurious (coloured) editions.[36] It is highly questionable whether such opulent books were in fact used in nautical practice, or if they were intended mostly for collectors. In any case, in later works by his hand, Waghenaer significantly reduced the number of sea charts and limited the imagery to depictions of the coastlines.[37]


Arenborch binnen S. Lambert kümpt/ſo ghat recht in oſt nordoſt.
Vor de Wylinge hoch Water ſüdweſt vnd nordoſt. Vnd na Walchern ſüden vnd norden Mæn.
De Wylinge vth tho ſegelen.
Knake. Terdoſs. Vthkercke.
Slüſe. S. Catrinen. Heis. Lyſswege. Blanckenborch.
S. Catrinen Thorn ys eine Spitze/vnd ys de negeſte Thorn / de weſtwert van der Schlüſe by dem Water ſteith/ vnd van S. Catrinen tho Landewert in/ ſteith eine ander Spitze/ dat ys thor Klocken/ vnd van S. Catrinen weſtwert by dat Water ſteith Heis/ dat ys eine Spitze/gröter alſe S. Catrinen ſpitze/ Darna by dem Water ſteith Lyſsweger Kercke mit einem ſtuuen Thorne/ Vnd van Lyſswegen tho Landewert in / licht ein Kloſter mit einem klenen Spitzeken/ dat heth Terdoſs/noch van Lyſswegen weſtwert by dem Water/ſteith eine Kercke mit einem ſtuuen Thorne / dat ys Blanckenborch/ Vnd van Blanckenborch tho Landewert in licht Vthkercke/ dat ys ock eine Spi-

Figure 14.3: The Low German rutter *De Seekarte Ost und West tho segelen* (1588), page with sailing instructions and depictions of church towers as landmarks on the Flemish coast. Staats- und Universitätsbibliothek Bremen.

Even though many of the more luxurious sailing manuals were primarily intended for collectors, they still contain the navigational knowledge of seafarers and pilots. Moreover, we know that at least some of the rutters were actually used on board of ships, as can be seen from a 1578 comment by Francisco de Eraso, ambassador of King Philipp II of Spain, who was surprised that the skipper of a ship sailing between Stralsund and Kalmar neither used a compass nor sea charts, but only a small book to nav-

36 Ibid., 15–23.
37 Ibid., 23.

igate.[38] This makes these books a useful source for attempting to reconstruct sea routes in the late Middle Ages and the early modern period. Although the earlier examples are particularly hard to interpret, it is nonetheless possible to reconstruct the described routes on a map to a certain extent. For the *Seebuch*, this has already been shown by Jochen Goetze in 1975.[39] More recently, Eduard J. Alvarez-Palau and Oliver Dunn have created a digital network of early modern sailing routes around England and Wales, primarily based on the highly detailed *Great Britain's Coasting Pilot* by Greenville Collins, which first appeared in 1693 and was reprinted many times afterwards (Figure 14.4).[40] For a comprehensive network of premodern sailing routes in the North and Baltic Sea, however, we need to combine the information from multiple sailing instructions, as the oldest rutters like the *Seebuch* "by no means should be seen as a comprehensive picture of the existing route network, as there are too many lacunae", as Albrecht Sauer rightly noted.[41]

At this point it is necessary to take a closer look at the practices of navigation in northern Europe in the late Middle Ages and the Early Modern period. Although de Eraso's remark suggests otherwise, compasses and sea charts were known in northern Europe at the time he was writing, but it seems that they were not much used. Instead, the main instrument was the sounding lead, used for measuring water depths. Not only was this instrument necessary to prevent the ship from running aground in shallow waters, but – combined with the corresponding information about depths and composition of the seabed at crucial points in the rutters – it could also serve as a positioning instrument.[42] One possible reason why skippers in northern waters did not rely on the compass as their main navigational instrument might be the influence of the tides: in the almost closed basin of the Mediterranean, the influence of currents and tides is negligible, making navigation by compass more reliable. In the North Sea and its surroundings, the currents and tides provided a constantly changing environment, making the sounding lead a much more reliable instrument to avoid running aground.[43] Curiously, the same method of navigation seems to have been common in the Baltic Sea as well, which more closely resembles the Mediterranean with its low influence of currents and tides.

Moreover, navigation depended to a large degree on eyesight, by identifying landmarks on the coast, and the experience and knowledge of the helmsman, skipper or

38 *Rösler*, Seekarte (1998), 103.

39 *Goetze*, Hansische Schiffahrtswege (1975), 71–88.

40 *Alvarez-Palau/Dunn*, Database (2019). See also *Dunn*, Sea of Troubles (2020); *Bogart* et al., Speedier delivery (2020).

41 *Sauer*, Seebuch (1996), 116: "Die Anweisungen des 'Seebuches' dürfen keineswegs als Gesamtbild des vorhandenen Wegenetzes verstanden werden. Dazu sind die Lücken zu groß."

42 *Rösler*, Seekarte (1998), 104–105.

43 *Sauer*, Seebuch (1996), 116–139.

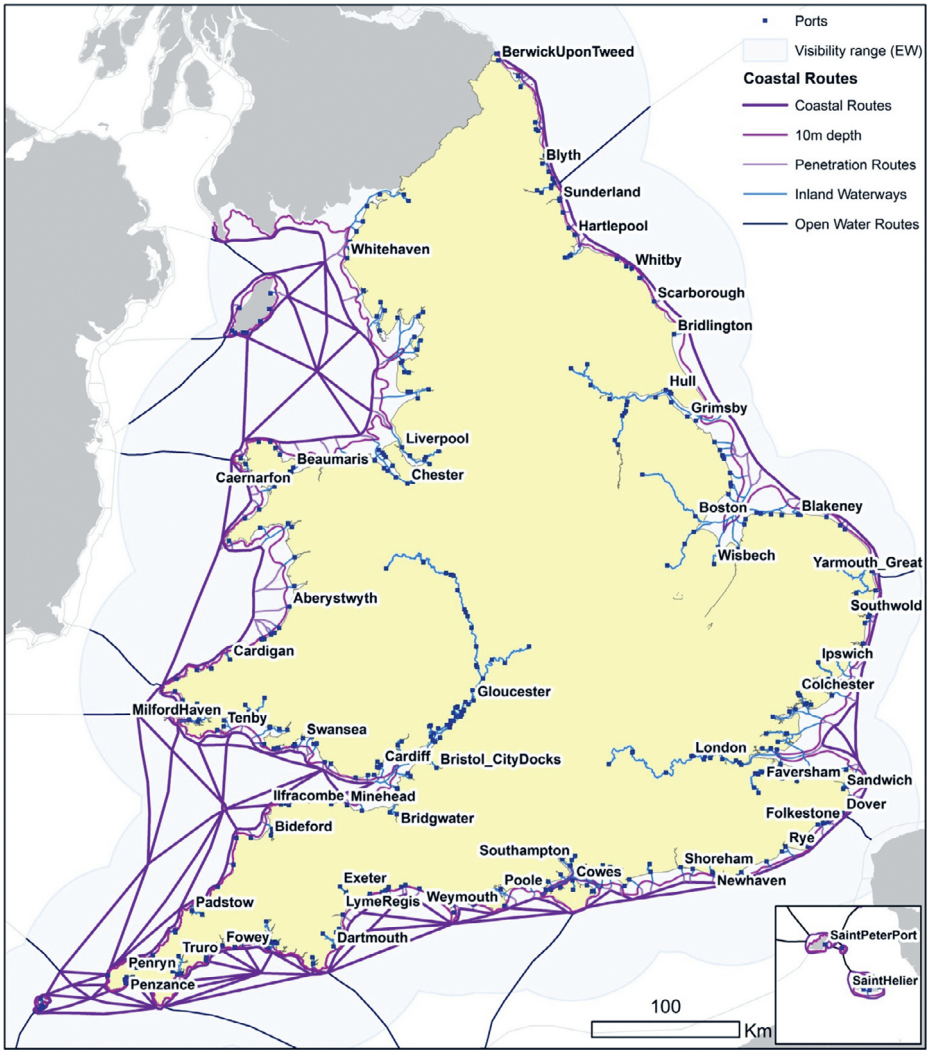

Figure 14.4: Network of early modern coastal sailing routes in England and Wales, from Alvarez-Palau/Dunn, Database (2019), 10. CC BY.

local pilots in coastal areas.[44] It is this kind of knowledge, originally transferred orally, which was increasingly codified in sailing instructions. Combined with the increasing size and draft of ships in the late Middle Ages and the early modern period, which made ships difficult to manoeuvre and impossible to row, most large sailing ships would have tried to stay as far away from the coast as possible, while at the

44 *Rose*, Rutters, Courses and Voyages (2023), 15–17.

same time keeping the coast within eyesight. Climbing the mast increased the range from which the coast was still visible in clear weather, reducing the risk of being pressed on the lee shore.[45] Moreover, it would have been acceptable on certain parts of known routes to leave sight of the coast for a while in order to sail a shorter route. In effect, therefore, the sailing instructions do not provide routes which can be drawn as a line, but rather corridors of possibility. These corridors were limited by the distance from the coast where the coast could still be seen and the distance where there was still enough water depth, using coastal landmarks as waypoints.[46] Of course the exact routes taken by ships within these corridors depended heavily on many factors such as the size and sailing characteristics of the ship, the experience and knowledge of the navigator, visibility, weather conditions, currents and tides.

14.4 Digital modelling

The nature of seafaring as a state of constant flux prompts the question whether more reliable results for historical sailing routes can be achieved using a probabilistic approach with the help of digital modelling techniques. At least in theory, these should be able to account for weather conditions and other parameters. The last decades have seen increasingly sophisticated attempts at employing digital modelling to reconstruct historical sailing routes. These models usually take an approach based on least-cost path calculations (LCP). In this calculation, a so-called cost surface is created in the area under consideration, taking the form of a grid of points with a certain cost factor based on various parameters, through which a path of "least cost" can be calculated.[47] An early 2006 attempt to model the possible route taken by Wulfstan in the late ninth century used a wildfire-spreading algorithm, normally used to model the spread of wildfire across terrain populated by a certain kind of vegetation, taking into account the wind speed and direction. The experiment showed that approaching the Baltic Sea as a plain grassland with the use of modern wind data produced a route between Haithabu and Truso that closely resembled the route sailed by experimental archaeologists.[48]

An LCP approach was also used by the ORBIS Geospatial model of the Roman World from 2012, which was designed to provide an all-encompassing model for all modes of transportation within the Roman Empire. For the calculation of sea routes on the Mediterranean and Black Seas, and a small part of the Atlantic, a simple yet

45 *Sauer*, Seebuch (1996), 108–115.

46 Cf. *Alvarez-Palau/Dunn*, Database (2019), 10–11.

47 E.g. *Blankshein*, (Sea)ways of Perception (2021). See also the chapter of Irmela Herzog in this volume.

48 *Indruszewski/Barton*, Simulating Sea Surfaces (2006).

sophisticated model was designed, which depends on a grid of points 0.1 degree apart. Each of these points is connected with each of its eight (or less, in the case of coastal points) surrounding points. A cost factor is applied for each of these connections that depends on the prevailing winds and wave heights for a certain month of the year. Regions in the Mediterranean where wave heights of more than 3 metres occur with a frequency of more than 10% in any given month were removed from the model for that month, since seafaring would have been too dangerous. This primarily effects a region between the French coast and Sardinia.[49] Thus, this model allows for calculating the most likely least-cost sea routes between two points at a given time of the year. However, as we have seen, sailing conditions in the Mediterranean significantly differ from those in northern Europe, which is why currents and tides can be reasonably omitted from the calculations.

A comparable but more advanced model based on LCP calculations was recently developed by a Litvine et al., who created a cost surface based on weather data for wind speed and directions and their variance, currents, waves, and visibility, for each month of the year. Regrettably, no tidal current data was available to further enhance the cost model, but this is mainly a factor which comes into play when sailing in and out of port, not necessarily for crossing the open sea. The model is designed for the European Atlantic and the western Mediterranean, but this is mostly due to concerns over computing capacity, and it could be expanded to other regions without many problems. A comparison of the calculated routes with logbook data from the CLIWOC database showed that the model delivers results comparable to actually undertaken voyages in the early modern period.[50]

Although LCP models provide good results in theory, they run into two main problems. The first is related to weather data, which are essentially modern observations, the oldest systematic and reliable weather series dating back only a few decades. Given that climate – and, correspondingly, the prevalence of certain weather patterns – tends to change, the models become less reliable the more the historical climate differs from the modern one. It is thus difficult to make assessments related to the influence of climate changes on historical weather patterns with the degree of certainty required for reliable calculations.[51]

A second problem concerns the sailing characteristics of the ships used for the calculations, especially when it comes to the time needed to travel a calculated route. The size, rigging, method of propulsion, material and shape of the hull, draft, and so on, all have their influence on the way a ship behaves under various weather conditions. Even for the Age of Sail in the eighteenth and nineteenth centuries, the sailing characteristics are hard to assess, which is why the Litvine et al.'s model is predomi-

49 See the ORBIS documentation: orbis.stanford.edu (accessed: 07.07.2023).

50 *Litvine/Lewis/Starzec,* Multi-criteria simulation (2024).

51 *Zwick*, Lineare nautische Netzwerke (2012), 97.

nantly based on the sailing characteristics of the modern Australian tall ship *Young Endeavour*, with some tweaking.[52] For the ORBIS model, two generalised models of Roman sailing ships were taken, a "fast" and a "slow" one, although it remains unclear which parameters are used and how these are derived.

With regards to the sailing characteristics of ships, we might be aided by reconstructions of historical shipwrecks made by maritime archaeologists, both in the real world and in the virtual. Much insight into the sailing capacities of ships from the Viking Age, for example, has been gained from the reconstructions of ships in the Viking Ship Museum in Roskilde dating to the eleventh century.[53] In recent years, ships have also been reconstructed with digital 3D models; a recent 3D model of the so-called Bremen cog from c. 1380, for example, has shown that the flat-bottomed ship was unsuitable for sailing the high seas where high waves could occur.[54] However, it should be kept in mind that the large variety of ship types and sizes, combined with ever-changing weather conditions, make LCP calculations hard to extrapolate for the voyages of individual ships taking specific journeys. Its results are therefore only useful for statistical purposes.

14.5 Conclusions and outlook

In light of the scarcity of sources for maritime voyages in premodern northern Europe, rutters or early modern sailing instructions would be the most promising sources for the reconstruction of a maritime network, at least for visualisation purposes. Although the rutters were not necessarily intended for use on board a ship, they most closely reflect nautical practices and provide a systematic overview of routes instead of reports of single voyages. In this sense, they accurately fit the documentary approach taken in the Viabundus project. However, sailing instructions provide corridors of possibility rather than actual routes. The latter can only be achieved to some extent by using a probabilistic approach of digital modelling, especially when it comes to calculations about travel times. Here, archaeological reconstructions can help provide the sailing characteristics of premodern ship types that are necessary to perform such calculations. It should be kept in mind that such models are useful only for statistical or comparative purposes and not so much for the reconstruction of individual voyages.

The question remains to what extent models and networks based on early modern rutters provide insights about navigation in the Early Middle Ages. Apart from

52 *Litvine/Lewis/Starzec*, Multi-criteria simulation (2024), 4–5.

53 E.g. *Crumlin-Pedersen/Vinner* (Eds.), Sailing into the Past (1986); *Englert/Ossowski*, Sailing in Wulfstan's wake (2009); *Bill* et al., Welcome on board (2007).

54 *Tanner/Belasus*, Bremen-Cog (2021).

the unsolved problem of modern weather data used in LCP models for historical navigation, there are two main obstacles to a direct use of early modern rutters for the reconstruction of early medieval sea routes. The first is the size of the vessels and their methods of propulsion. The later Middle Ages saw a significant increase in the size and draft of trading ships, which consequently became difficult to manoeuvre and could hardly be rowed anymore.[55] The significantly smaller, lighter ships of the earlier periods – even if they were equipped with a sail – could sail closer to the coast, not least because they could be rowed, and could possibly be drawn upon the shore during the night.[56] Rowing as a means of propulsion is both ignored in the digital seafaring models developed so far and in the rutters, which exclusively reflect the sailing directions for large sailing ships.

Yet, the choice for sheltered routes and the possibility of sailing close to the coast as, for example, reflected in Waldemar's Itinerary, was by no means something that disappeared with the upscaling of sea-going vessels in the late Middle Ages: early modern sea charts still show the sheltered routes in seascapes dotted with islands sometimes, indicating the continuing use of these routes. Moreover, major ports were still frequented by small-scale coastal vessels, the significance of which should not be underestimated. For example, the late sixteenth and early seventeenth century toll registers from Hamburg, known as the *Schifferbücher*, show that a large number of the ships visiting the Hamburg harbour were coastal liners, sailing to or from small ports on the Dutch and German Wadden Sea coast. Many of these lesser ports only had small tidal harbours. Some of the Dutch towns listed as ports of origin and destination could even be considered inland towns, such as Utrecht, Leiden, Sneek and Bolsward.[57] This means that the vessels visiting these ports must have been small enough to manoeuvre in the narrow canals and rivers, staying close to the coast when sailing the open sea. We must therefore consider the inland waterways as an extension of the premodern network of sea lanes rather than as a totally different transport system, especially for the Early Middle Ages, where most seagoing vessels would have been small enough to navigate the inland waterways as well.

With the coastal and inland waterways we come to the second main obstacle for projecting early modern routes onto the Early Middle Ages. In many places, the topography of coastal regions has undergone fundamental changes during the Middle Ages and the early modern period. Significant early medieval trading places – such as Haithabu and Truso, as mentioned in Wulfstan's Itinerary – were abandoned in later centuries. However, this is a problem that is easily resolved, since these trading sites were often superseded by medieval towns in their vicinity: Schleswig for Haithabu, Elbląg for Truso, Wijk bij Duurstede for Dorestad, all of which could serve as substi-

55 *Sauer*, Seebuch (1996), 108–109.

56 *Sauer*, Navigation im Mittelalter (1998), 371.

57 *Baasch*, Hamburgs Seeschiffahrt (1893), 323–331.

tutes in a routing algorithm.[58] More challenging however are the changes in the coastline and in the course of coastal rivers, especially on the southern coast of the North Sea. Changes in the Rhine delta and the development of the Zuiderzee and Dollart, to name just a few,[59] seriously affected sailing routes in this coastal region during the Middle Ages. Once the ships reached the open sea, however, the conditions must have been quite similar to later periods.

14.6 Bibliography

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58 See e.g. *Jöns*, Ports and *emporia* (2009); *Jagodziński*, Truso (2009).

59 E.g. *Walsmit*, Zuiderzee (2009), 15; *Vos/Knol*, Ontstaansgeschiedenis (2013).

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