GISing dead-reckoning; historic maritime maps in GIS

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Abstract: The Dutch mapmakers of the 16th and 17th century were famous for their accurate and highly detailed maps. Several atlases were produced and were the pride and joy of many a captain, whether Dutch, English, French, fighting or merchant navy.

For modern eyes, these maps often seem warped and inaccurate; besides, in those times it still was impossible to accurately determine ones longitude, so how could these maps be accurate at all?
But since these maps were actually used to navigate on, and (most of) the ships actually made it to their destination and back, the information on the maps should have been accurate enough.
Using old navigational techniques and principles it is possible to place these maps, and the wealth of information depicted on them, in a modern GIS. That way these old basic-data not only provides us with an insight in the development of our rich maritime landscape over the centuries, but also gives an almost personal insight in the mind of the captains using them and the command structure of the fleets dominating the high seas.

Keywords: historic Dutch maritime maps, georeferencing historic data, maritime archaeology

Introduction

The Dutch maps from the 16th and 17th centuries were famous for their accuracy and detail level. These charts were also very popular with seafarers, both in the Netherlands, as in other seafaring nations of that time. Many of those charts had, in addition to the editions for actual navigational use also editions for presentation, often beautifully coloured and bound together into atlases. These atlases were sold to merchants, ship owners and lovers of precious books. Although these editions were not for use at sea, they were based on the actual navigational charts. Because these charts were not exposed to the dangers at sea, a number of these atlases survived.

Fig. 1 – an example of a Dutch 17th century presentation edition atlas

Georeferencing

If we look at old maps with modern eyes they often seem distorted and unreliable; the relationship between different areas on the map appears warped, coastal lines seem either sketchy, or with excessive detail, and the maps are not in a recognizable (modern) projection. Yet these maps contain a wealth of information that can provide much insight in the maritime landscape in that period. If we can compare this information with other periods and with modern data, we can see the developments in that landscape over time. With modern techniques it is possible to place these maps in a geographic information system (GIS), in which the information can be used for modern research. One often used technique is based on some form of ‘rubber-sheeting’, whereby a scan of the map is stretched to fit the modern projection. GIS packages like ARC-GIS rely on this technique and give quite good results for most 19th and 20th century maps. These relatively modern maps mostly use a Mercator projection-system, which make them comparable with more modern maps and projections used in GIS. The distortion needed to make them fit the GIS-projection is quite minimal and doesn’t disturb the raster image legibility. Older, not Mercator maps can be ‘rubber-sheeted’ by photogrammetry in modern programs like Photoplan. In these kinds of programs lots of fixed reference points can be given on which the raster image of the map is transformed to the desired GIS-projection. The downside of this method is that, although the map is quite accurately transformed, the legibility of the texts is reduced dramatically, since the pixels that make up the text are ‘rubber-sheeted’ as well. The older the map, and the less fixed reference points given, often gives a greater distortion. This is especially the case with maritime maps. Another problem arises when the original map has several scales used in the image. This practice, incorrect as it might be, was often used to emphasize the importance of a region compared to its surroundings. Even the well known, and renowned, mapmaker Blaeu has used this to e.g. emphasize the county of Holland against Friesland and Utrecht. These maps can’t be ‘rubber-sheeted’ accurately.

So ‘rubber-sheeting’ can provide a good comparable image in a GIS. But that is also the other limitation; whilst it is possible to visually compare the maps with modern geo-data, it doesn’t give the original map-data, such as depths, sailing-routes, etcetera, in a comparable database. The only way of translating the map, including its data, into a GIS is by truly translate them into GIS, that is, digitize them into GIS-regions or points with the related datasets attached. I want to explain this process with two examples.

Fig. 2 – a map of the Wadden islands shows a large degree of warping: the islands as well as the Dutch-German coast appear in a straight west-east line.

Navigation

Orientating on board ships was mainly done in two ways: by dead-reckoning and by measurements. In addition, observations of the colour of the water, the presence of certain types of birds or fish and identifiable points along the coast were used.

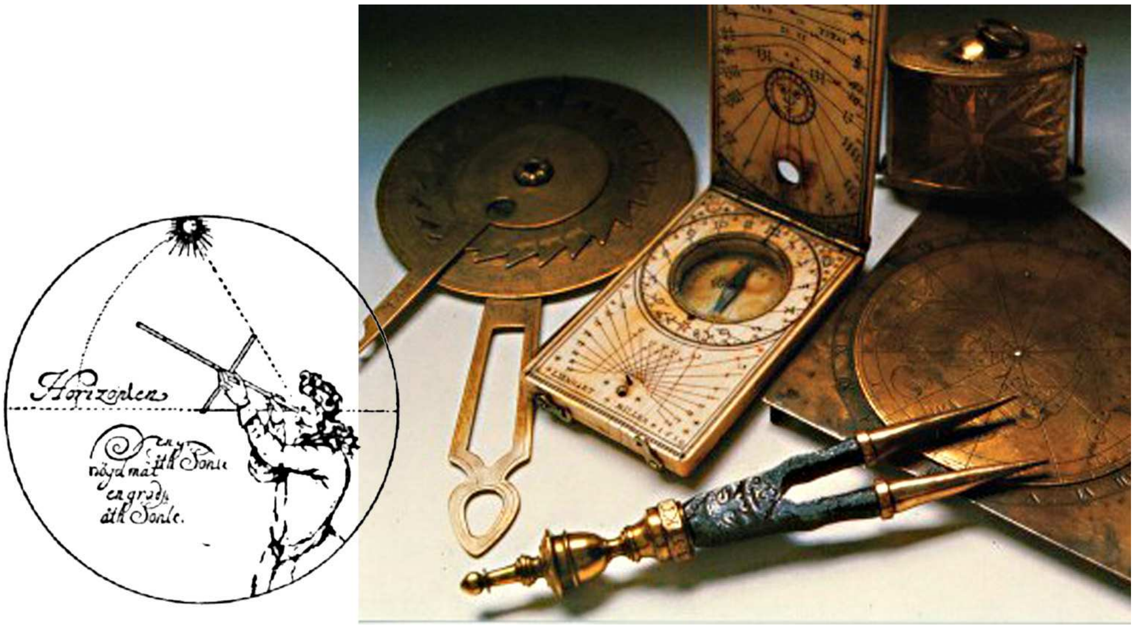

Fig. 3 – examples of 16th and 17th century navigational instruments.

Dead-reckoning was done by plotting a course-line from a known point where speed, compass-course, drift and currents were included in the calculation. In addition ships carried instruments with which the position of celestial bodies could be measured. With these celestial measurements the latitude could be calculated, using astronomical tables. But these instruments were still very primitive and difficult to read. There were calculation methods to determine the longitude using instrument data, but they were very unreliable and even more sensitive for calculation errors and misreading. Only with the invention of the chronometer in 1762 by John Harrison could the longitude be determined correctly. For a long time the most reliable way of determining ones position remained measuring the angle between two or more identifiable points along the coast. Therefore ships mainly sailed within sight of the coast.

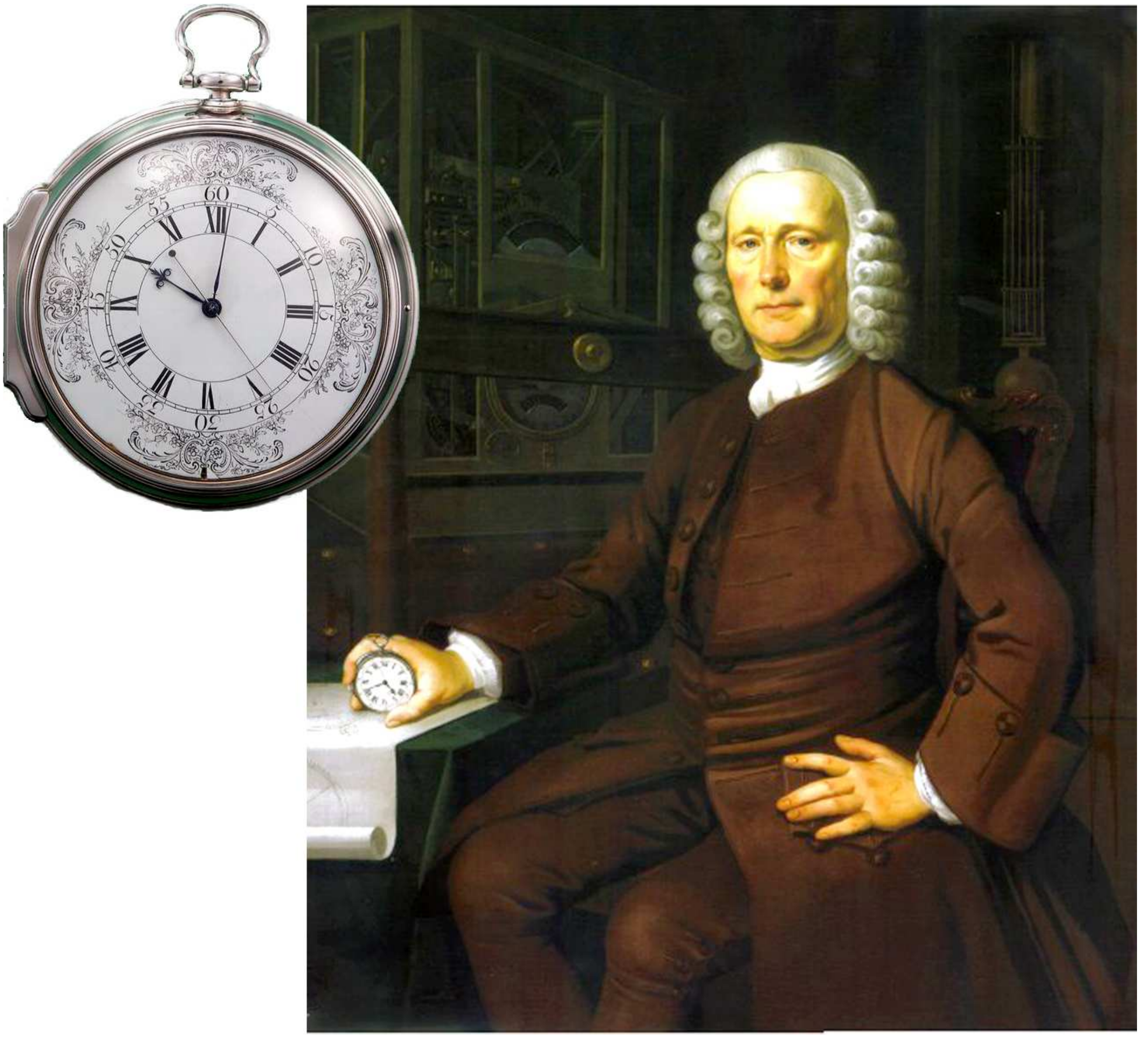

Fig. 4 – John Harrison and his chronometer.

These kinds of problems existed not only for sailors: mapmakers had the same problem, especially with maritime charts. It should also be pointed out that precise angle measuring instruments, such as mirror quadrants, were only invented in the 18th century. A coastal area therefore was mapped by combining different small sections, measured by triangulation. In many cases information from existing maps, that were considered reliable, was used and often copied.

Lucas Janszoon Waghenaer

Lucas Janszoon Waghenaer (ca. 1533-1606) was ‘Navigator in Enchuijsen’ and completed in 1584 the first part of his 'Spieghel der Zeevaerdt, van de navigatie der Westersche Zee, innehoudende alle Custen van Vranckrijck, Spaingen ende ‘t principaelste deel van Engelandt, in diverse zee caerten begrepen.’

(Mirror of Navigation; on the navigation of the Western Sea, containing all the coasts of France, Spain and the main part of England in several maps).

This work was an extension of the traditional 16th-century seaman’s almanacs because, in addition to the textual information, Waghenaer added maps. These charts, 23 in total, depicted the European coast from Texel to Cadiz. The second part, which appeared one year later, contains the maps of the coasts north of Texel, into the Baltic Sea. Since there are no indications that Waghenaer (partly) copied his charts from existing sources, it is assumed that these charts were based purely on his own observations and knowledge of navigation, which he had acquired as a navigating officer. Although the used edition is a decorated presentation edition, engraved by Baptist and Deutecom, the map information is equal to that of the original charts.

The map that I use as an example is that of 'De vermaerde stroemen, Tvlie ende Tmaersdiep, opstreckende inde Zuijder Zee voorbij Enchuijsen tot Amstelredam, met alle sanden plaeten en ondiepten opde selve stroemen geleghen.’ (The well known currents, Vlie and Marsdiep, going into the Zuider Sea past Enkhuizen to Amsterdam). This is the most northerly sheet of the first part of his 'Spieghel’. At first glance the province of North-Holland appears too broad and plump, Friesland relatively too small and the Wadden islands north of Texel are positioned in a straight line. Despite this, the map was reliable enough to navigate; most of the ships that used Waghenaer's almanac arrived at their destination and returned safely.

Fig. 5 – The map ‘De vermaerde stroemen, Tvlie ende Tmaersdiep…’ (The well known currents, Vlie and Marsdiep) by Lucas Janszoon Waghenaer. 1854.

Translating the map into GIS

To correctly place this map in a modern GIS, we first have to find out for what purpose this map was made, so what degree of reliability was needed. As I said above this map is the most northern sheet of a series of navigational charts from Texel to Cadiz. That means that this map was made for navigating the shipping routes from the major trading cities such as Amsterdam and Enkhuizen to the southern regions of Europe. The main routes through the Wadden Sea for these destinations were the western passage through the Marsdiep and the northern passage through the Vliestroom. These routes are therefore the most detailed parts of the map. Friesland, especially north of Harlingen, and the islands north of Terschelling are only to ‘complete’ the map image, and didn’t need to have the same level of detail or degree of accuracy as the shipping routes.

To georeference the map I applied the same techniques as those which whom the original map was created: small parts of coastline charted using triangulation and sightlines. These separate areas are then ‘redrawn’ in a modern projection and combined later. For this map sheet, I started with the area around Enkhuizen.

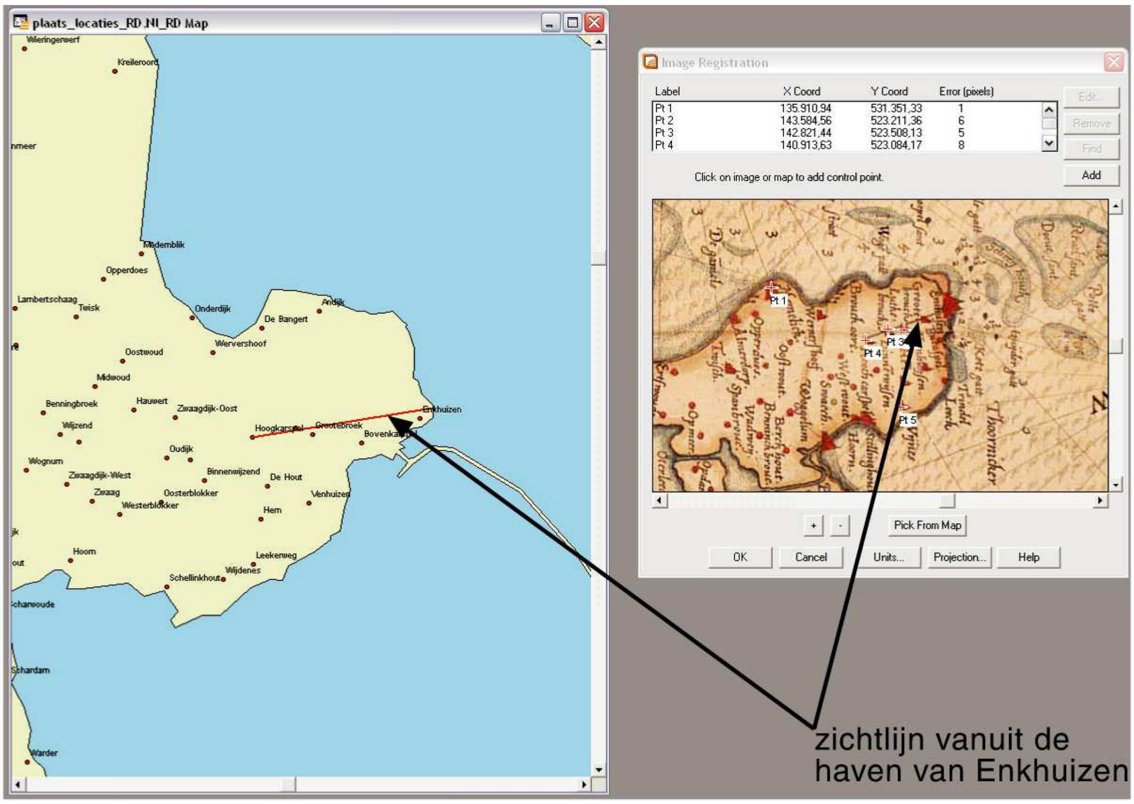

Fig. 6 – The area around Enkhuizen; on the left the modern map, on the right the georeferenced part of Waghenaer’s map.

Looking at Waghenaer's map, it is clear that this particular area is pretty well charted; the angles between Enkhuizen, De Kreupel sands, Stavoren and Enkhuizen, Medemblik are properly depicted, and the relative distances are reasonably correct. By vectorising this part, and adding the names, depths and other information to a database on the location shown on the map, this part could be transformed into a modern projection.

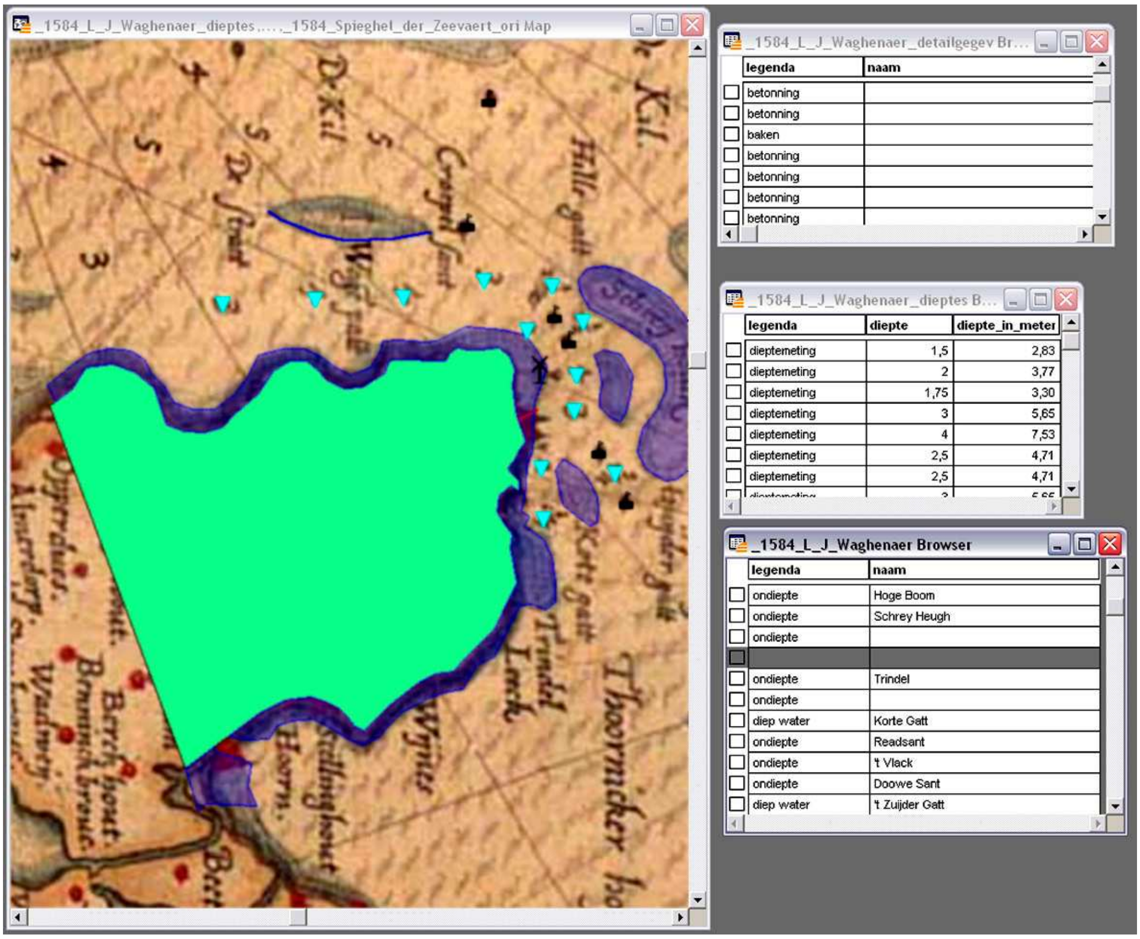

Fig. 7 – Vectorized part of Waghenaer's map with all the data put into the database.

Next the same was done for the area Den Helder, Texel, Den Oever. This way the entire map was put into a GIS, whereby Friesland and the northern islands were more or less 'sketchy' digitized, similar to the original. After the various parts were combined, the distances between some reference points, such as the Breezand, Texel, Harlingen, Stavoren and Enkhuizen, on both maps (the new GIS map and the original map of Waghenaer) were compared, and adjusted where necessary.

Fig. 8 – Check of reference distances on the map in modern projection (on the left) and on the original map (on the right).

That eventually gave a map, in the modern projection, in which all data from the chart from 1584 could be compared with modern data.

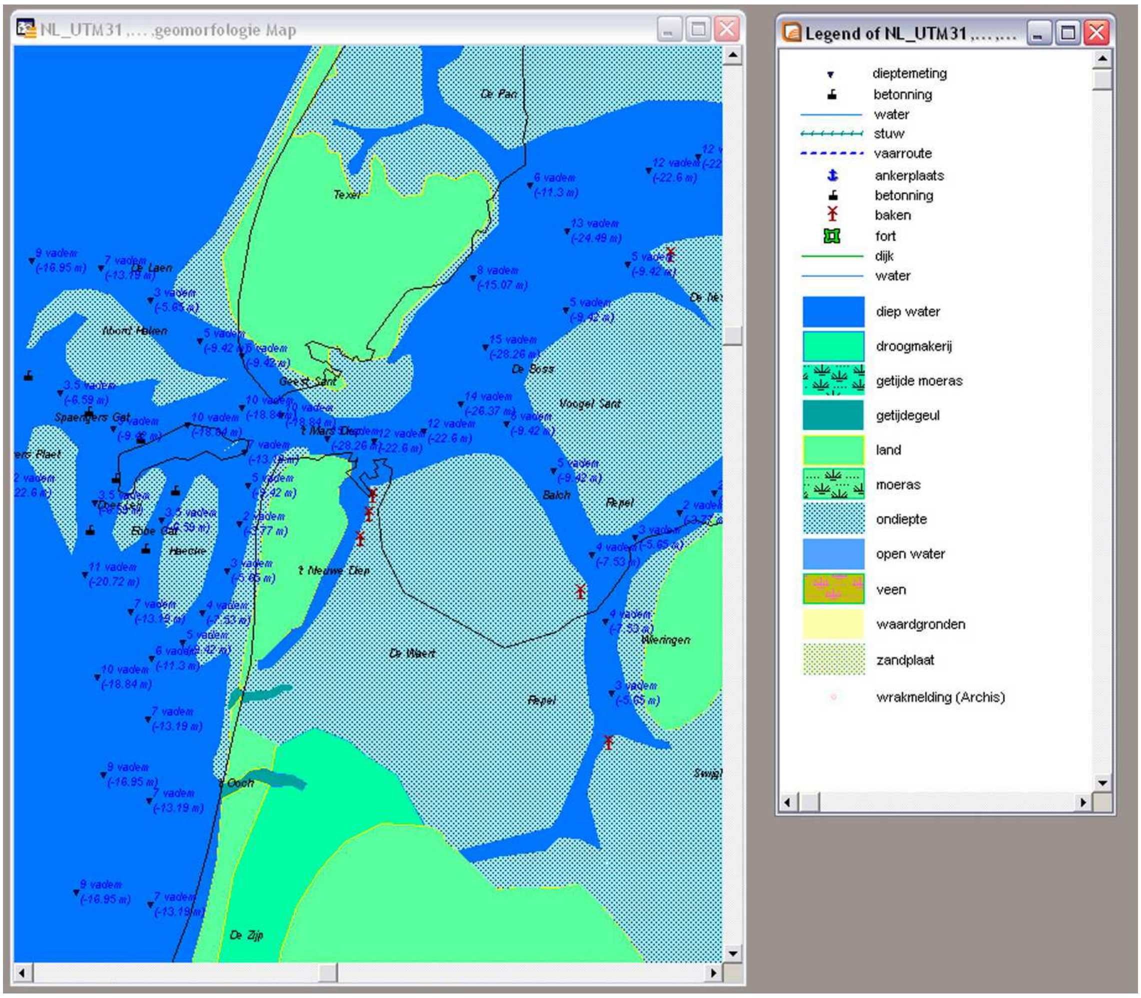

Fig. 9 – Detail of the 1584 Waghenaer map in a GIS.

Pieter Goos

Pieter Goos (1615-1675) was a bookseller and engraver in Amsterdam and became in 1650 one of the major publishers and retailers of seaman’s almanacs and charts. In 1666 he published his ‘Zee-atlas of the waterwereld waer in vertoont warden alle de zee-kusten van het bekende des aerd-bodems. Seer dienstig voor alle heeren en kooplieden, als oock voor alle schippers en stuurlieden.’ (Sea-atlas or water world in which is depicted all the seacoasts of the known world. Very useful for all lords and merchants, as well as for all captains and officers). This atlas contained 40 or 41 maps. All these maps are very nicely coloured and decorated, which suggests that this atlas was mainly intended as a presentation edition.

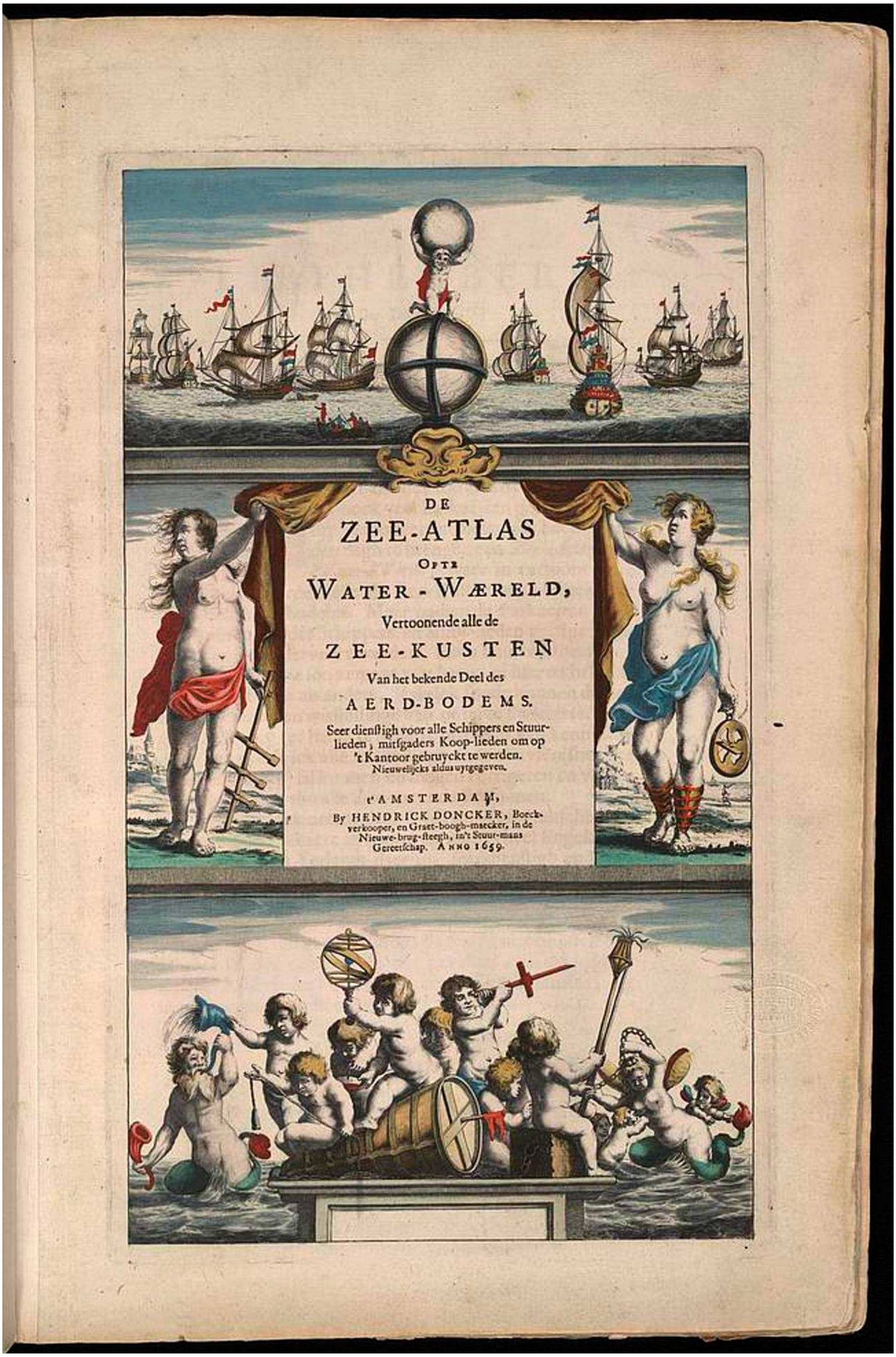

Fig. 10 – Title page of the 1659 ‘Zee-atlas’ (Sea-atlas) by Hendrick Doncker.

The actual charts were not by Goos himself, but were copied from the ‘Zee-atlas ofte water-waereld’ (Sea-atlas or water world) by Hendrick Doncker, also from Amsterdam. This atlas was published in 1659 and, because it was regarded the most accurate in maritime cartography in the second half of the 17th century, was copied by several other publishers.

The chart from the ‘Zee-atlas’ I use as an example is the 'Pascaerte vande Zuyder-Zee, Texel ende Vliestroom alsmede ‘t Amelander-gat.’ (Portulan chart of the Zuijder-Sea, Texel and Vlieland strait as well as the Ameland strait).

Fig. 11 – The ‘Pascaerte vande Zuijder-Zee’ (Portulan map of the Zuider-Sea) by Pieter Goos. 1666.

As the title indicates, this is a portulan chart, a small-scale chart on which a route could be plotted. To ensure the route could be plotted by compass course, this map was set in a Mercator projection. The Mercator projection has the advantage of ‘angle equality'. That means that the angles on the map equal the angles (compass directions) in reality, so a line of constant compass direction gives a straight line on the map. Because most modern maps are also in some form of Mercator projection, Goos’s map is more recognizable to the modern reader than that of Waghenaer. However, this map is similarly hard to place under a modern map. To put it into a modern GIS I used the same technique as I did with that of Waghenaer. Although Goos gives more detail information in the northern part of the

Wadden Sea, this portulan, like the map from the 'Spieghel' was also mainly intended for navigation on the Zuider Sea and the routes to the southern North Sea.

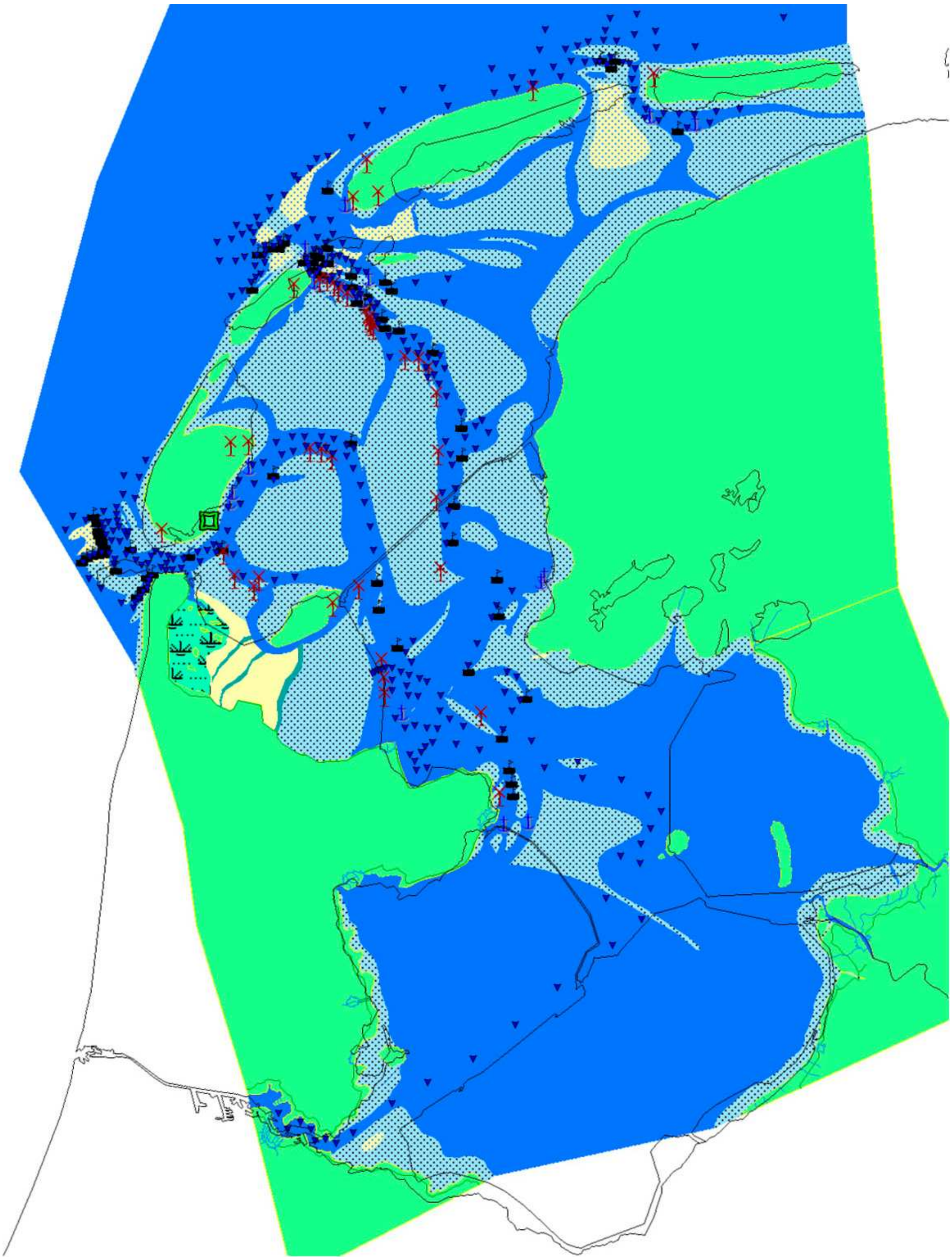

Fig. 12 – The Pieter Goos map in a GIS.

Waghenaer and Goos compared

If we compare these two maps it is immediately clear that the large shallows in the western Wadden Sea have moved slowly to the west, and worse, that the indicated deep-water channel has moved dramatically westwards.

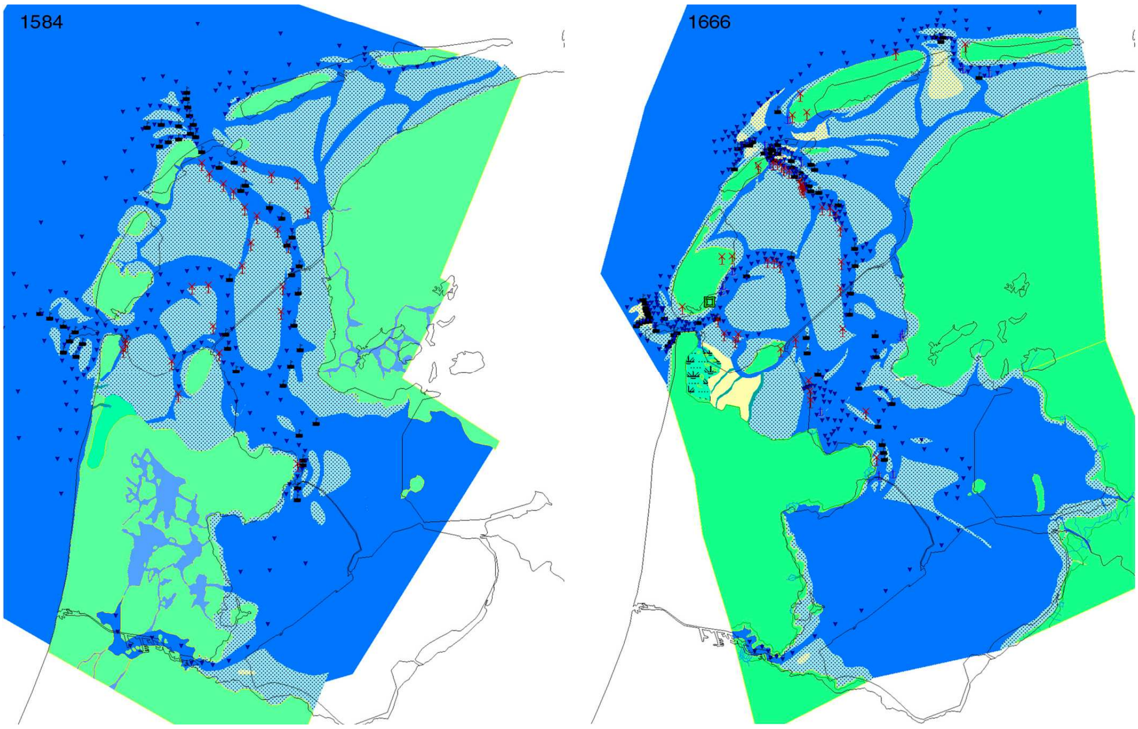

Fig. 13 – The Waghenaer (on the left) and Goos (on the right) maps compared.

We have to realize that these maps were not only very popular, but also very expensive, so it is not inconceivable that many captains did not, as nowadays, replace their maps regularly. That would have led, certainly in cases of poor visibility and bad weather, to dangerous situations, when a skipper trusted Waghenaer blindly...

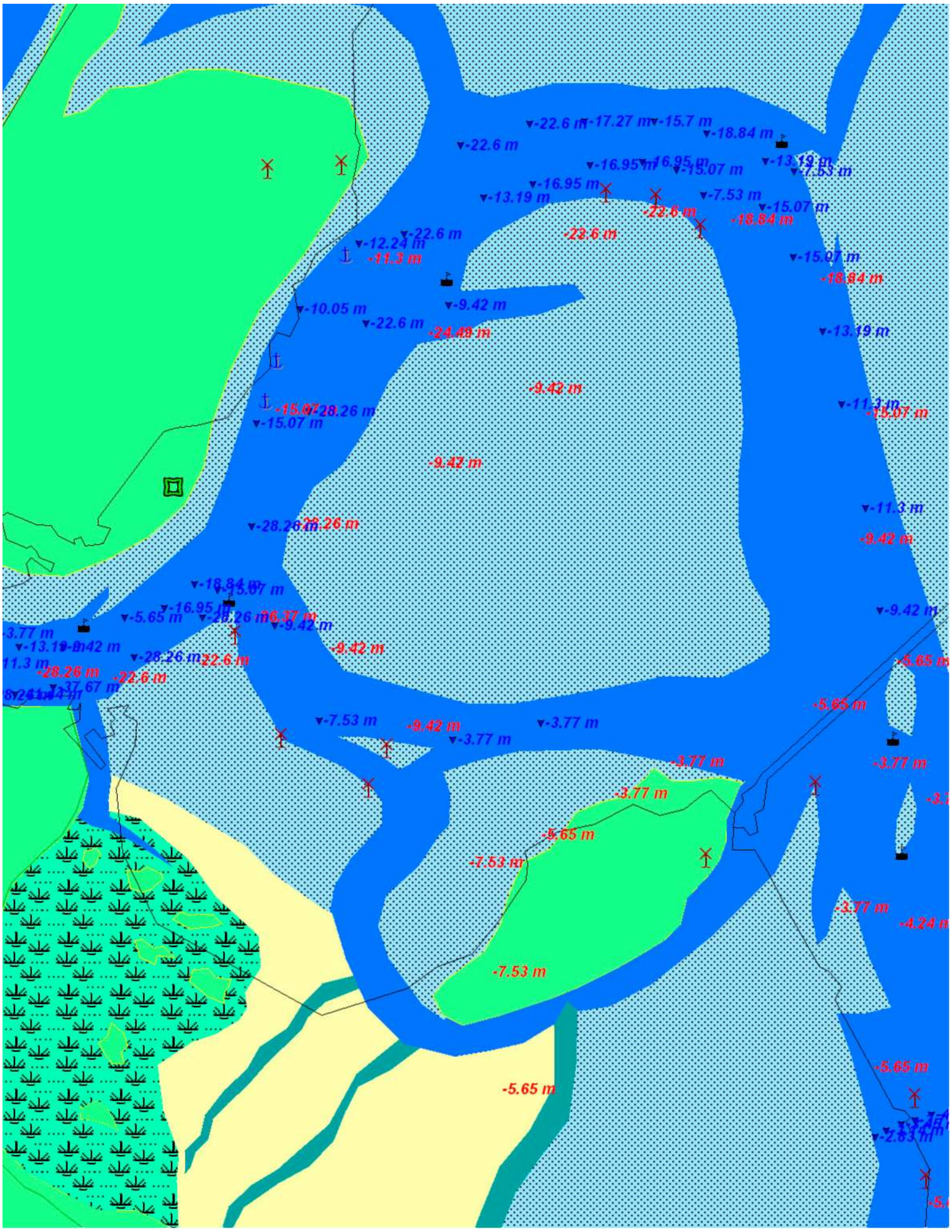

Fig. 14 – Detail of the 1666 map in a GIS with the soundings of the deep-water channel of 1584 superimposed in red.

A case in point is when we plot the 17th century known wreck-sites on these maps in the GIS. Where on the 16th century map the safe deep-water channel is located and beacons mark the shoal, on the 17th century map we see the edge of the shoal, and the concentration wrecks! Possibly these unfortunate captains still had their old Waghenaer maps, and was the weather too bad to navigate on sight. The habit (trading) fleets had to operate in a ‘cloud’ of ships probably played a negative role as well. Despite the fact that pilots were an obligation in the Dutch waters, this type of navigation errors, especially in that era, cannot be ruled out.

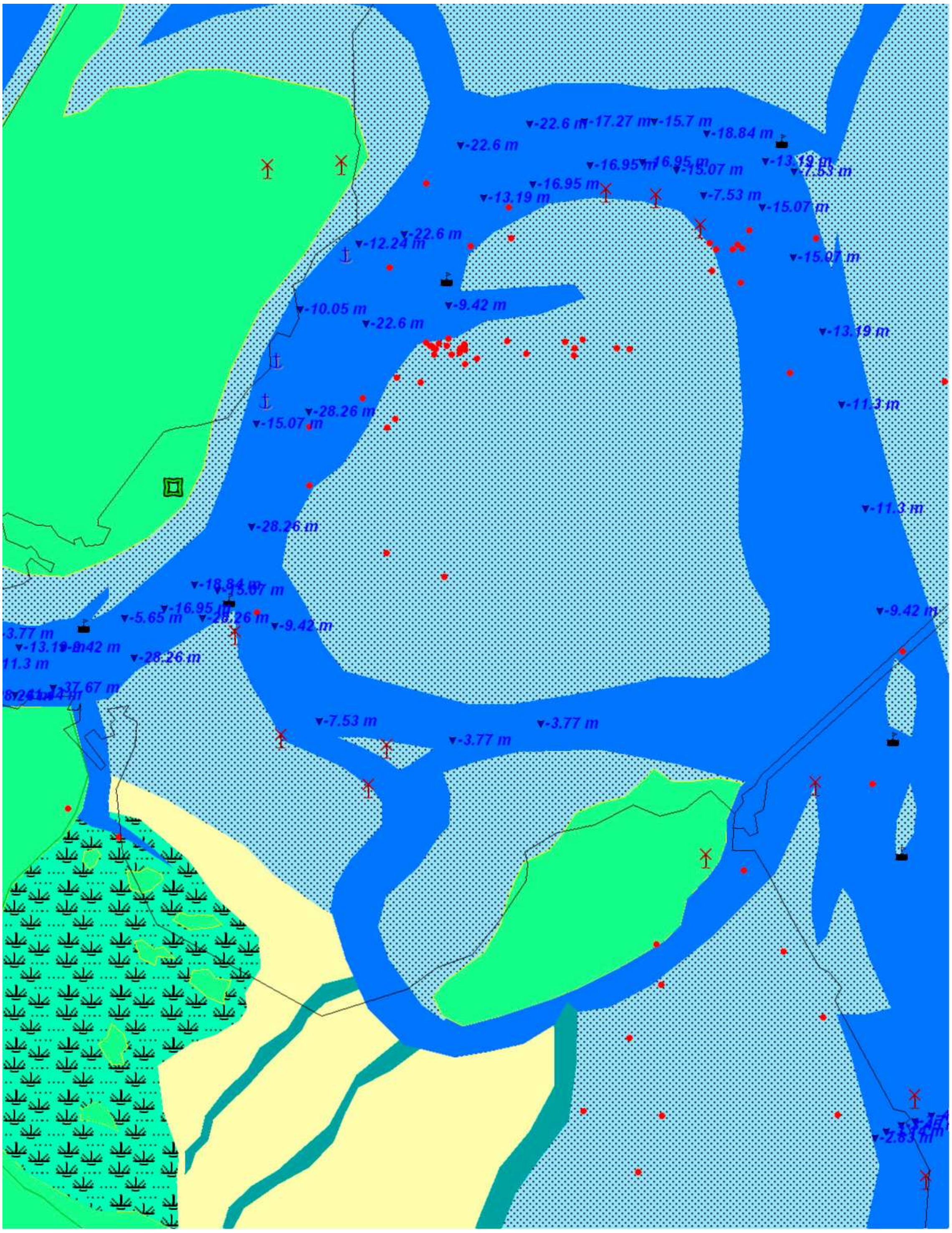

Fig. 15 – The location of known 17th century wrecks superimposed on the 1666 map in a GIS.

Conclusion

Old maps are not only a pleasure to watch, they are also an important source of information about the geographical situation at that time. For this information to be used in combination with modern information and maps it is necessary to place the historical maps into a GIS. To do so it is necessary to first determine the purpose of the map (and with that its most accurate part). The title is often a good source of information. Then should be determined how the original map was charted. Fixed points along the coast, charted navigational- and sightlines are a clue for this. Then the map should be vectorized in several small, coherent areas, whereby point data such as depths, buoys, beacons and so could be put into the database. After these separate parts are combined and the in-between distances are checked, all the information from the historical map can be compared to the modern maps.