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Preserving a layered history of the Western Wadden Sea : managing an underwater cultural heritage resource

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2.

Developing a landscape approach to underwater cultural heritage: the Historical Geomorphological Map Set for the Wadden Sea

Fig. 2.1 Buoy on a wreck at the Burgzand area. Photo: M. Manders

2. Developing a landscape approach to underwater cultural heritage: the Historical Geomorphological Map Set for the Wadden Sea

2.1 Introduction: the necessity of a new approach

For much of its history, archaeological heritage management has been a reactive endeavour.¹ Heritage management in the Netherlands is no exception to this rule. Until the mid-1990s, recommendations on how to deal with heritage in the Netherlands were based on well-documented heritage locations, or 'known resources'.² Starting in 1992, these locations could be requested via the National Archaeological Database System, ARCHIS, but also via other data collections of variable reliability.³ However, in addition to the fact that some of the data were less reliable than others (especially with regard to the exact location of sites), it quickly became clear that the known heritage sites were just a fraction of the heritage that remained hidden underground in the Netherlands. This unknown or 'potential' heritage was thought to be many times larger than the known heritage.⁴

Maritime and underwater cultural heritage are also strongly connected to the landscape. Specific landscape qualities identified by people determine the use of an area. The need and willingness to use a specific area have determined the way that it may have been altered by people to better fit the landscape to their needs. We can use such links to connect individual sites and the landscape. Through the 'reading' of recent and past landscapes, we may be able to predict where we can expect the still unknown sites to lie. This is the reason why a new tool, the Historical Geomorphological Map Set (HGMS), has been developed. The HGMS approaches underwater cultural heritage on a landscape scale. In this way, it facilitates the making of period and area-specific landscape reconstructions (palaeogeography). By reading and interpreting the landscape we can understand how people may have used it. Below, I will explain how the HGMS was developed and how it can be used.

The seabed, as mentioned above, not only consists of the cultural heritage we already know about. There is a lot of potential that has not been discovered. This potential heritage may be covered by metres of sand and clay deposited on top, or it may

have completely or partially disappeared due to heavy erosion. The problem is that archaeological sites, and especially underwater archaeological sites, are not easily seen and, unfortunately, are thus not naturally taken into account when managing areas.

It is not easy to capture the known underwater cultural heritage in a single two-dimensional map. To be able to predict areas of interest we need to combine a large amount of information about the area from different time periods. By understanding the appearance and the daily use of the area in the past and present we can make some predictions about where cultural heritage might lie in the terrain.

The data for this comes from different sources, collected for many different purposes by many different people and organizations. The data is therefore not uniform for every area and every period.⁵ The quality of the data also differs as to when and how it was collected and the degree of accuracy.⁶ Some sets of data are also more important for one period than for another. This is because knowledge of the geological and morphological characteristics of the terrain can help determine whether prehistoric sites (previously on dry land) are present in the area or not, while knowledge of the use of the water and the adjacent coastlines and the dynamics of the Holocene sand layers are essential to the understanding of shipping and trade in the later periods. Thus, with a variety of maps we can gain an insight into



Fig. 2.2 Indicative Map of Archaeological Values (IKAW), 1997 version. Figure: courtesy RCE.

¹ See also Chapter 1 and Gould 1983, Hamersveld 2009, 109, Manders & Tilburg 2010.

² Deeben 2008, 7.

³ These include WrakSys, a database system that records the locations of tens of thousands of shipwrecks uncovered through the efforts of a number of amateur archaeologists (Ruggenberg 1995).

⁴ These differences are also pronounced abroad. For example, Historic England uses a chart of shipwrecks listing 53 historic Designated Wreck Sites. These only include protected shipwrecks (<https://www.historicengland.org.uk/advice/planning/consents/protected-wreck-sites/>, accessed 10-12-2017). Another chart compiled by a private party contains thousands of sunken ships, many of which have never been localized (http://www.shipwrecks.uk.com/info1_2.htm, accessed 29-01-2017). See also Manders 2012(2).

⁵ See Chapter 1.

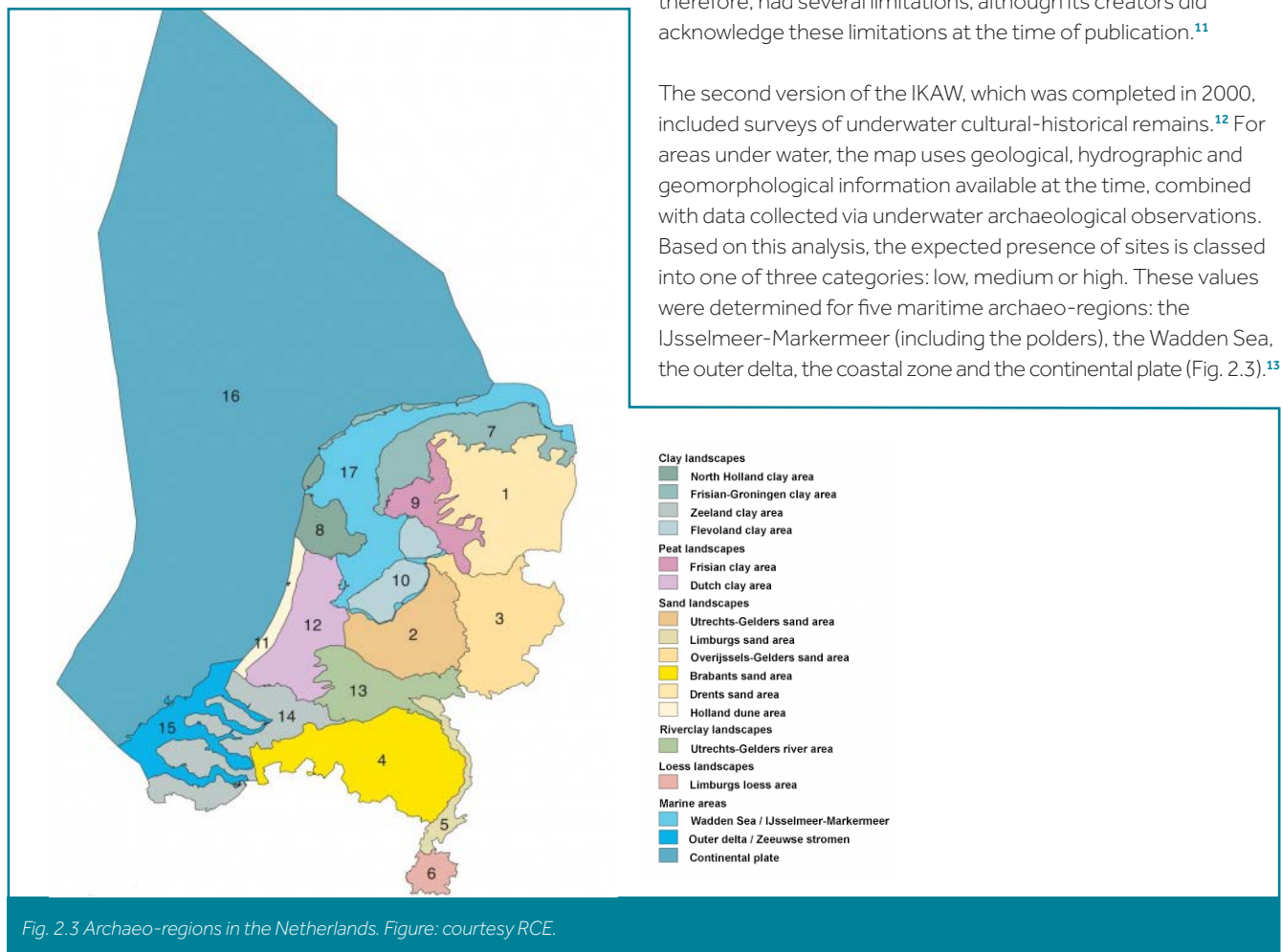
⁶ See Chapter 1, for a discussion of this, see also Wiemer 2002.

the former use of the landscape, and by hindcasting and forecasting we can make decisions on which area has what probability of containing well-preserved sites. The sites become predictable and 'visible' without us needing to go to the place itself.

The realization that the Netherlands' cultural heritage was rapidly disappearing without anyone studying or even seeing it provided the impetus for a survey of the heritage that had not yet been discovered; that is, its 'unknown resources'. In 1996, the Cultural Heritage Agency of the Netherlands⁷ made its first attempt to develop a national map of expected finds: the Indicative Map of Archaeological Value (IKAW). This map was completed in 1997 (Fig. 2.2).

The IKAW was based on an analysis of the archaeological regions ('archaeo-regions')⁸ defined in the digital geomorphological map,⁹ the archaeological observations recorded in ARCHIS and expert knowledge on the formation of archaeological data for each archaeological region (Fig 2.3).¹⁰ The result was a flat two-dimensional 1:50,000 map indicating zones with a high, medium or low level of expected archaeological value. The analysis conducted for each area relied almost exclusively on geological and soil survey information. In the areas where this information was lacking, in built-up areas such as cities and villages, it was not possible to provide such an indication. Areas under water were completely absent from the map, and recent disturbances in the soil were not included in the expectation valuations. This product, therefore, had several limitations, although its creators did acknowledge these limitations at the time of publication.¹¹

The second version of the IKAW, which was completed in 2000, included surveys of underwater cultural-historical remains.¹² For areas under water, the map uses geological, hydrographic and geomorphological information available at the time, combined with data collected via underwater archaeological observations. Based on this analysis, the expected presence of sites is classed into one of three categories: low, medium or high. These values were determined for five maritime archaeo-regions: the IJsselmeer-Markermeer (including the polders), the Wadden Sea, the outer delta, the coastal zone and the continental plate (Fig. 2.3).¹³



⁷ Successor to the Netherlands Archaeological Field Survey Agency (ROB). This agency was absorbed by the Netherlands Agency for Archaeology, Cultural Landscapes and Monuments (RACM), which later became the Cultural Heritage Agency of the Netherlands (RCE). For the sake of clarity, this thesis uses the abbreviation RCE to refer to all of these organizations.

⁸ An archaeo-region is an area in which there is a general relationship between the landscape and the history of habitation, as well as between the processes that form the landscape and the development of archaeological sites. It also takes into

consideration the geological archive in general.

⁹ De digitale geomorfologische kaart van Nederland: <http://www.wageningenur.nl/nl/show/Geomorfologische-kaart.htm>, (accessed 29-01-2017).

¹⁰ Deeben 2008, 8.

¹¹ Deeben et al. 1997, 111–113.

¹² Lauwerier 2002, 66–72.

¹³ Deeben 2008, 9, Maarleveld 1998, 55–71.

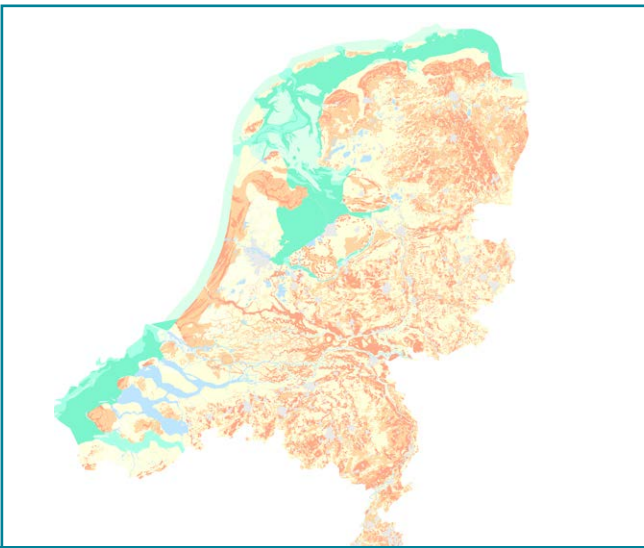


Fig. 2.4 Indicative Map of Archaeological Values (IKAW), version 2007. Figure: courtesy RCE.

The third-generation IKAW from 2007 provides more detail as to the possible location of cultural-historical remains in certain areas, such as the Province of Flevoland and the Zeeland Delta archaeo-region.¹⁴ An integrated General Archaeological Chart has also been drawn up for the continental plate in the North Sea at a scale of 1:500,000 (Fig. 2.4).

With regard to underwater areas, the IKAWs that have been published thus far have major limitations regarding their use in a scientific or a cultural-historical management context. In the first place, the later versions of the IKAW were intended to give an indication of the expected quality of the possible finds in an area and not of actual sites themselves.¹⁵ In this respect, these maps have not kept pace with the land maps, despite the fact that they have been integrated into a single map. Important data sets that could provide better predictions are entirely lacking.

The IKAW for the North Sea is based on the existence of a well-preserved Pleistocene strata covered by later sediments and peat. This approach can provide relatively good insight into the condition of prehistoric locations, as long as they have not been disturbed. However, it does not provide insight into the locations with the greatest likelihood of finding traces of habitation because it does not take into consideration the entire prehistoric landscape ('palaeo-landscape') covered during this

period, or the interpretation of the use of the area during the period. New technological developments have recently made this a possibility. Sub-bottom profiling,¹⁶ for example, produces a large-scale image of the prehistoric landscape with hills and valleys.¹⁷ This knowledge helps us to predict the presence of prehistoric habitation because it can tell us something about locations suitable for former habitation and land use, and thus about the possible cultural landscape during the period.

Other data sets that are missing from the current indicative values map include disturbances in the geological profile. These are essential because they can provide insight into the potential heritage that has already been lost, and can therefore help rule out areas that do not require archaeological surveys.¹⁸

Soon after publication of the third-generation IKAW, it became clear that a different approach was required to generate an indicative map for sea, lake and riverbeds. The map of the North Sea was too general and, in addition to the lack of the important data sets listed above, it also did not take into consideration the dynamics of the area. As a result, the IKAW maps either had a demoralizing effect ('we can never pay for or manage so much heritage, because underwater and shipwreck archaeology is very expensive')¹⁹ or they were used improperly and large areas were approved for use because no heritage was expected to be present.²⁰ Despite the fact that the map only provided an indication of the presence of cultural heritage in the ground (and, for submerged areas, only the possible condition of potential finds) and was not intended to inform immediate policy decisions, several government agencies used it for precisely that purpose.²¹

In 2012, work began on a new version of the Maritime IKAW.²² This project initially focused on producing an Indicative Map of Archaeological Values in a few priority areas (the Western Wadden Sea, the Markermeer, the North Sea and the river delta),

¹⁴ Deeben 2008, 9 and Peeters 2008, 31–34.

¹⁵ In part, because it is based on the assumption that the presence of individual shipwrecks cannot be predicted, while the possibility that any shipwrecks have survived to the present can be calculated.

¹⁶ A sub-bottom profiler uses powerful low frequency sound waves to create profiles of the upper layers of the seabed.

¹⁷ See Fitch et al. 2007; Dix et al. 2006; Gupta et al. 2004; Gaffney et al. (eds) 2007(1), 2007 (2), 2011; Dix & Sturt 2011; Heteren et al. 2014; Ward et al. 2014.

¹⁸ Including information about 'recent' disturbances has a mere management purpose. When attempting to interpret past use of an area this kind of information may reflect the view of the investigator and should not be taken into consideration. However, when attempting to focus on future protection and determining the archaeological value of an area at present, this information is of much importance since it can shed light on threats and the potential of a site.

¹⁹ Alkemade et al. n.y. The website of the SIKB, in its 'handreiking Archeologie, Cultuurhistorie en Aardkundige Waarden voor waterbeheerders' 2015 ('Guide to Archaeology, Cultural History and Geological Values for Water Managers' ([http://](http://handreikingarcheologie.sikb.nl/188)

handreikingarcheologie.sikb.nl/188) still mentioned the high costs involved in underwater and shipwreck archaeology, which would certainly not stimulate involvement in the field. See, in this light, also the statement of Mr G. Poster of the Texel2010 party in the discussion report No. 4 of the Municipality of Texel, meeting of 27 October 2009, with respect to the Monuments Policy Document of Texel 2009, including the financial consequences: 'Texel2010 is tegen. We moeten af van alle extra uitgaven. We hebben niets met onderwaterarcheologie. We letten op de portemonnee.' (Texel 2010 is against. We have to rid ourselves of additional expenses. We want nothing to do with underwater archaeology. We must take care of our wallet).

²⁰ In the announcement of the Symposium 'Erfgoed in waterbodems 28-11-13', the organizers even mention the water beds to be exempt from the archaeological perspective. www.cultuurcompagnie.nl/clientdata/downloads/Uitnodiging-congres-over-waterbodems-28-11-2013.pdf. (this link is not accessible anymore checked 29-01-2017).

²¹ See, for example, Cleveringa et al. 2012, pp. 19–20.

²² Manders 2012 (1).

taking new insights into consideration.²³ However, it was soon decided not to produce a new generation of indicative maps but to draw up more detailed Historical Geomorphological Map Sets (HGMS) for two of the areas – the Western Wadden Sea and the Markermeer-IJmeer – and to make them available to third parties.²⁴ These sets of maps were intended to serve as the foundation for the further development of policy and value maps. There were several reasons for this change in the product's final form. First of all, as stated above, the development of value and policy maps requires a set of basic data and this had not yet been gathered. Thus, it was first necessary to determine which data was needed and then to collect it. Secondly, due to the decentralization of archaeological heritage management in 2007, the responsibility for managing cultural heritage was largely delegated to municipal and provincial governments.²⁵ Subsequently, roles shifted. Would it still be appropriate for the national government to decree which areas inside the municipal borders had high or low value when drawing up archaeological value maps? There would be several implications for municipal policy in allocating high and low values. For example, a high value could result in additional costs for preliminary surveys or consulting.²⁶ It would therefore be more logical, and management-wise more effective, if municipalities themselves drew up the indicative maps and subsequent policy plans.

On this basis, it was decided to focus more on the use of the right data than on the outcome of the predictive modelling. The Historical Geomorphological Map Set would provide the basic knowledge and relevant maps to serve as a sound foundation on which municipalities could base their value assessments. The basic map set would be provided in digital format and the instructions for use would be explained via sample questions. This would provide a minimum level of quality for future value and policy maps, whether they are to be drawn up by the municipality itself or by archaeological firms at the municipality's request.²⁷

The pilot area for developing the HGMS was chosen to be the Western Wadden Sea, roughly bordered by the Afsluitdijk in the south, off the coast of the island of Texel in the west, the Frisian mainland in the east and stretching up to Terschelling in the north (Fig. 2.5). The Western Wadden Sea area has been inhabited,

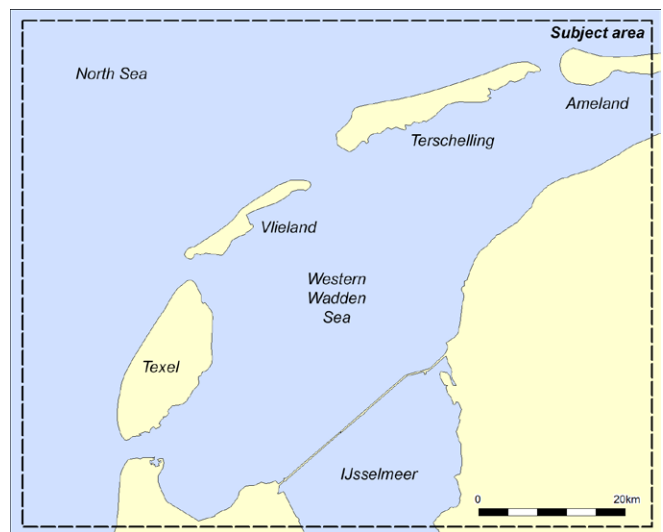


Fig. 2.5 The pilot area of the Western Wadden Sea. This is the subject area for this thesis and the development of the HGMS. Figure: courtesy Periplus Archeomare/RCE.

navigated and used intensively, but fortunately it has also been intensively monitored from an early phase, in order to provide information on shifting sand bars and shipping channels for navigational purposes.²⁸ The history of the area, in combination with its dynamics, the density of information available and the active local involvement in cultural heritage, were important considerations for choosing this pilot area for the development of the HGMS.²⁹

2.2 The value of place and object

The decentralization of heritage management and more active local involvement may be a consequence of budget cuts by the national government, but it also reflects a wider development in which 'heritage participation' plays a larger role. This also gained more official status with the Treaty of Faro (2005).³⁰ Consequently, local governments and residents are increasingly taking matters into their own hands in order to improve their living environment, without waiting for the central government to take action.³¹ This changes the way people value cultural heritage.

When talking about significance and value and the active involvement of different stakeholders, it is important to understand that the concept of 'value' does not have a fixed definition. Rather, cultural-historical value is determined by a group or

²³ Manders 2012 (1). The new insights into e.g. dynamics and preservation conditions in the Wadden Sea had evolved from the European cooperation projects of MoSS (Cederlund 2004) and MACHU (Oosting & Manders 2007, Manders et al. (eds) 2009 (1) and 2009 (2)).

²⁴ Manders et al. 2014, Houkes et al. 2014.

²⁵ Included in the Archaeological Heritage Management Act (WAMZ, 2007).

²⁶ The national government will remain active in drafting policy maps at the national level and where the national government has a direct responsibility due to national or international interests, such as the North Sea.

²⁷ The maps can also be used to characterize landscapes in the future in the manner currently used in England. See Dudley & Johns 2014, for example.

²⁸ See Chapter 6.

²⁹ And this was also the reason to choose the Burgzand Area as a testing site for in-situ preservation and monitoring methods. See also Chapters 1 and 3.

³⁰ Treaty of Faro (<http://conventions.coe.int/Treaty/Commun/QueVoulezVous.asp?NT=199&CM=8&DF=1/5/2008&CL=ENG>, accessed 29-01-2017). This treaty of the Council of Europe has not yet been ratified by the Netherlands. On heritage participation in the dive community, see Boelen 2009. For perception and practice of the Faro Convention in the Dutch Cultural Heritage sector, see Scharff 2013.

³¹ See also Manders 2013 or the letter that was sent by 'Stichting de Noordzee' (The North Sea Foundation) to the Secretary of State Zijlstra on behalf of different stakeholder groups to protect the shipwrecks in the North Sea (21 November 2011).

society that assigns importance to an object or find, usually as a reflection of its identity. An example of this is the value assigned to the wrecks associated with the battle of the Java Sea in Indonesia, which have a different value not only to different countries – Indonesia, the Netherlands, Australia, the UK, the US and Japan – but also to different stakeholder groups, whether archaeologists or, for example, scrap metal salvagers.³² The same is true for the three British battle ships (the *Aboukir*, *Cressy* and *Hogue*) and the Jutland wrecks of the First World War in the North Sea.³³

Similarly, the wrecks found in the Wadden Sea may also be valued differently, reflecting a search for a different identity. Value is created in contemporary scientific and social contexts, and may therefore also differ depending on whether it is assigned by the national government or the local municipal administration. In the context of reinforcing identity, one municipality may place a higher value on the history of its own fishery, along with the material remains related to it, while other towns or cities may consider trade to be a stronger element of their own identity. Also, it should also be kept in mind that an object or place has different values depending on the perspective of the person or group concerned and the proposed use of the object or place in the future.

The identification of what should or should not be preserved relies almost by definition on the concept of significance or value; for example, intrinsic value and the significance of change. Who has the right to determine the value of an object? Is it a specific stakeholder group such as 'archaeologists' or regional marketeers? Or perhaps 'policymakers'? Or does the value depend on the proposed 'use' of that place or object? Will we need to differentiate between the cultural significance and economic significance of an object or place? And what will we do based on that differentiation? Who will make the decision about the most 'important value', which will determine the future of the place or object? This may be a complex exercise, becoming even more challenging with the inclusion of stakeholder groups such as amateur archaeologists and even the general public in the evaluation process, due to the implementation of the Faro Convention.

To conclude, different values can be attributed to objects, sites and areas. Furthermore, place and object influence each other's value. Events that have occurred in an area have left behind material traces, which – if culturally valued – contribute to the overall value of the area, in a cultural sense but also as a living environment and as an area of economic interest. The different values given by different stakeholder groups may also influence each other.

This differentiation in the value of sites to various stakeholders is insuperable but need not be regarded as a problem as such, as long as the process of valuing the object, site or area is retracable and solid information is used. It is for this reason that a basic set of retracable information was collected for the HGMS as a starting point – as a kind of minimal requirement. The modular structure of the HGMS facilitates the addition of new information to the existing data set without the existing data becoming superfluous or obsolescent. The addition of data collected by different organizations, such as archaeological firms, can add diversity to the outcome of the process and therefore also add diversity to the archaeological market, which has developed as a consequence of the implementation of the Valletta Convention.

Due to the decentralization of heritage management, municipalities and provinces will now have to develop their own value maps and make their own assessments of the value of individual sites. We can expect that the added local insight and commitment will result in better management which is tailored to local needs and conditions. The role of the central government may be to supervise the process by which municipalities shift their focus to managing underwater heritage – which is still in its infancy – as well as acting as a source of expertise by answering questions, organizing workshops and meetings and developing and providing tools such as the Historic Geomorphological Map Set. Another important role is that of caretaker of the overall cultural heritage of the Netherlands, which means assessment (partly implicit and partly explicit) on the national level and serving as a fall back for the protection of those sites that will not be assessed as having high cultural heritage value from a local point of view but would be assessed as such at the national level.

2.3 The method used for the HGMS

To create a HGMS for the Wadden Sea, a project was set up as part of the Maritime Programme of the Cultural Heritage Agency of the Netherlands, executed in cooperation with the University of Leiden and Periplus/Archeomare.³⁴

The project was divided into three phases:

Phase 1: Collecting all of the relevant data and editing it for comparative purposes

Phase 2: Drafting the maps and modelling the data collected in Phase 1

Phase 3: Presenting the separate data sets, including the accompanying metadata

³² See <https://www.theguardian.com/world/2016/nov/16/three-dutch-second-world-war-shipwrecks-vanish-java-sea-indonesia> (accessed 29-01-2017).

³³ <http://www.dailymail.co.uk/news/article-2042294/Dutch-vessels-ransack-sunken-British-warships-containing-bodies-1-500-sailors-scrap-metal.html> (accessed 29-01-2017). and <http://thepipeline.info/blog/2016/05/22/exclusive-named-the->

[salvage-company-which-looted-jutland-war-graves-as-mod-fails-to-act/](http://thepipeline.info/blog/2016/05/22/exclusive-named-the-salvage-company-which-looted-jutland-war-graves-as-mod-fails-to-act/) (accessed 29-01-2017).

³⁴ This resulted in a publication (Manders, Brenk & Kosian 2014). This chapter relies heavily on this project report.

A description of each data set was provided, explaining what the specific set could reveal about the presence of cultural heritage in the soil.

Future predictive answer models (indicative/expectation maps) can be built on the basis of a diverse range of maps, which are in turn compiled from several sets of data. The map set presented in the HGMS is the foundation – a minimum requirement – of these expectation maps. Each map is available digitally via GIS³⁵ and furnished with metadata concerning the drafting method, accuracy, scale and location where the original data are stored.³⁶ By combining various maps, we can answer questions posed by policymakers and researchers.

The HGMS for the Wadden Sea has a modular structure and consists of objective (or as objective as possible), visualized data sources, as well as maps compiled on the basis of interpretation (and therefore subjective). These maps can be divided into three categories:

1. Maps based on objective measurement data
2. Combined maps (and data sets) or results from combinations of Category 1 maps
3. Maps that illustrate the reconstructed or current use of the area

The Category 1 maps form the foundation: they are visualized data sources based on objective measurement data, which can differ in refinement and accuracy. This information is provided for each map and attached to it as metadata information. They consist of coring information and for example multibeam data. Category 2 consists of those maps combined, showing for example the amount of sediment eroded or deposited in an area. Category 3 consists for example of information derived from historical sources about trading routes.

Visualizing historical maps with GIS by digitizing them according to current projection methods involves considerable interpretation. In fact, it involves several layers of subjective interpretation: the moment of measuring depths, drawing the landscape, drafting the map, preparing it for print and, finally, converting it to the current projection and digitizing the file. Each step requires interpretation and decision-making. A depth chart of the Wadden Sea that is made up of single-beam measurements and multi-beam area measurements contains fewer layers of interpreta-

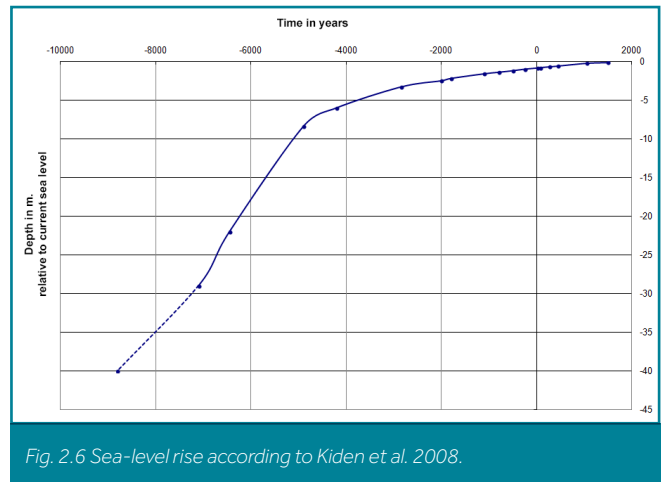


Fig. 2.6 Sea-level rise according to Kiden et al. 2008.

tion.³⁷ After such measurements are made, any irregularities (spikes) are deleted and the data are 'gridded': the measurements are compiled into a grid of standard-sized blocks with an average depth. This involves a small degree of subjectivity, but does not significantly distort the image of the sea bottom. Each map not only contains a different level of detail, but also of accuracy and subjectivity. However, each map also adds knowledge about the area and increases the likelihood of making accurate predictions, as long as the limitations inherent in each map are taken into consideration.

Initially, the HGMS used models that described the Pleistocene surface. The derived models of the location of the Pleistocene surface were based on the second version of the digital vector files used for the *Atlas of the Netherlands in the Holocene*.³⁸ These vector files were reconstructed from tens of thousands of core samples to act as the foundation for the palaeogeography reconstructions.³⁹ The location of the Pleistocene surface entailed a reconstruction of its morphology at the start of the Holocene. This reconstruction was based on the current location of the upper Pleistocene strata, empirical data on soil erosion (and preservation) in the Pleistocene surface and expert judgement. This means that the map was also partly based on interpretations and assumptions based on the current state of knowledge.

The map of the current location of upper Pleistocene deposits also includes some interpretations, extrapolations and interpolations, as it is compiled from profiles of analysed core samples. For the spaces between these samples, mathematical models of the landscape were added to produce a full landscape

³⁵ To this end, the MACHU GIS: http://www.machuproject.eu/machu_gis.htm (29-1-2017) was made available to provide data from the RCE, RWS and the Hydrographic Service. When the new ARCHIS 3 (Netherlands Archaeological Database) becomes available, this will be integrated as a maritime component.

³⁶ The metadata or 'data behind the data' consists (among other things) of information about the owner of the data, the place it is stored, when it was produced, by whom and the accuracy of the data.

³⁷ The single-beam and multibeam methods are both acoustic geophysical

techniques to record the seabed surface. While a single-beam approach only uses one beam to measure the depth (as its name suggests), multibeam uses many more and basically maps larger parts of the seabed with a footprint as small as 5 by 5 cm. See more in Chapter 6.

³⁸ Vos et al. 2011, Vos & De Vries 2013.

³⁹ These cores are registered in DINO, Data en Informatie van de Nederlandse Ondergrond-loket (<https://www.dinoloket.nl/>, accessed 29-01-2017).

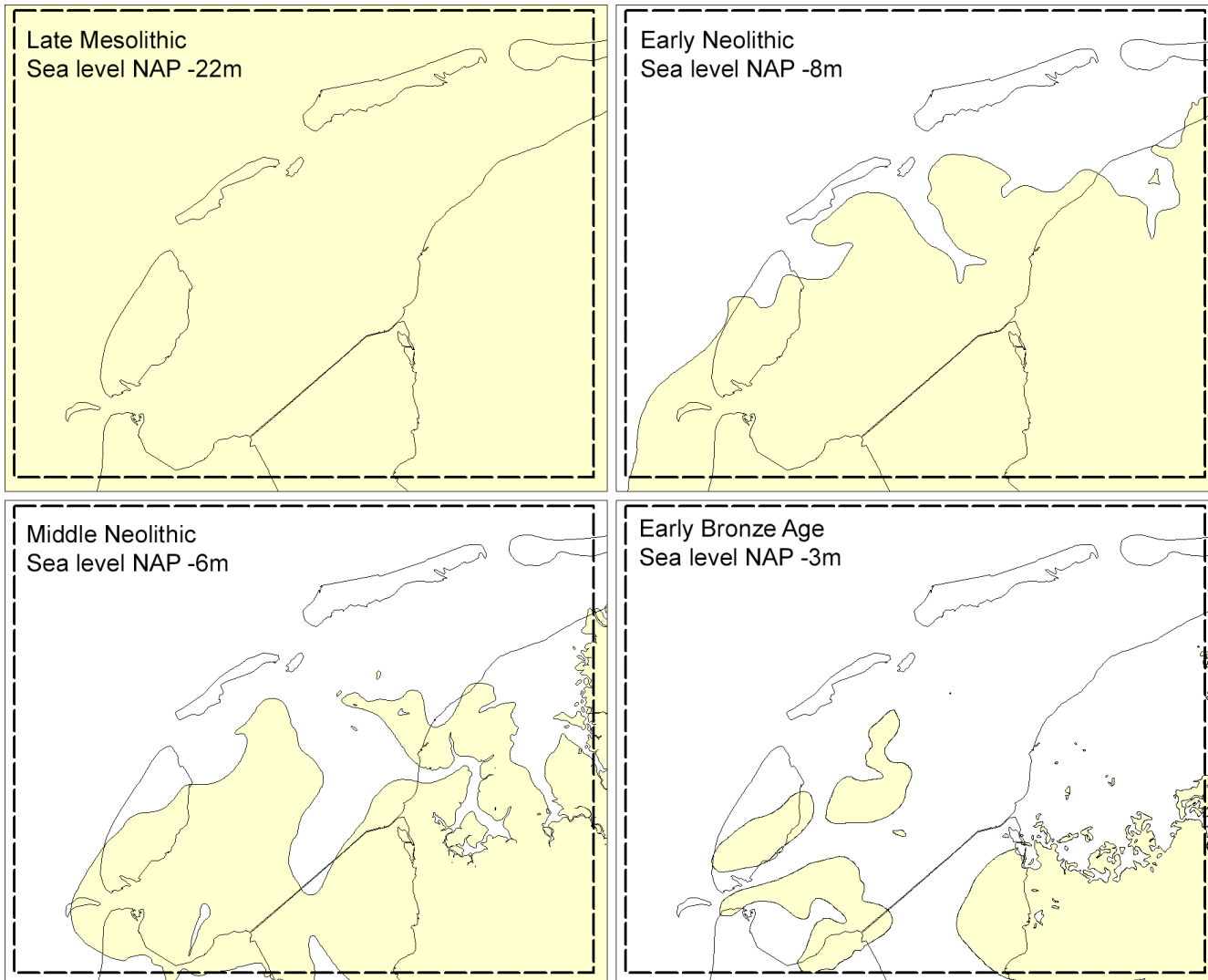


Fig. 2.7 The influence of sea-level rise in the pilot area. This is the reconstructed landscape according to Vos & De Vries (2013) with Kiden et al. (2008). Yellow is dry land, white is inundated land. Figure: courtesy Vos-De Vries/Periplus Archeomare/RCE.

reconstruction.⁴⁰ At the start of the Holocene (9000 BC) the sea level was 30 metres lower than it is today.⁴¹ Between 9000 BC and 4200 BC (middle Neolithic) the sea level rose to NAP -6 metres. Assuming that the dry landscape in this period was not subject to dramatic changes, the model can be used to reconstruct the prehistoric and historic coastlines, and therefore indicate the high and dry areas where habitation was possible. This was done by comparing the upper Pleistocene with the sea-level rise curve (Fig. 2.6).⁴²

If we wish to arrive at an expectation of the presence of prehistoric (roughly pre-Roman) sites, objects and traces, then other data is important to reconstruct the past landscape. An erosion map or a map of the current Pleistocene surface will tell us about the possible disappearance of areas in a manner similar to the map of disturbances. However, it is just as important to make an expert estimate of the human land-use system at that time using current knowledge about the prehistoric communities that used the area, combined with an interpretation of the palaeo-landscape itself.⁴³

This estimation can be further divided into use of the area by hunter-gatherer societies and by early agriculturalists (starting from 5300 BC).⁴⁴ An important reason for this is the possible differences in landscape use, and therefore the distribution of sites. An interpretative map of the use of the Western Wadden Sea in prehistory has not been added to the HGMS because, as explained above, this tool has been created to allow others to make the decision about which area is more or less important to preserve. However, maps have been included that show the influence of sea-level changes over time (Fig. 2.7).⁴⁵

Factual knowledge about the formation of the landscape and the existence of sites, combined with interpretations and the current level of knowledge about communities in this period may provide a scientifically justified expectation of finding cultural-historical values from this period.⁴⁶ Over the next few years, this perspective may be refined as better information becomes available regarding the sub-surface or sub-strata, including research into the subsequent accumulation of geological layers (including flooding, the creation of fresh water and salt water basins and the

⁴⁰This is done through interpolation between the areas where data was available.

⁴¹Kiden et al. 2008.

⁴²The curve used is that provided by Kiden et al. 2008.

⁴³This primarily deals with the estimation of whether an area was inhabited at the time.

⁴⁴See, for example, the role of food storage in relation to mobility (Cunningham et al. 2011) and an overview of recent theories on the life of hunter-gatherer, horticultural

and agropastoral societies (Sapignoli 2014).

⁴⁵Kiden et al. 2008.

⁴⁶Deeben, Hallewas and Maarleveld 2002, 15–17, Maarleveld 2003.

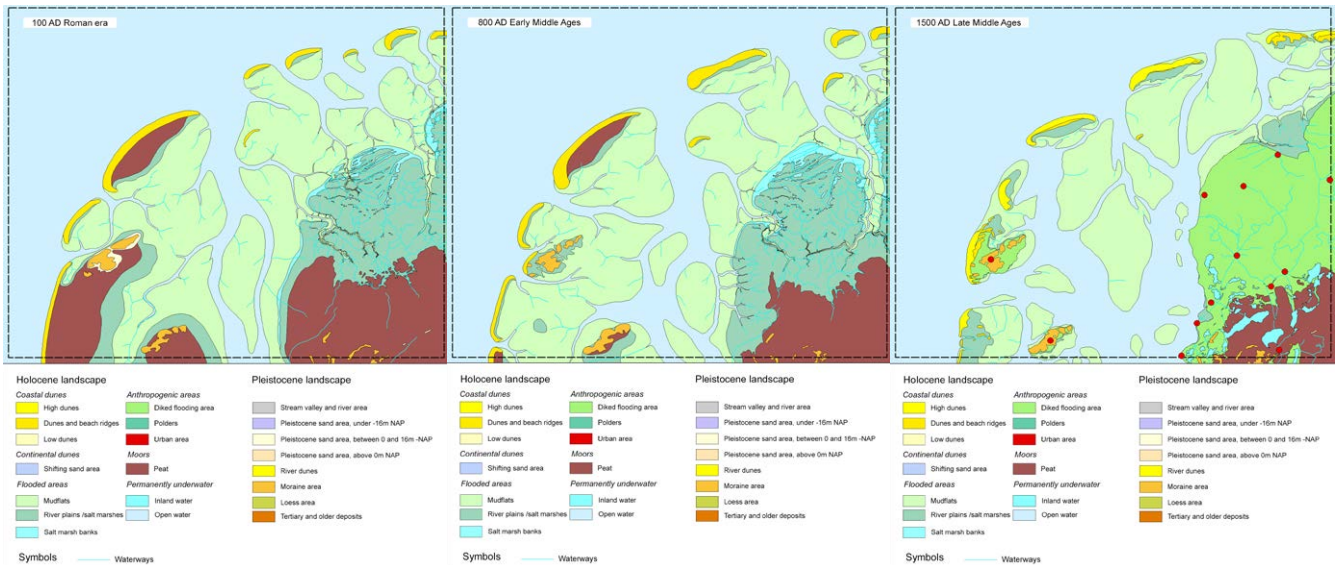


Fig. 2.8 A, B, C The reconstructed landscapes for the Roman, early and late medieval periods. RCE, based on Vos & De Vries (2013).

formation of peat bogs),⁴⁷ as well as new interpretations of the land-use practices of the various prehistoric communities based on ongoing archaeological research.⁴⁸

An extrapolation of knowledge acquired through archaeological research on land can also be used to develop a valuation and an archaeological indication for the Western Wadden Sea area. Areas with comparable characteristics that are currently permanently under water can be allocated the same value as areas from the same period on land.⁴⁹ Since there is little historical information on the Roman to the late Middle Ages, and there are no accurate maps of those times, these periods can be analysed in roughly the same manner as the prehistoric period. Maps of the Roman era (100 AD), the early Middle Ages (800 AD) and late Middle Ages (1500 AD) were included, based on the work of Vos and De Vries (2013) (Fig. 2.8 A, B, C).⁵⁰ Maps displaying the currently known shipping routes for these periods were also added.⁵¹ They show that the known or suspected use of the areas through the ages may help in formulating indications of the importance of certain areas during the period, and the likelihood of finding material remains from that period.⁵² To make any statements about the prehistoric cultural-historical expectations, geological information is still needed.

2.3.1 Different periods, different data

As mentioned above, the HGMS has a modular structure. It is therefore also possible for future researchers to add their own data and thus make more accurate predictions, or to answer other scientific or policy questions using the various combined data sets.⁵³ Thus, different uses and different questions require different sets of data to be combined. This also counts for the answering of questions focusing on different periods. Not all of the data is relevant for each period.

When attempting to predict the presence of cultural heritage from a specific period, we need to identify which data it would be useful to combine and which not. A model for the prehistoric periods was created using the current data available, primarily consisting of geological maps.⁵⁴ In combination with the historic sea-level rise curve, these provide an indication of the high (often dry) and low (often wet) areas in prehistory and the condition of the surface of the Pleistocene strata (intact or eroded, and to which depth) (Fig. 2.9). The same applies to the maps for the Roman period (100 AD), the early Middle Ages (800 AD) and the late Middle Ages (1500 AD). A prediction concerning where cultural heritage can be located can be done on the basis of the existence of dry land and navigable water.⁵⁵ In the future, more

⁴⁷ See, for example, Van Zijverden's research. After the deluge, a palaeogeographical reconstruction of bronze age West-Frisia (2000–800 BC) (PhD thesis, Archaeology, Leiden) and that of Van Lanen 'Occupation patterns and land use in the Dark Age of the Lowlands'. See Van Lanen et al. 2015 (1) and 2015 (2). The amount of data available for research on land is much higher than what we have for areas under water. However, by analysing and interpreting data for land areas and from different periods in time we may also acquire more knowledge about similar areas that are now inundated.

⁴⁸ See, for example, the new theories on the life of the Neanderthal (Burke 2012).

⁴⁹ The same also applies to drained or raised areas which were used for similar purposes in specific periods, but which are now parts of the Wadden Sea that are still under water. The comparison and valuation of similar geological areas was also done in surveys of the Maasvlakte 2. There, a test excavation was performed based on the presence of a raised area in the future harbour site. Moree & Sier 2014.

⁵⁰ See, for some theory behind landscape reconstruction and its past use, Yang et al. 2014.

⁵¹ This is largely based on the information and maps collected for De Bosatlas voor de

Geschiedenis van Nederland (Beukers ed. 2011).

⁵² In combination with Maritime Cultural Landscape theories that have been developed by Westerdahl (1996), we may be able to identify, for example, transit zones (locations where trade goods were moved to other means of transport, adjusting to the changing environment).

⁵³ Scientifically driven questions and policy-driven questions can both be answered using the HGMS.

⁵⁴ The project uses the second version of the digital vector files used for the Atlas of the Netherlands in the Holocene (Vos 2011 & Vos & De Vries 2013).

⁵⁵ This is based on the theory that people settled on the higher and dry areas in the Dutch Delta. Although this seems to be the case, we know that in the northern provinces, when the water level was rising (around 500 BC), the people raised the land artificially to stay dry in an area that was often flooded. Indications of where navigable water lay can also be deduced from the archaeological resources by studying the types of ships that were used in specific periods and specific areas.

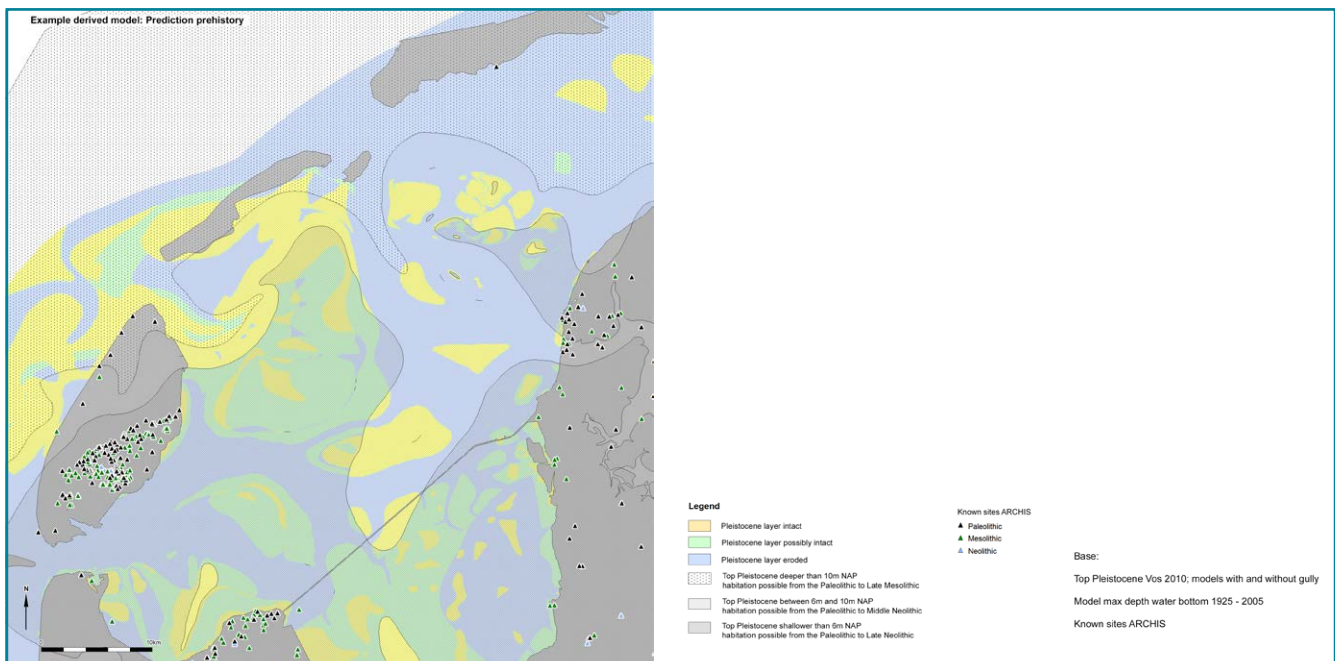


Fig. 2.9 Predictive mapping of the prehistory in the Wadden Sea (pilot area), based on the preservation of the Pleistocene layers. Figure: courtesy Periplus Archeomare/RCE.

research on the geological structure, the geomorphology and the use of the landscape (including water) will reinforce our knowledge of these periods with new, more refined, data and interpretations.⁵⁶

For the late Holocene period (starting in the sixteenth century), a digital map set was created using historical map materials and soundings. This allows us to predict where cultural-historical objects may be located, from which period they may date and their current condition based on the natural protection provided by the soil, by examining changes in the past and creating a 'hindcast' model. This involved the use of data pertaining to changing sea currents (changes in use and an indication of hazards to navigation, sedimentation and erosion), differences in sedimentation and erosion over time (indication of hazards to navigation, loss of archaeological potential and the possible current condition of a wreck), the use of the area (for trade, fishery, other) and infrastructure works (a disturbance map of current threats and loss of archaeological potential). This data helps us to deduce the original (what was there in the beginning), extant (resources still there) and the lost resources, and the predicted or recovered resources.⁵⁷ A set of maps with known archaeological values has also been added. The known cultural-historical finds or the 'known resources' are an indication of the possible presence and condition of other sites. However, it is not always clear what is meant by 'known resources', and whether the data collections are sufficiently reliable.⁵⁸ This problem can be dealt with by keeping the various data sets with 'known values' separate,⁵⁹ and by describing the accuracy of the information for each individual set.⁶⁰

2.3.2 Known sites

With the help of geological, geomorphological, historical data and maps and theoretical models,⁶¹ we can acquire a reliable image of the creation of and subsequent changes to the sea floor in the Western Wadden Sea area. We can also gain insight into the possible uses of the area over time. Past cultural-historical finds can help confirm this image, as their presence in an area may be an indication of the specific use of particular areas. However, the question remains whether the discovery of shipwrecks can be predicted based on modelling an area through time, and whether, on this basis, the drafting of an indicative map of archaeological values is useful for heritage management or not. This is a topic of considerable debate in the maritime heritage management community.⁶² To answer this question, it is first important to differentiate between the utility of predictions for scientific purposes and their utility for cultural heritage management.

Modelling using GIS techniques makes it possible to determine whether shipwrecks from various periods are likely or unlikely to be found in a certain area. In areas where expectations are low, it is of course still possible that sites may be found. It is a matter of deduction and spatial statistics, and the more information that is available the more accurate this process will be. The same applies to areas where expectations are high, as it is possible that nothing will ever be found in these areas. Identification of areas with high or low expectations is therefore primarily important for cultural heritage management purposes on a landscape scale. This knowledge derived from the calculation of likelihoods based on modelling can help policymakers make decisions about the best measures to be taken in relation to infrastructure projects

⁵⁶ See also, Optically Stimulating Luminescence Dating (OSL), which makes it possible to discover differentiations in the dynamic Holocene sand strata (Manders, Os & Wallinga 2009 (1) and 2009 (2)).

⁵⁷ These definitions have been derived from Deeben et al. 2006. In simplified form, see Manders 2012(2).

⁵⁸ For a discussion of this topic, see also Chapter 3.

⁵⁹ And not as one database for 'known resources'.

⁶⁰ In the metadata that should always be attached to each data layer. This is also

according to the INSPIRE rules (<http://inspire.ec.europa.eu/index.cfm/pageid/48>, accessed 29-01-2017).

⁶¹ For example, on the maritime cultural landscape (Westerdahl 1992 and 1998), or cognitive landscape and information (Farina et al. 2005).

⁶² Frost 1964 (<http://www.saudiaramcoworld.com/issue/196406/diggings.in.the.deep.htm> (29-1-2017)), Muckelroy 1978, Deeben et al. 2002, Holk 2009, 111.

that may disturb the sea floor or in the selection of areas that require additional monitoring or preservation measures.

Predicting the likelihood of the presence of shipwrecks involves a close analysis of both the existing landscape and preceding palaeo-landscapes. What did the landscape look like in the past? How was it used? Has anything changed over the course of time? What influence did these changes have? Only by answering these kinds of questions can we provide an indication of the possibility of shipwrecks being located and preserved in certain areas. The distribution of underwater cultural heritage, whether prehistoric sites or wrecks from the Second World War, is not uniform, nor is it random – it follows certain patterns.⁶³ Moreover, since current techniques cannot provide 100 percent certainty about whether shipwrecks will be found in an area or not, it is vital that we are able to predict their possible presence in an area.⁶⁴ Ships are point locations, and although wreck formation processes may cause disturbances in the surrounding sea floor, they are notoriously difficult to find.⁶⁵ This makes it difficult to find shipwrecks over time, but it is still possible to predict the likelihood of a find in the anticipation and facilitating of the eventual discovery of a site. It is also possible to provide an indication of the likelihood of shipwrecks being located in places where ships do not normally sail, such as extremely shallow areas.

An indicative map provides a tool for making well-informed decisions on the management of heritage, in concert with economic developments. Newly developed techniques and the improvement of existing techniques are making it increasingly easier to predict and even find archaeological sites. It is even possible that we may soon be able to 'look' into the subsurface strata using geophysical prospection techniques on a large scale.⁶⁶ These may overtake the role of predictive modelling when sufficiently developed.

However, this leads to the question of how detailed the evidence-based or modelled image would or should be. To determine the value of the heritage located, we require other data about the period and the condition of the covered site.⁶⁷ These can be determined through research into landscape formation. Shipwrecks which remain completely covered are not easy to

localize. It is even more difficult to appraise their value. Nevertheless, it is recommended that as much of the archive as possible is preserved in its current position (in situ). The best way to do this is to adjust plans at an early phase. This, in turn, requires a risk analysis for the area in question. Are there already sites known? Is there a high likelihood of finding heritage buried in the area? Are there other alternatives for the project? A risk analysis makes the option of adjusting plans more realistic. Although great strides have been made in working according to this method – which has also been promoted by the Valletta Convention, the Dutch Heritage Act and also the quality norms for archaeology (KNA) – plan adjustment and preservation in situ is still not the most common practice in Dutch archaeology heritage management.⁶⁸

2.4 Sources and data

To make a risk assessment or prediction of unknown cultural heritage resources, it is necessary to work with what is already known about the area. The known resources – sites already discovered – are often a good indication that other heritage from the same period may still be present. The question in this respect is: What do we understand by 'known resources'? We might suggest that they comprise all of the archaeological sites that are known to us at a particular moment,⁶⁹ including all known physical remnants that pertain to human activity in the past. However, what does 'known' mean exactly in this context? Are these only the officially appraised sites? Or does it include other observations, such as those by non-professionals? And, if so, by whom? Do observations by fishermen, recreational divers and amateur archaeologists count as 'known resources'? In other words, is a site considered to be a known resource only when its exact location is known, or when we have a general idea of its location but still little information about its quality and value?⁷⁰

The 'Erfgoedbalans' ('Heritage status') report⁷¹ states that the data on the known archaeological resources in the ground should primarily be stored in the Archaeological Information System (ARCHIS⁷²) and the Central Monument Archive (CMA). This implies that (according to the authors of the 'Erfgoedbalans') the known resources must be centrally registered, although the addition of the word 'primarily' may mean that this is not entirely

⁶³ Tilburg & Staniforth 2012, 13; Manders 2012 (2), 11.

⁶⁴ There are still no techniques available for solid identification of objects in the seabed. Sub-bottom profilers can give a reasonable idea of palaeo-landscapes, but not of small objects and certainly not over vast areas. Magnetometer research can only reveal metal objects (the differences in the earth's magnetic field). See also Dix et al. 2006 and G-Tec 2008.

⁶⁵ Smyth & Quinn 2014.

⁶⁶ At the moment, we can use sub-bottom profiling (seismic), but the level of detail is too low and the amount of data is too great to be able to easily trace shipwrecks. Magnetometers can also explore the sub-surface of the sea floor, but can only detect a large mass of metal. The images are not specific and only display the disturbances in

the earth's magnetic field.

⁶⁷ The fact that the value of heritage is determined by who is appraising it will be discussed in Chapters 4, 7 and 8.

⁶⁸ Schute et al. 2013, 6.

⁶⁹ Manders 2013, 6. See also 4.6.

⁷⁰ The discussion here is about known sites. It is also important to register the absence of sites/evidence/traces in certain areas. Long-term lack of findings of any evidence of human use may turn into evidence of absence in these areas. This is just as important for the prediction of the unknown resources.

⁷¹ Beukers (ed.) 2009, 26.

⁷² ARCHIS2. A new national database (ARCHIS3) is currently under development.

the case. The same 'Erfgoedbalans' also examined maritime heritage resources in more detail⁷³ using ARCHIS as the sole source for this analysis. This research searched for sites based on ground use labels such as 'under water, in channels, on sandbanks and bars', 'on the beach', 'in ditch or on bank', in combination with complex types of sites such as 'ships', 'other' (a variety of complex types such as infrastructure, settlements, sanctuaries) and 'unknown'.⁷⁴ This was an attempt to make maritime heritage more accessible. The survey found a total of 2,863 underwater observations in the Netherlands, including 544 shipwrecks.⁷⁵ This number may still be exceptionally small in comparison to the total potential or unknown heritage, even with the number of sites that are known outside of the ARCHIS system, which currently consists of over 60,000 contact points (see Fig. 1.4).⁷⁶

The Ministry of Infrastructure and Water Management (RWS) and the Hydrographic Service (Navy) also manage wreck and obstacle databases, as do several amateur archaeology and recreational diving groups. Each data set has its own limitations. The Hydrographical Service looks for obstacles and potential threats⁷⁷ and is specifically interested in where such obstacles are located. As a result, the positions are often excellent but they are not always interested in what the find represents. Additionally, the cultural-historical value of the site has a very low priority. The same can be said of the databases of the Ministry of Infrastructure and the Water Management.⁷⁸ The many, often regional, databases maintained by amateur archaeologists and other parties interested in maritime history are generally made up of data collected by other organizations and individuals. Therefore, the quality of the data in these sets varies widely, and the provenance is often difficult to trace. As the data are often

simply thrown together, it is not always clear how much value should be placed on the individual data. However, the data from these databases are a welcome addition when wishing to provide an indication of the likelihood of finding cultural heritage on or in the sea floor. Individual cases must be treated with a healthy dose of scepticism.

The ARCHIS 2 system that has been used up until now by the Cultural Heritage Agency (and in fact the entire archaeological community)⁷⁹ also had its own shortcomings. First, only a very limited number of observations on and under the sea floor were included in the system (see above). Moreover, the use of land-related, complex types and the entry of data by people with little to no knowledge of underwater and/or maritime archaeology, such as fishermen and recreational divers, made it difficult to find certain observations in the system. The observations – especially the precise locations – have not always been accurately recorded.

There is also the additional problem of converting position information, as many of the observations were so old that their positions had to be converted from DECCA⁸⁰ to the more up-to-date ED50⁸¹ and WGS84.⁸² Many of these positions have also been converted to the Rijksdriehoeks Meetsysteem (RD)⁸³ for the ARCHIS system. This presents problems for large areas of the North Sea, since it returns negative X-values, meaning that the positions of some find locations may have changed considerably. A study of this issue has discovered deviations of up to 100 metres between the shipwreck's current position and that recorded in ARCHIS (Fig. 2.10).⁸⁴ However, ARCHIS contains the relevant archaeological information for the few shipwrecks

⁷³ 'Erfgoedbalans' 2009, 35.

⁷⁴ The sections on Maritime Heritage in the 'Erfgoedbalans' primarily refer to underwater cultural heritage. However, this is not always consistent. The 544 ship finds include more than 400 wrecks located in the IJsselmeer polders (see also: <http://www.verganeschepen.nl/> (29-1-2017)). For a proper definition of 'maritime heritage', see Wit & Sloos (2008, 55), who state that the number of observations for the complex type 'nautical' was 1,875 on 5 August 2008.

⁷⁵ Beukers (ed.) 2009, 35.

⁷⁶ A combined data set of positions in Dutch waters obtained from the databases of the Hydrographic Service, the Ministry of Infrastructure and the Environment, the Cultural Heritage Management Agency (RCE) and various amateur archaeologists managed by the RCE in Amersfoort accounts for these more than 60,000 locations.

⁷⁷ Hydrographical Service Wreck Register.

⁷⁸ SonarReg92 database, see also Hessing et al. 2013.

⁷⁹ There is an obligation to register archaeological finds in the ARCHIS2 database. <https://www.rijksoverheid.nl/onderwerpen/erfgoed/inhoud/archeologie-en-opgravingen>. ARCHIS 2 has recently been replaced by a new – although not completely ready – system, ARCHIS 3 (<http://archeologiein nederland.nl/bronnen-en-kaarten/archis/> (accessed 29-01-2017)).

⁸⁰ DECCA (developed by Decca Radio and Television Ltd): was a hyperbolic navigation system that worked based on medium frequency radio. The system was used for

coastal navigation. <http://nl.wikipedia.org/wiki/DECCA> (accessed 29-1-2017).

⁸¹ ED50. By calculating a long series of triangulation measurements that covered all of Europe (with the exception of the UK) and even parts of North Africa, ED50 was able to meet its clients' demands in a fairly short time, although it did not satisfy all of the geodetic precision and reliability requirements. ED50 locations can deviate by as much as 10 metres. MD report number: MDGAP - 2000.31. December 2000, 11.

Since the block assignments for the oil and gas industry on the Netherlands' continental shelf are based on the ED50, this information is still used by the industry.

⁸² WGS84 is a geocentric and earthbound system of coordinates. It was defined in 1984 by the Defense Mapping Agency (DMA), the predecessor to the current NIMA. MD report number: MDGAP - 2000.31. December 2000, 13.

⁸³ Rijksdriehoek Meetsysteem. This is the system maintained by the land register. The benchmark for this system is the tip of the Onze Lieve Vrouwen tower ('Lange Jan') in Amersfoort (X = 155 000, Y = 463 000).

⁸⁴ Brenk & Lil (2010). It is not always clear which projection other parties, such as fishermen, have used to record the location of shipwrecks. If ED50 was used, then the projection can occasionally be traced, but this is not possible if the location was recorded using UTM projection (Universal Transversal Mercator projection). Map projections always result in the loss of some information due to distortion of the Earth's curved surface. MD report number: MDGAP - 2000.31. December 2000, 27.

that have been entered into the system.

The first steps in linking the best databases with one another involved connecting three government databases (the Hydrographic Service's Shipwreck Register, the Ministry of Infrastructure and Water Management's SonarReg and the Cultural Heritage Agency's ARCHIS2) into a GIS environment and then issuing each object a National Contact Number (NCN).⁸⁵ This means that the location of a shipwreck on the Burgzand in the Wadden Sea that has been recorded by the Ministry of Infrastructure and Water Management or the Hydrographic Service, for example, can now be linked with the cultural-historical information collected by the RCE.⁸⁶ Since 2006, the RCE has also been developing its own maritime database and GIS. This system was developed in cooperation with the Ministry of Infrastructure and Water Management as part of the EU-sponsored MACHU project (Fig. 2.11).⁸⁷ The benefit of this system over ARCHIS 2 is that it is a GIS that is specifically geared towards collecting and presenting maritime data. Information such as the position notation has been adjusted, but specific

geophysical data can be incorporated as well. Moreover, it has a worldwide coverage and is able to differentiate between various validated and invalidated data sets.⁸⁸ The MACHU system will eventually have to be integrated into the RCE's new archaeological database, ARCHIS 3.⁸⁹ This will also provide input for the Netherlands National Contact Number.

Knowledge about known heritage thus helps in making an estimate of the potential – the yet unknown – heritage in a certain area. We should realize, however, that there is a good reason why we know about these locations. The techniques for underground observation are extremely limited, so the known locations are almost, without exception, found due to them being exposed as a result of erosion.⁹⁰ Almost without exception, the known cultural-historical finds in the Western Wadden Sea are located in the zones most prone to erosion. Almost nothing has been found in the most stable zones, which are the areas with the highest potential for finding prehistoric sites. This is somewhat less the case for shipwreck sites, at least where the sea has always been relatively shallow, or with regard to larger ships, which

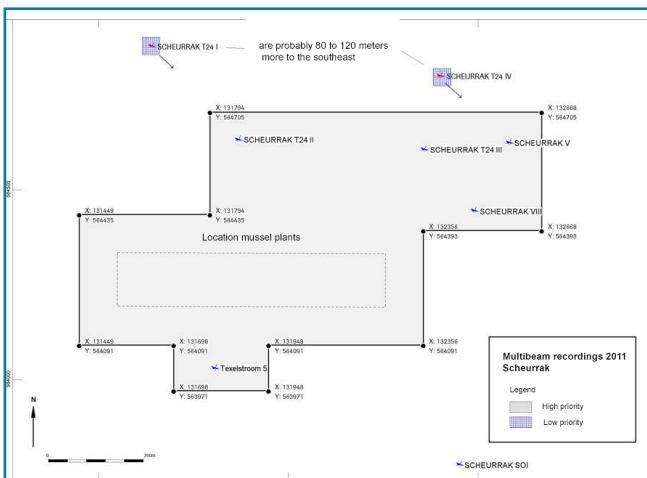


Fig. 2.10 The difference in location between positions known from the ARCHIS 2 data and the actual positions of the sites measured with multibeam sonar. Figure: courtesy Periplus Archeomare/RCE.

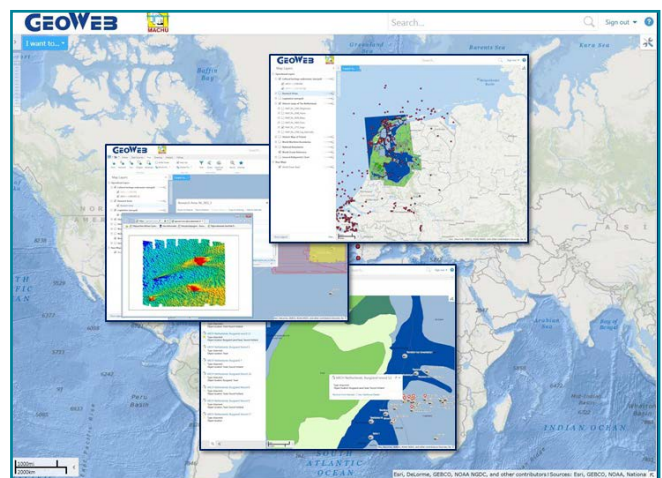


Fig. 2.11 The MACHU GIS viewer. Figure: courtesy MACHU/RCE.

⁸⁵ National Contact Number: <http://www.periplus.nl/home/nl/referenties/projecten/nationaal-contactnummer-ontsluit-databases-met-wrakken-en-obstructies-onder-water> (accessed 29-1-2017).

⁸⁶ However, it must be clear that the various positions in the different databases all apply to the same wreck site. This often requires considerable preparation, including surveys under water and on the surface.

⁸⁷ Managing Cultural Heritage Underwater (MACHU). Financed by the European Union Culture 2000 Programme. www.machuproject.eu (accessed 29-01-2017). Hootsen & Dijkman 2009.

⁸⁸ There are several reports and articles available about the MACHU project and the GIS. See the project reports by Oosting and Manders (eds.) 2007, Manders, Oosting and Brouwers (eds.) 2009 (1) and Manders, Oosting and Brouwers (eds.) 2009 (2).

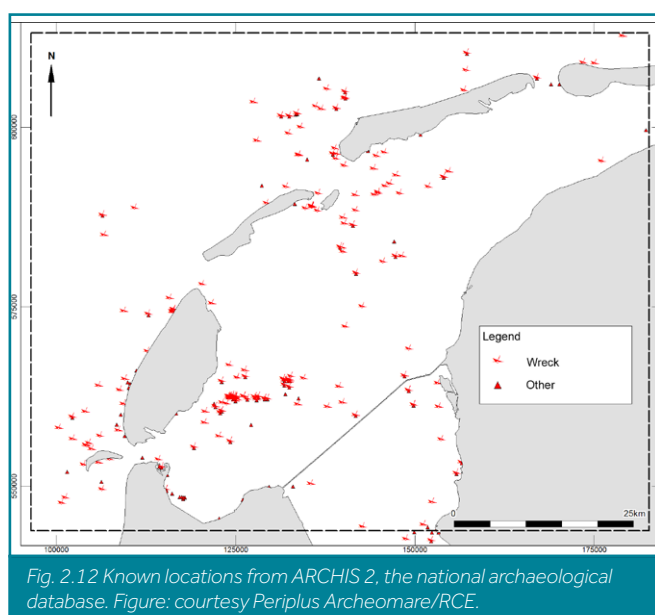
⁸⁹ Unfortunately, this has still not been accomplished. It is now planned for some time in 2017.

⁹⁰ Brenk and Manders 2014, 26.

would usually avoid these areas. However, if any shipwrecks are located in these areas, then their quality is probably extremely high, due to them having been covered for centuries.⁹¹

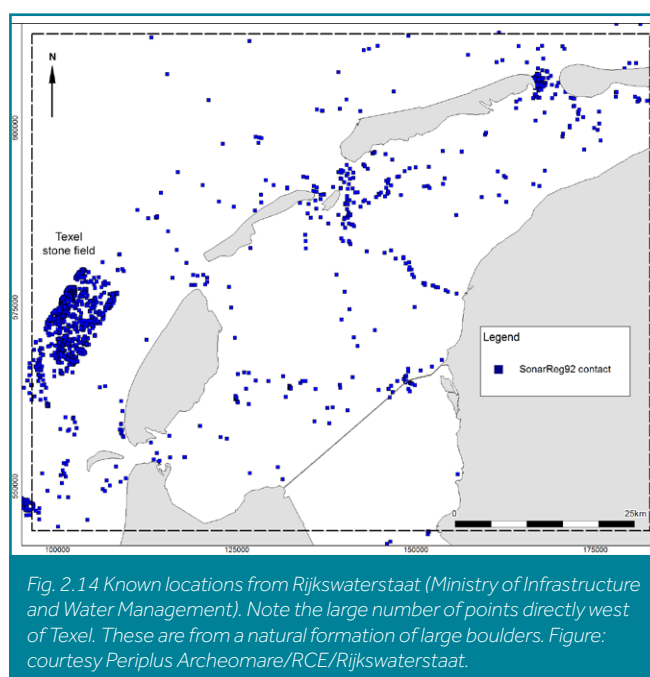
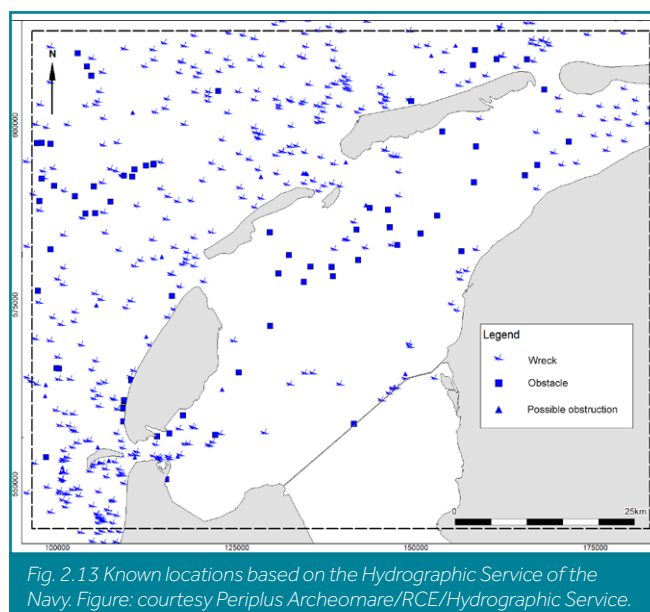
2.5 Different databases with different numbers

Research in ARCHIS 2 in December 2013 resulted in a number of observations about the current sea bottom in the research area.⁹² (based on a graphic-filter top-10 vector file); in fact, 190 wreck reports spread over 175 locations and 416 other observations spread over 109 locations (Fig. 2.12).



The Hydrographic Service maintains an overview of obstacles that may pose a hazard to navigation. This overview is published in the wreck register, HP39.⁹³ The register differentiates between three types of contacts: Wrecks, Obstructions and Possible Obstructions (or Foul Ground). For the same area as above, this register contains 378, 71 and 25 of these types of locations, respectively (Fig. 2.13).

Since 2009, all of the observations by the Ministry of Infrastructure and Water Management have been registered in the SonarReg92 database. Of these, 2,775 fall within the limits of the defined study area in the Western Wadden Sea. A large proportion of these (approx. 2,280) are, however, individual



rocks in the Texel stone field (Fig. 2.14).⁹⁴

⁹¹ As a validation of the model, for example, in 2014, a shipwreck (Westerveld 2) was discovered on a sandbank south of Vlieland. The HGMS for the Western Wadden Sea, indicated that this area has been exceptionally stable since at least the late sixteenth century, and little to no erosion has taken place. The wreck was located next to a new channel that ran over the sandbank, disturbing the area for the first time in centuries. This information, together with the photos that the discoverer sent to us of a clinker-built boat with a naturally formed frame, resulted in a follow-up study because the boat was potentially very old. It was eventually dated to around 1500. This makes

it one of the oldest vessels discovered in the Wadden Sea area. Opdebeeck & Koehler, 2014.

⁹² Only objects currently under water, and no reports in former water channels or sea bottoms currently silted over.

⁹³ 'HP39 Wreck Register Netherlands Continental Shelf and Westerschelde', publication by the Hydrographic Service.

⁹⁴ See also Erdbrink 1950.

Based on the concept 'Simple storage – multiple use', in 2009, the three government agencies thus, took the initiative to link their databases containing information about underwater objects in the Netherlands (ARCHIS 2, the Shipwreck Register and SonarReg92). This resulted in the National Contact Number (NCN) database, a central register in which each contact is issued with a unique number. These numbers are linked to the databases at the various government agencies and are managed by a private company (Periplus) on behalf of Rijkswaterstaat, Sea and Delta.⁹⁵ Once each quarter, the numbers are updated, based on new reports from the various agencies. The NCN is accessible via a closed geoweb application managed by the Zee and Delta Infrastructure and Public Works Agency.⁹⁶ In total, 3,393 observations in the NCN fall within the limits of the study area (Fig. 2.15).

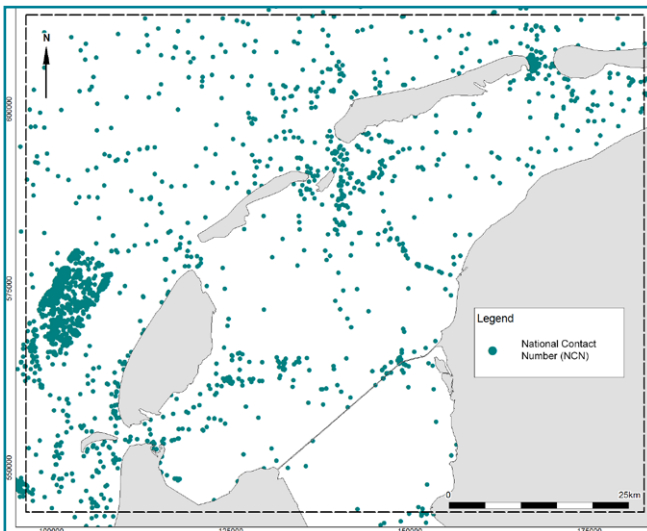


Fig. 2.15 Known locations from the National Contact Number or NCN database. Figure: courtesy Periplus Archeomare/RCE.

There are also other sources that record the locations of obstacles and shipwrecks. These are often difficult to access, or the accuracy of the data is difficult to confirm. When these data are encountered, they are reviewed to determine whether they add anything to the existing overview, after which the RCE decides whether to incorporate the data or not. In 2012, the RCE digitized an analogue register of wreck data in the North Sea and the Wadden Sea.⁹⁷ This involved two binders with 648 pages of

typed text, plus three A0 format maps entitled 'Wrakkenregister Noordzee- en Waddengebied, Rijkswaterstaat Directie Friesland, Arrondissement Friesland-West'.⁹⁸ This register describes shipwreck discoveries for the period 1820–1988. The texts include descriptions of approximately 700 shipwrecks. Of these 700 wreck locations, 443 fall within the Western Wadden Sea research area (Fig. 2.16).

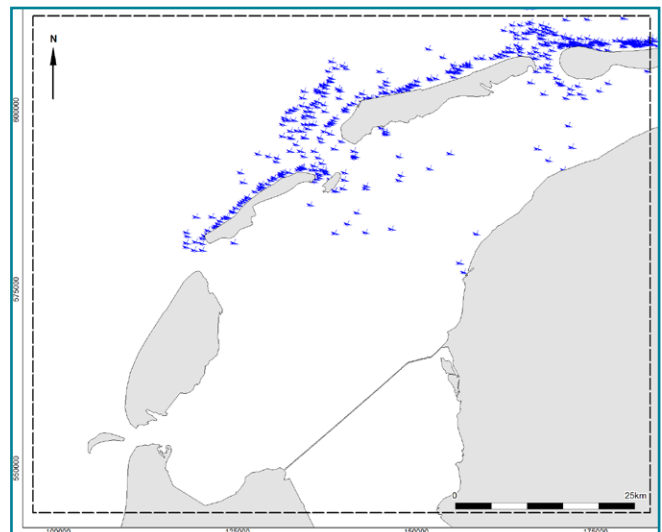


Fig. 2.16 Known locations from a regional database of Rijkswaterstaat North. Figure: courtesy Periplus Archeomare/RCE/ Rijkswaterstaat.

Recreational divers and commercial survey firms in the Netherlands also collect observations in a variety of lists and databases. These databases, which can be very large, contain unique data, as well as that accumulated by other collectors or other known private or government databases. It is therefore often impossible to differentiate between these data. Thus, the information they contain should be used with care, but may constitute unique material. These sources include the wreck files for the National Working Group for Underwater Archaeology (LWAO),⁹⁹ Pandora (now, Wrecksite.eu),¹⁰⁰ GIS_RWS_DNH (Wraksys)¹⁰¹ and Periplus Archeomare¹⁰² (Fig. 2.17).

⁹⁵ The Periplus Group is a consultancy organization specialized in hydrography, geology, geophysical, maritime archaeology, GIS, data processing, data management, project management and engineering, based in the Netherlands. www.periplus.nl.

⁹⁶ <https://geoweb.rijkswaterstaat.nl/GeoWeb41/?Viewer=Legger%20Rijkswaterstaatswerken> (accessed 29-01-2017).

⁹⁷ Muis & Brenk 2013.

⁹⁸ Wreck register for the North Sea and Wadden Area. Department of Public Works, Directorate Friesland, district Friesland-West.

⁹⁹ LWAO is the avocational archaeological diving association in the Netherlands.

<http://www.awn-archeologie.nl/archeologie-onder-water/> (accessed 29-01-2017).

¹⁰⁰ Pandora.be is now known as Wrecksite.eu.

¹⁰¹ The Wraksys Foundation is now managed by Hille van Dieren, Wrakkenmuseum Terschelling.

¹⁰² Periplus Archeomare: hydrographic and maritime archaeological consulting bureau, part of the Periplus group.

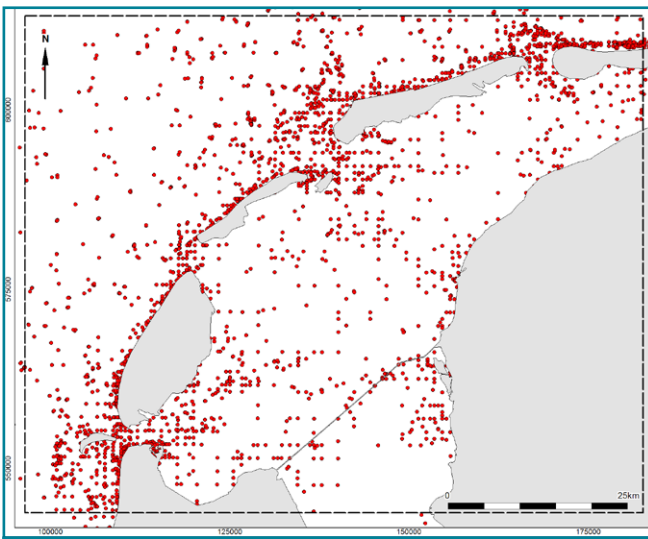


Fig. 2.17 Known locations of combined amateur archaeologists' databases. Figure: courtesy Periplus Archeomare/RCE.

In total, 6,636 observations are known for the Western Wadden Sea area. None of these observations have been verified and the overlap with the NCN has yet to be determined. Due to the number of sites, this will be an ongoing process.

It is probable that a lot of the data collected will never be shared on a large scale and therefore will not end up in a central database such as ARCHIS. There are multiple reasons for this. First, there is a long-term debate concerning public access among heritage professionals in the Netherlands, as well as other countries. Some consider that the publication of sites and their positions is a hazard to their preservation,¹⁰³ as the location will ultimately become known not only to those who have the best intentions but also those who mean to harm the resources, such as souvenir hunters and commercial salvagers. Until now, the level of law enforcement has not been sufficiently adequate to ensure protection against damage to cultural heritage.¹⁰⁴ Second, although promoted on a European level and followed up by some countries, others still, and by law, prohibit the publication of the positions of cultural heritage sites.¹⁰⁵

Another reason for not sharing information has to do with the feeling of exclusive ownership of a site. Among several amateur archaeologist groups, there is still a sense that the sites are owned by those who discover them.¹⁰⁶ Sharing information does not correspond with that idea (see also Chapter 4).

2.6 Combining data in interpretive maps

The more we know about an area, the more we can understand its importance for past users and predict the unknown resources that may well be hidden under the soil surface. We can gain better insight when we correlate, combine and compare different data sets with each other and start to interpret what we see.

2.6.1 Geology and geomorphology

Composite maps can be produced by combining basic geological and geomorphological data. Identification of newly obtained data allows the assessment of the possible presence of heritage, its condition, its accessibility and any threats. This section provides a few examples based on the following basic maps, for illustrative purposes:

- » The Pleistocene land surface at the start of the Holocene (reconstruction based on the current location, minus erosion areas) (Fig 2.18B)
- » Current location of the Pleistocene upper strata (with erosion channels) (Fig 2.18A)
- » Most recent depth model (2005)

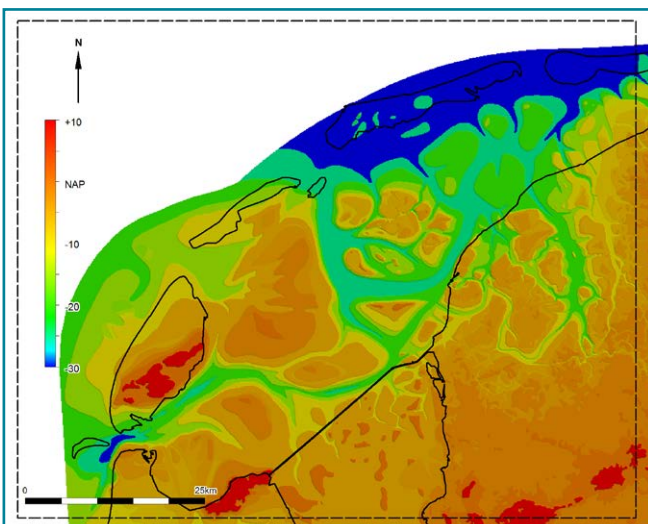
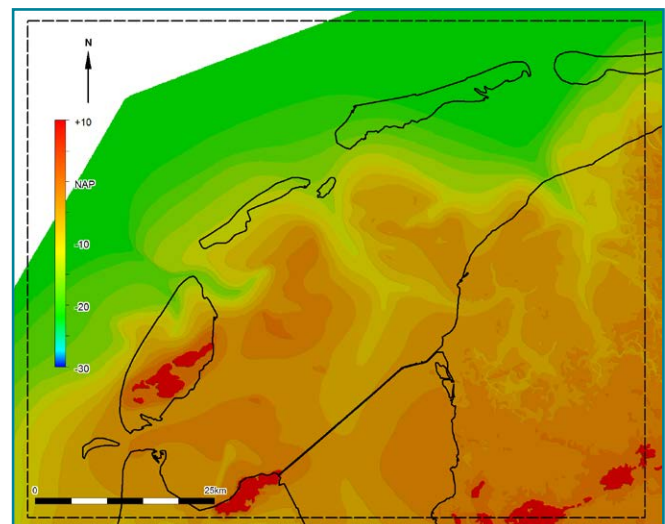


Fig. 2.18 A. The currently preserved Pleistocene layers, including the eroded areas.



B. The reconstructed Pleistocene surface, ignoring the erosion gullies. Figure: courtesy Periplus Archeomare/RCE.

¹⁰³ The MACHU Project Team 2009, 132.

¹⁰⁴ Erfgoedinspectie 2012, 4–5.

¹⁰⁵ See <https://www.erfgoedinspectie.nl/toezichtvelden/archieven/inhoud/wet--en-regelgeving/overige-informatiewetgeving/openbaarheid-van->

[documenten-van-de-europese-unie](#) (accessed 29-01-2017).

¹⁰⁶ <http://www.nd.nl/artikelen/2007/mei/25/schatgraven-in-een-wereld-van-stilte> (accessed 29-01-2017).

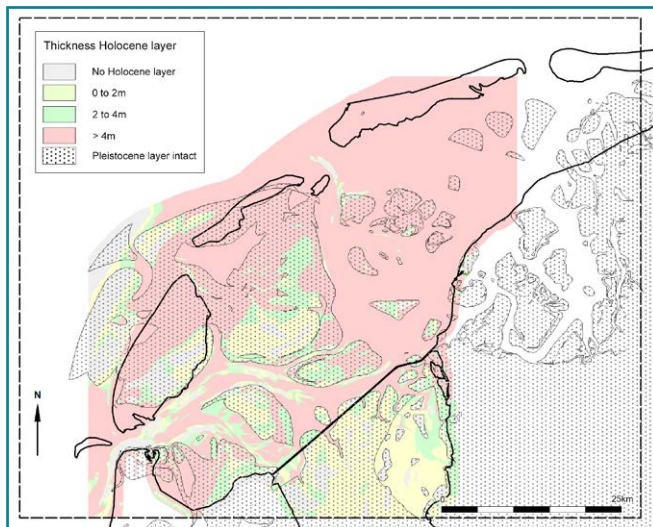


Fig. 2.19 The thickness of the Holocene layer. Figure: courtesy Periplus Archeomare/RCE.

Subtracting one Pleistocene model from the other creates a model that already indicates where the original Pleistocene surface may still be intact.¹⁰⁷ This surface also defines the maximum depth for wrecks from later periods, since the Pleistocene package is too compact for shipwrecks to sink below it (Fig. 2.18 A + B).¹⁰⁸

In the early Mesolithic period (start of the Holocene), approximately 11,000 years ago, the sea level was 40 metres lower than it is today. The model for the location of the Pleistocene upper strata at the start of the Holocene, therefore, shows the dry landscape that existed at that time. The entire area, including large sections of the North Sea Basin, was above sea level and potentially suitable for habitation. As the sea level rose, more and more land became submerged. Based on the location of the upper Pleistocene strata, we can define the historical coastlines from this period (See also Fig. 2.7).

The thickness of the Holocene cover strata is determined by subtracting the current location of the sea floor (most recent depth model, 2005) from the model of the current location of the upper Pleistocene strata (Fig. 2.19). The much less compact Holocene strata is also considered to be the 'mobile layer', since it is very susceptible to erosion and sedimentation processes, at least in certain areas. It is possible that well-preserved shipwrecks could be found in this layer. Shipwrecks may become completely covered by the Holocene strata due to settling (often caused by erosion around the wreck) or sedimentation.¹⁰⁹ Areas with a thick layer of Holocene sand, but no shipwrecks located on the surface, may still have shipwrecks buried under the sea floor.

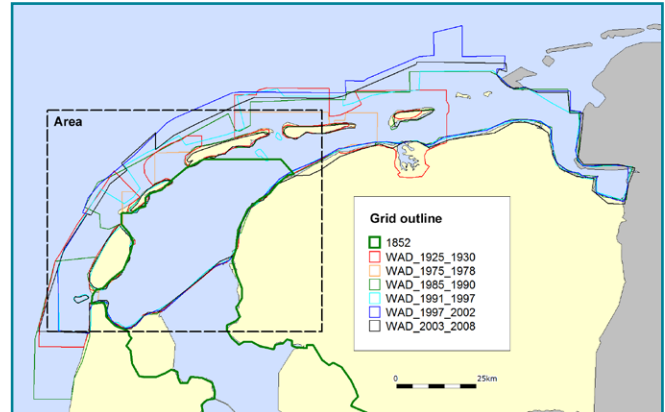


Fig. 2.20 Areas of known depth surveys. Figure: courtesy Periplus Archeomare/RCE.

Changes in morphology through time can be illustrated by combining the basic information for various years since 1925. To this end, all of the basic grids since 1925 have been combined into a single model (Fig. 2.20).¹¹⁰ This model consists of 20 x 20 metre grid squares, with the minimum and maximum number of values and average value for each square. Exporting the difference between the minimum and maximum value for each grid square (with a minimum of four values) results in a model that describes the thickness of the mobile layer (Fig. 2.21).

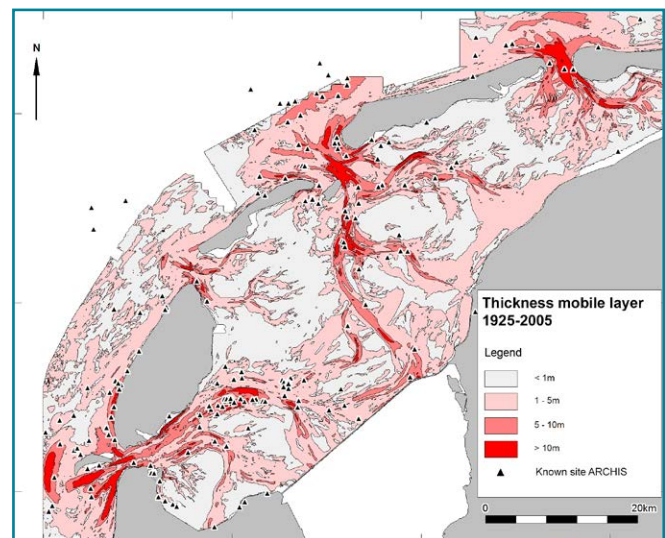


Fig. 2.21 Thickness of mobile layer, measured between 1925 and 2005. Figure: courtesy Periplus Archeomare/RCE.

¹⁰⁷ However, this is subject to the limitations inherent to the basic models.

¹⁰⁸ Manders, Os & Wallinga 2009, 46. However, due to the erosion of the Pleistocene surface, ships may sink to levels lower than the original Pleistocene upper strata.

¹⁰⁹ See Dix et al. 2009, 48–54.

¹¹⁰ Sounding Grid Utility, QinSy.

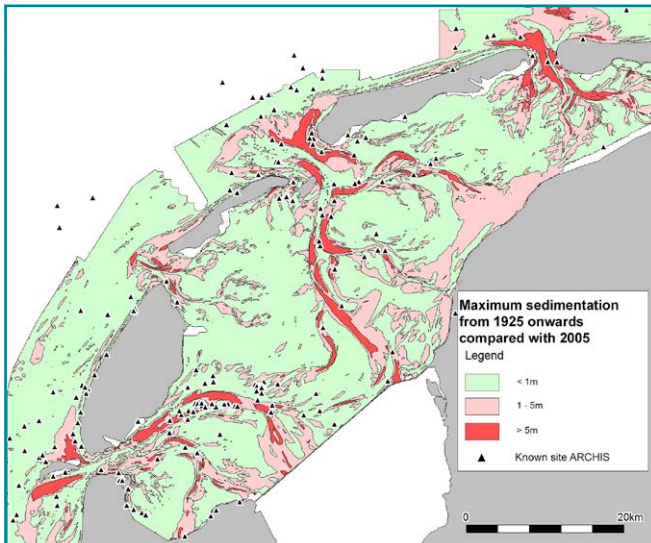


Fig. 2.22 Maximum sedimentation from 1925 onwards and in comparison with 2005. Figure: courtesy Periplus Archeomare/RCE.

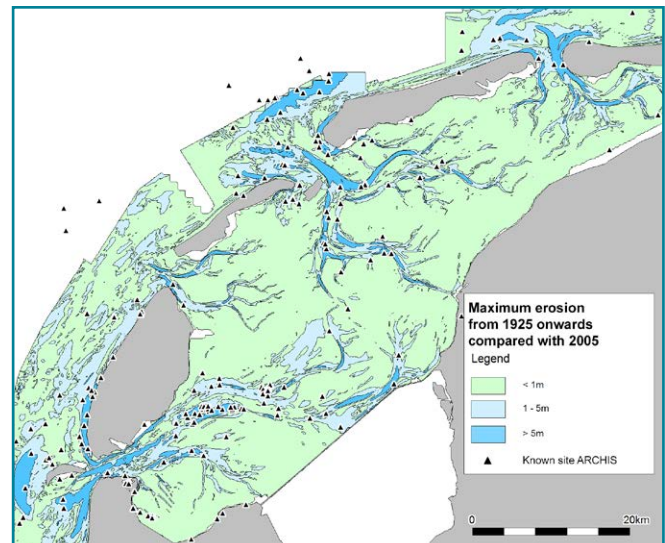


Fig. 2.23 Maximum erosion from 1925 onwards and in comparison with 2005. Figure: courtesy Periplus Archeomare/RCE.

These data sets can immediately exhibit which areas have remained stable over the 80 years between 1925 and 2005 and which areas have changed, with the model easily showing the changes over that period. Changes may include erosion, sedimentation or a combination of both. In the areas that have remained stable over the period, few archaeological observations have been recorded. However, this does not mean that no cultural heritage is present in these areas. The stable areas may simply be less travelled by ships, due to shallow waters, and, since the Holocene deposits are stable, any objects will be covered by sand and out of sight.

By comparing the shallowest value for each grid square with the most recent depth, we can create a model of the maximum degree of sedimentation (Fig. 2.22). Areas that were deeper by a metre or more in the past (between 1925 and the present (2005)) have been filled in with sediment over the past 80 years. For archaeological expectation purposes, we can determine that these areas will thus harbour no cultural-historical remains from before 1925 down to the level of the maximum depth for this period, or any such remains will be in a disturbed state. By comparing the deepest value for each grid square with the most recent depth, we can create a model that shows the maximum depth in the area (Fig. 2.23).

Areas that were shallower in the past (between 1925 and the present (2005)) have been eroded over the past 80 years. With regard to archaeological expectations, we can state that any remains in these areas will be located on the current sea floor or deeper. Almost all of the known observations in ARCHIS are plotted in these areas. They are also the areas where sites, discovered or not have disappeared over the course of time.

2.6.2 Historical data as an add-on for understanding

If we add historical data to the geological models, we can gain a better understanding of the cultural landscape during the various periods. This is because the use of the landscape largely determines where the cultural-historical remains are deposited. From a spatial and geographical perspective, historical information is often not of a uniform nature. The detail, accuracy and reliability differ from source to source, from period to period and from area to area. The information (as well as its interpretation) is also influenced by a number of factors, such as skill, utility and economic or political objectives. It is interesting to see that while beaches and harbours are often the outer limits of land maps, they are the starting point for navigational charts.¹¹¹ These, therefore, add a different dimension to our understanding of the landscape. Much of our knowledge of the sea and its uses has been recorded in historical sources, but much has not. This knowledge, often recorded in oral traditions, has been lost over time.¹¹²

¹¹¹ Lambert et al. 2006, 482. An integration of a land-based perspective and a sea-based perspective in studies about dynamic urban geographies could

produce new ideas.

¹¹² Lambert et al. 2006, 483 & 486.

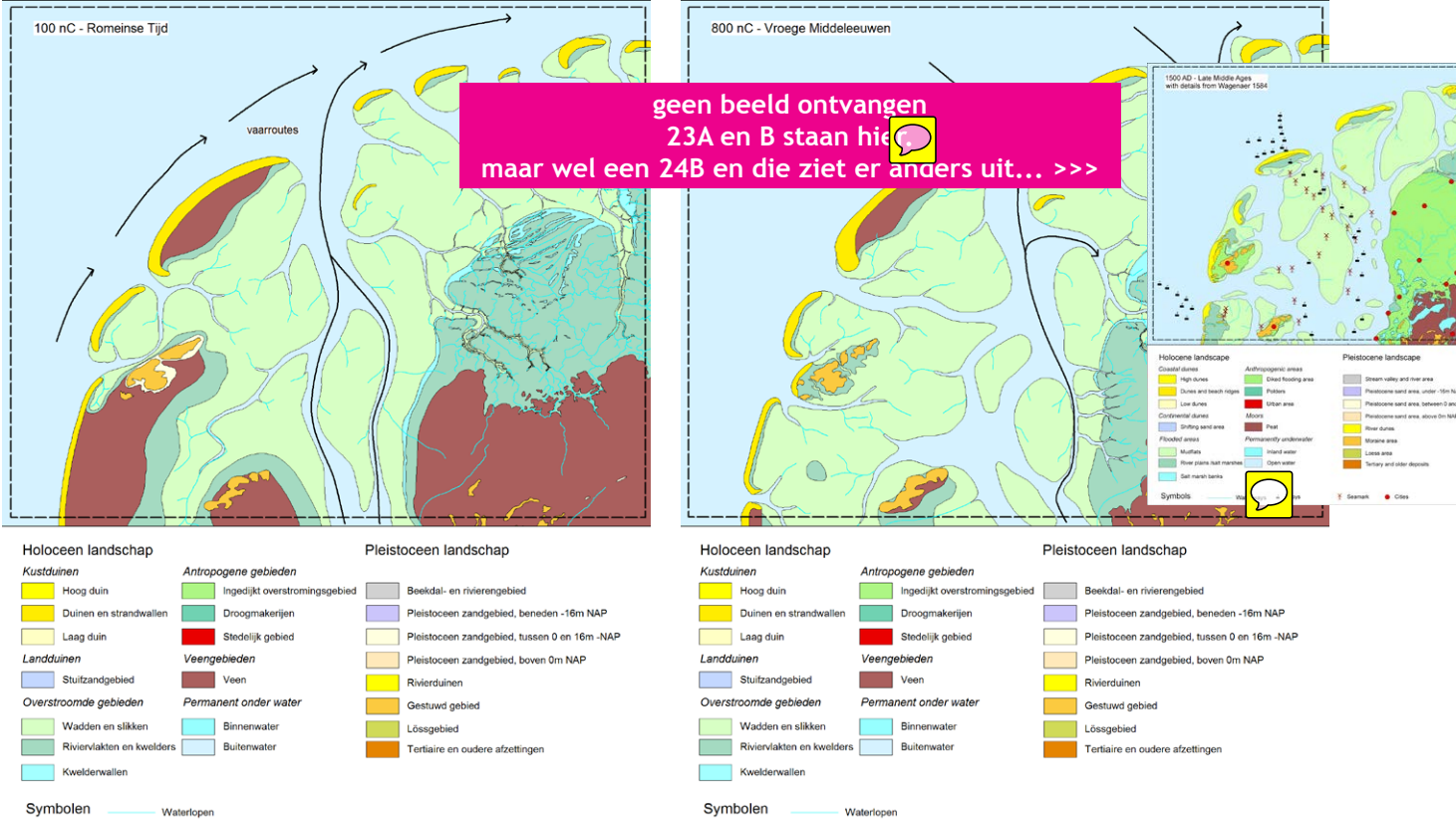


Fig. 2.24 A + B Reconstruction of the landscapes in the (A) Roman and (B) Early medieval periods (After Vos & De Vries 2013), including information on the major sailing routes. Figure: RCE.

As mentioned above, in the Netherlands, we can add historically known shipping routes from the Roman era and the early Middle Ages (Fig. 2.24 A + B). This can help clarify certain shipping lanes, but also the areas of habitation that they connected within the maritime cultural landscape. An indication of the use of the area in the modern period has been implicitly included through the digitization of historical navigational charts which also contain information about such use (Fig. 2.25).

However, historical maps also contain much more information than data about depths and currents, such as the routes used,



Fig. 2.25 Map of the Wadden Sea by Wagenaer from 1584. A. Original map, B. the digitalized and vectorized map. Figure: courtesy Periplus Archeomare/RCE.

the harbours, beacons and anchorages.¹¹³ This information can help us analyse the use of an area, especially when we compare the maps over the course of time. Historical information from written sources can also provide useful information, while sea battles or major storms may provide insight into the likely number of ships that have sunk in a specific area.¹¹⁴

By georeferencing historical maps and comparing them to more recent morphological maps, we can extrapolate the processes of erosion and sedimentation 'backwards' to the end of the sixteenth century. This, in turn, helps us visualize more than four centuries of dynamics in the Wadden Sea and may provide information on the use of the area, supported by theories on the use of maritime cultural landscape, such as those developed by Westerdahl,¹¹⁵ and the presence and preservation conditions of sites. The level of detail this provides is in comparison with the high-resolution morphological models, low. We therefore have to be careful to combine them into one model. They serve a purpose on a regional scale however to visualize changes that have occurred.

2.7 Geomorphological models

2.7.1 Basic geomorphological models

As stated above, the dynamics of the sea floor and the coastline is one of the Wadden Sea's defining characteristics. Since the creation of the Wadden Sea, the area has been formed by gullies that can move or change directions over time under the influence of tidal currents.¹¹⁶ Insight into these geomorphological

¹¹³ http://celebrating200years.noaa.gov/new_york_charts/welcome.html#info (accessed 29-01-2017).

¹¹⁴ Areas where battles have taken place may be referred to as landscapes of war. Where sea battles have taken place, we usually see no evidence on the surface of the water. However, historical knowledge ('what has happened according to a people'), knowledge of warfare and sailing ('what would be the most logical thing to do') may assist in

developing a view about what may actually have happened. Based on such interpretations we can decipher the seabed and make an estimation of what material witnesses may be left under water. At the same time, any evidence found on or in the seabed may strengthen or weaken our theories and thus assist us to move closer to the truth.

¹¹⁵ Westerdahl 1996.

¹¹⁶ See also Wang et al. 1995



Fig. 2.26 Historic (non-navigation) maps of the Wadden Sea by Jan van Scorel (c. 1552) (left) and Christiaan Sgroten (right) (*Delineatio Sinus Meridionalis Maris, Vulgo De Zuyder Zee; Phrisia occidentalis, et Watterlandia*, 1573).

changes is absolutely vital to draw up expectation maps for the late medieval and early modern periods. The most important information for modelling morphological changes comes from depth soundings (depth measurements) of the sea floor. By comparing different soundings through time, we can gain insight into these changes. If sufficient data is available, we can also draw up predictive models for the future. As mentioned above, the current Pleistocene surface is the bottom limit for the depth in these models, since shipwrecks cannot sink into this compact layer of sand.

The depth models available for the Wadden Sea in the modern period (after 1500 AD) can be divided into three chronological stages based on the map materials available (for navigation purposes) and the accuracy and resolution of the data:

1. The period 1584–1852
2. The period 1852–1975
3. The period 1975–present

While maps dating from before 1584 are available (Jan van Scorel, c. 1550 and Christiaan Sgroten, 1573), these were not intended as navigational aids and, therefore, details of water areas, such as depth soundings and shoals, are only sporadically illustrated and almost never measured (Fig. 2.26 A + B).¹¹⁷

2.7.2 The period 1584–1852

Six navigational charts from the period between the last quarter of the sixteenth century and the mid-nineteenth century were studied. These include the 1584 map by Waghenauer,¹¹⁸ the 1649 map by Blaeu,¹¹⁹ the 1666 map by Goos,¹²⁰ the 1773 map by Sepp,¹²¹ the 1799 map by the British Admiralty¹²² and the 1850 topographic map for the Dutch military¹²³ (Fig. 2.27).



Fig. 2.27 Series of historic maps by (A) Pieter Goos (1666), (B) J.C. Sepp (1777), (C) British Admiralty (1799) and the Chromo-topographic military chart of the Kingdom of the Netherlands from 1850.

¹¹⁷ This does not mean that these maps cannot provide additional detail regarding the use of the landscape in this period.

¹¹⁸ Lucas Janszoon Waghenauer (1533/34–1605/06). Coxswain, but became famous for this sea cartography. His *Spiegel der Zeevaart* from 1584 was a benchmark for future sea navigation mapping.

¹¹⁹ Dr Jan (Joan) Willemsz. Blaeu (1596–1673) was a Dutch printer, publisher and cartographer. In 1649, he published (among others) the *Hollandia Comitatus*, which contains map material of known gullies and sandbanks in the Wadden Sea area.

¹²⁰ Pieter Goos (1616–1675) was a Dutch map maker, engraver and bookseller. The first edition of his *Zee-Atlas Ofte Water-Weereld* (Sea Atlas of the Water World) was published in 1666, including some navigation cartography of the Wadden Sea area: 'Pascaarte vande Zuyder-Zee, Texel, ende Vlie-stroom, als mede 't Amelander-gat'.

¹²¹ Jan Christiaan Sepp (1739–1811) was an engraver, etcher, bookseller, author and

illustrator. In 1773, he published the *Nieuwe Geografische Reise- en Zak Atlas van De VII Verenigde Nederlandsche Provinciën*, including data from the Wadden Sea in 'De Vereenigde Nederlanden of Zeven Vrye Provinciën Gesloten in den Jaare 1579 te Utrecht in 1773'.

¹²² This map, 'Dutch men of war Surrendered in the Nieuve Diep (Nieuwe Diep) to the Admirals Duncan & Mitchell. Augt. 30 1799', was probably partly produced to prepare for an Anglo-Russian invasion of Holland by the British Admiralty and partly during the invasion (according to the date). This campaign took place between 27 August and 19 November 1799, during the War of the Second Coalition, in which an expeditionary force of British and Russian troops invaded North Holland, at that time part of the Batavian Republic.

¹²³ Chromo-topographic military chart of the Kingdom of the Netherlands. Made by the Topographic Office of the Ministry of War in 1850.

The first known navigational chart for the Western Wadden Sea is the map entitled 'De vermaerde stroemen. 't vlie ende 't maersdiep' (The renowned currents Vlie and Marsdiep), by Lucas Janszoon Waghenauer in the Spiegel der Zeevaart, the first volume of which was published in 1584. It is assumed that Waghenauer based the charts on his own observations and measurements,¹²⁴ and they were used by sailors for many years. It is even possible that the charts were still in common use long after the most important shipping channels and sandbanks had shifted to other locations.¹²⁵

The historical maps were made using dead reckoning. This involved drawing a coastline starting at a known point. From there, the surveyor determined the position of the coast based on the speed at which the ship was sailing, the compass course, the degree of drift and the sea currents.¹²⁶ Instruments were also available to determine latitude.¹²⁷ Longitude was much more difficult to calculate, and the methods were very unreliable. It only became possible to measure longitude accurately with the invention of the chronometer in 1762.¹²⁸ Taking this into consideration, there must have been major discrepancies between the calculated position and the actual position. This is also reflected in the maps. The map projection is also often different from that used in maps today.¹²⁹ These maps, therefore, needed to be digitally georeferenced, vectorized and,

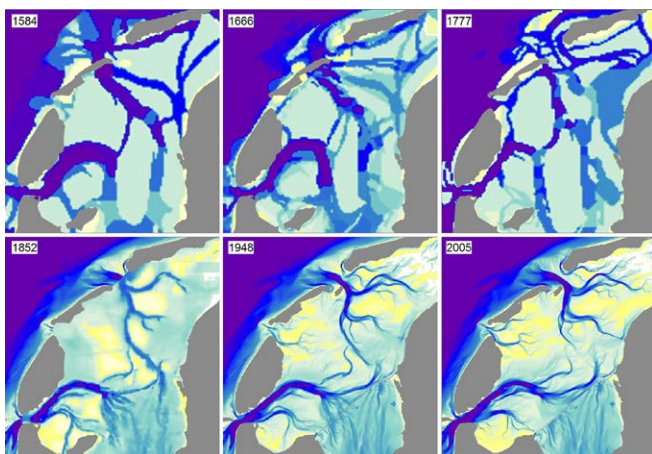


Fig. 2.28 Series of digital maps of the pilot area from 1584 (after Waghenauer), 1666 (after Goos), 1777 (after Sepp), 1852 (after Hulst Van Keulen), 1948 and 2005. Each subsequent map shows more detail due to the increasing resolution of the data. Figure: courtesy RCE/Menne Kosian.



Fig. 2.29 Original map of the Zuiderzee and Waddenzee by Hulst van Keulen (1852).

where necessary, corrected for modern projections.¹³⁰

Subsequently, similar scales and cut-outs were applied to each map. However, the maps still differ from one another in detail. For example, some contain more information than others, and several areas do not feature depth soundings. This is primarily due to the purpose for which the maps were made. They were intended as navigational aids, and ships were expected to sail along the recognized shipping channels. It was important to indicate the depths of the sailing channels and the navigational aids at sea,¹³¹ while shoals were a threat to shipping and were to be avoided if possible. The exact depths of the sandbanks were therefore less important (Fig. 2.28).

¹²⁴ Kosian 2009, 27.

¹²⁵ Kosian 2009, 28.

¹²⁶ Kosian 2009, 26.

¹²⁷ Kosian 2009, 27.

¹²⁸ The chronometer was invented by John Harrison.

¹²⁹ The Mercator projection was in use for most of the maps after 1569. It is a cylindrical map projection which was introduced in that year by the Flemish geographer and cartographer Gerardus Mercator. It became the standard map

projection for nautical purposes because it represented lines of constant course as straight segments which conserve the angles with the meridians. This is essential for navigation at sea. Therefore, it is still often in use for navigation charts. However, for many global and landmass charts, other projections are used. See also http://en.wikipedia.org/wiki/Map_projection (accessed 29-01-2017). for more information about map projections.

¹³⁰ Kosian 2013.

¹³¹ See also Sigmond 1989, 157–158.

2.7.3 The period 1852–1975

The first detailed and reliable depth chart was the 1852 'Kaart van de Zuider Zee' (Map of the Zuyder Zee) by Hulst van Keulen.¹³² The depth values are expressed in 'Amsterdam feet'¹³³ at normal ebb tide', and were obtained through systematic manual depth soundings.¹³⁴ The map contains more than 7,000 soundings in the current Western Wadden Sea and the IJsselmeer area. Based on these measurements, depth contours were then added by hand (Fig. 2.29).

The entire original map was digitized (soundings and contour lines), and then the values were converted to the current NAP¹³⁵ in the following steps.

1. Digitization of original soundings
2. Digitization of original depth contours
3. Conversion of Amsterdam feet to metres (factor 0.2831)
4. Conversion of Normal Low Water to NAP in accordance with correction model (based on data provided by the Ministry of Infrastructure and Water Management)

The values converted to RD¹³⁶ were then applied to a grid model with 50 x 50 metre cells (Fig. 2.30).

Hand-drawn overview charts were published for the periods 1925–1930 and 1948–1951. These were then digitized in the 1980s by the Friesland Directorate for Infrastructure and Public Works. This involved drawing vertical and horizontal lines on the map, varying in distance from 90 to 250 metres. The degree of coverage for some areas may also have been examined at this time. Following this, the average value for each 250 x 250 m square was calculated. These values were then interpolated to a 20 x 20 m grid.

The soundings from before the Second World War were conducted using a manual lead, and the positions were determined using a sextant (horizontal angle measurement). It is unclear when acoustic sounding and hyperbolic positioning systems were first used, although it was probably no earlier than the late 1970s. A full-coverage system only came into use in the late 1980s and early 1990s. The original overview maps were destroyed after they were digitized.¹³⁷

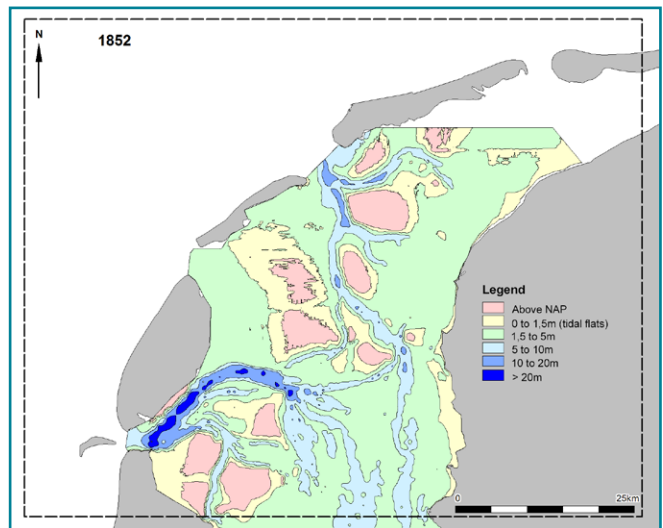


Fig. 2.30 Digitalized and vectorized map of the Zuiderzee (from Hulst van Keulen, 1852). Figure: courtesy Perplus Archeomare/RCE.

2.7.4 The period 1975–present

Starting in 1975, the depth of the Wadden Sea was systematically measured using zone soundings. The area was divided into a number of zones, with a pattern of cross-sections for each zone (Fig. 2.31). The maximum distance between the cross-sections was 200 metres. These cross-sections were measured using a single beam acoustic sounding system, which measured depth in average increments of 20 centimetres. When the data was processed and validated, spikes were removed and the values were referred to NAP. The data was then placed in a grid of 20 x 20 metre squares. The gridding method has improved significantly over the years; and since the turn of the century the preferred method has been Digipol, an interpolation technology designed by the RIKZ especially for seabeds.¹³⁸

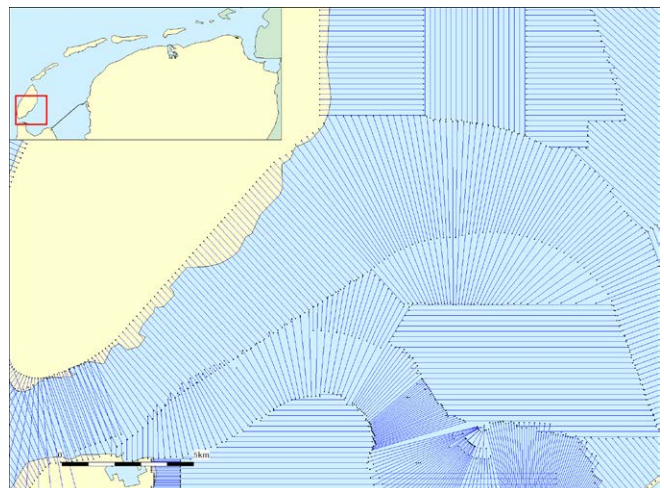


Fig. 2.31 The pattern of zone soundings in the southwestern part of the Wadden Sea near Texel and Den Helder. Figure: courtesy Perplus Archeomare/RCE.

¹³² The navigation chart 'Zeekaart van de Zuiderzee en de Waddenzee (Texel - Ameland)' was published by Weduwe (widow) G. Hulst van Keulen, in 1852 in Amsterdam. Although Gerard Hulst van Keulen died in 1801, his wife must have continued the trade, as did others after her, as maps were produced throughout the nineteenth century.

¹³³ An Amsterdam foot is equal to 0.231 metres.

¹³⁴ Sounding was done from a ship using a sounding lead. See also Horsten et al. 1979, 316.

¹³⁵ Normaal Amsterdams Peil (Normal Amsterdam Level): reference level for water-level measurements in the Netherlands.

¹³⁶ Rijksdriehoekstelsel, coordinated conversion using RDNAPTRANS (Kadaster.nl).

¹³⁷ Source: Willem van der Hoeven, consultant for DID-DSDG.

¹³⁸ Halderen 2005, 8. RIKZ: Rijksinstituut voor Kust en Zee (National Institute for Coastal and Marine Management).

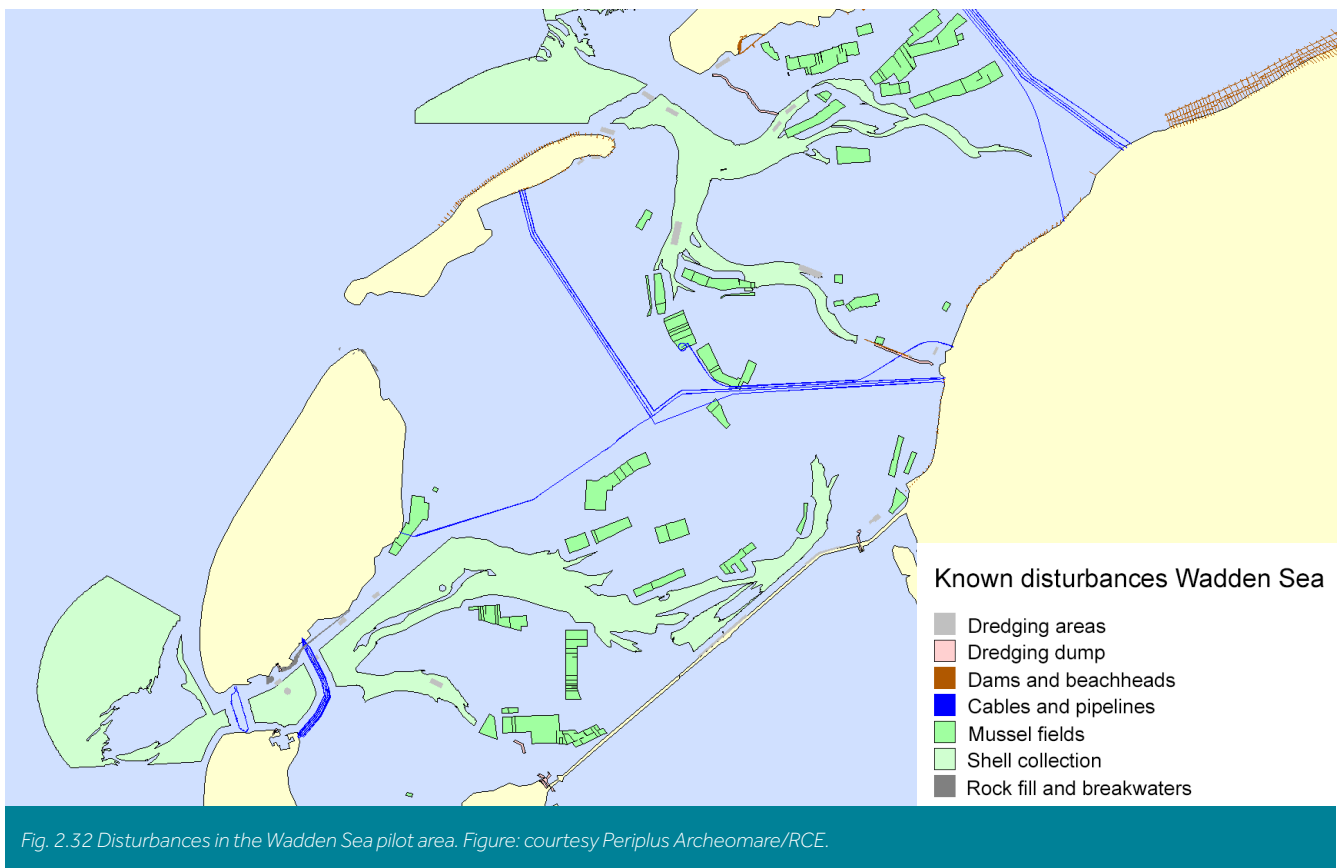


Fig. 2.32 Disturbances in the Wadden Sea pilot area. Figure: courtesy Periplus Archeomare/RCE.

2.8 Known and allocated areas for disturbances

The seabed has increasingly become a place that needs to be adapted for commercial activities, whether this is the installation of wind farms, pipelines, electric cables, the dredging of shipping lanes, sand abstraction, sea farming or the reclaiming of land for building purposes.¹³⁹ These human and other threats will be further discussed in Chapter 3.

The Ministry of Infrastructure and Water Management issues permits to keep track of which areas have been disturbed due to public works or where such disturbances are permitted. These data can be used to inventory the current disturbances of areas of interest based on geological and historical data. This is in turn

valuable information for drafting policy maps for municipalities with the aim of obtaining exemptions to a certain depth, or to mark the current potential of an area.¹⁴⁰

The digital map of disturbances in the HGMS shows the known disturbances of the sea floor in the pilot area, based on various sources from within the Ministry of Infrastructure and Water Management (Fig. 2.32). The disturbed areas are defined by the Ministry as polygons, in which the object information regarding sources and disturbance depth are recorded.¹⁴¹

Known sea-bottom disturbances can be divided into a number of categories.

Type	Description	Degree of disturbance
Dredging areas	Normal dredging work to keep shipping channels clear to a certain depth	In principle, only disturbance of recently accumulated sediment
Dredging dump	Dumping of dredging debris	No disturbance of the sea floor; only accumulation
Dams and beachheads	Construction of moles	Limited disturbance of sea floor only coverage
Cables and pipelines	Trenching and burying cables and pipelines	Disturbance to maximum depth of 6 m, 20 m wide
Mussel fields	Raising mussels for consumption	Disturbance of the sea floor to a depth of approx. 15 cm during harvest
Rock fill and breakwaters	Construction of reinforcing structures underwater	Limited disturbance of sea floor, only coverage
Shell collection	Shell collection through suction	Disturbance to a maximum of a few metres in depth

Table 2.1. Overview of the known disturbances in the Dutch Wadden Sea.

¹³⁹ See, for example, 'Ontwerp beleidsnota Noordzee 2016–2021' (attachment to the National Water Plan 2016–2021), for an overview of activities planned for the North Sea floor, which was published in December 2014 by the Ministries of Infrastructure and Water Management and Economic Affairs.

¹⁴⁰ It is also important to indicate which areas have already been disturbed, and in which areas such disturbances are permitted but where no interference has taken place. Each

type of activity involves a specific degree of disturbance. See also Table 2.1.

¹⁴¹ Some of the polygons were provided via the Ministry of Infrastructure and Water Management web service, and are based on the permits issued. In reality, this information should be included in the metadata.xml provided along with the files, but unfortunately this is often limited or incomplete.

The HGMS provides vector files describing the various types of disturbances which cover the entire Dutch Wadden Sea area.

2.9 Refinements

Several refinements could be made to the HGMS in the future. The grid for the basic files derived from the original data for the palaeographic maps of the Netherlands is not a gradual model but a 'stepped' model with two metre intervals (Fig. 2.33). As the original information was no longer available, these large steps may pose some problems in interpretation.¹⁴² For example, the model does not show variation between NAP -10 and -12; rather, it assigns the same variable to the entire area, then jumps two metres to the adjacent area. This may mean that the local/relative high points, where habitation may have been possible, are not shown.

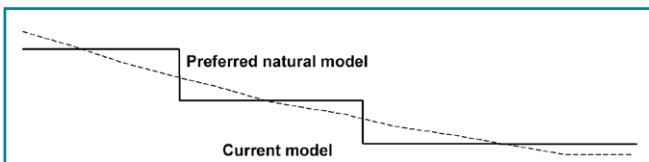


Fig. 2.33 The current maps based on the Pleistocene surface data are 'stepped models'. Ultimately, it would be better to have a more gradual model. Figure: courtesy Periplus Archeomare/RCE.

Another problem is that, in certain areas, the eroded Pleistocene surface is higher than the model for the original surface, which is, by definition, impossible. This must be due to a mistake in the original or the interpreted data.

The basic models are part of the large-scale national model, which has a relatively low resolution. The GeoTOP model would be a better alternative. In GeoTOP, the underground volume is divided into millions of 100 x 100 metre voxels (blocks) in the horizontal axis and 50 centimetres in the vertical. Parameters are then linked to each voxel. These can include geological characteristics, such as the stratigraphic unit to which the voxel belongs and the soil type (sand, peat, clay), but also physical and chemical parameters, such as the permeability to ground water. Since 2012, TNO has been working on an expansion of GeoTOP to the Wadden Sea region.¹⁴³ At the time of the analyses described above, this was not yet available.

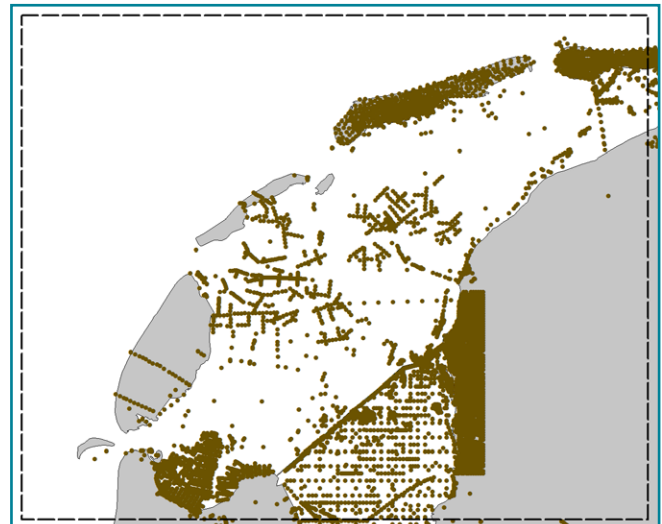


Fig. 2.34 Core density in the pilot area as registered in DINO. Figure: courtesy Periplus Archeomare/RCE/TNO.

Furthermore, it must be noted that the density of the data used for the HGMS is highly variable, with distances of up to 10 kilometres between two core samples (Fig. 2.34). This means that, in certain areas, such as the highly erosive zone of the Burgzand, the density of core samples is so low that any interpretation of whether channels are suitable for shipping must be made with the greatest of care. The map material included in the HGMS is still in the early stages, and it should be improved as new data is added over the coming years.¹⁴⁴ However, as municipalities and archaeological companies will use the data sets, not only will these be improved, but new local and more detailed data may also be included in the analyses, improving the overall product.¹⁴⁵

Historical maps are also subject to limitations. We should keep in mind that such maps are also historical interpretations and, therefore, do not always reflect the facts and figures which may interest archaeologists and heritage managers. They are influenced by many factors, such as the quality of the surveyor and the draughtsperson, the amount of knowledge available, as well as the purpose for which the map was made.¹⁴⁶ Each map has its own degree of accuracy and detail. The earliest historical maps (up to 1852) are all different with regard to the density of information provided. In order to compare the maps with one another and with later depth charts, a comprehensive process of re-projection has been undertaken. This means that the resolution for these maps is very low. The first detailed and reliable depth chart is therefore the 1852 map by Hulst van Keulen.

¹⁴² The original grid/point file from which: the Plzgeul.shp, Plzmgeul.shp, 100 nC.shp, 800 nC.shp en 1500 nC.shp. Vos & De Vries 2013.

¹⁴³ <http://www.waddenacademie.nl/nl/themas/geowetenschap/instituten/geotop-in-de-waddenregio/> (accessed 29-01-2017).

¹⁴⁴ It is recommended that the RCE should take up the task of regularly updating the basic maps of the HGMS.

¹⁴⁵ At the time of writing (December 2016), the municipality of Texel is working with

the HGMS to produce policy maps for its seabed area.

¹⁴⁶ This may include navigational purposes, but also political objectives. The latter may mean that additional attention is paid to certain areas, such as borders, or names may be changed or details consciously deleted or falsified. Lambert et al. (2006, p. 487–488) argued that since gender, class and race play an important role in creating a historical geography of the sea and its landscape, they may also influence the material products, such as the map materials, as well as our image of the past.

The accuracy of the maps increases as we approach the present day. After 1975, the charts utilized a fixed cross-section pattern, so the depth charts are easier to compare to one another as the data was collected with the same method and from the same cross-sections. However, the single-beam soundings used in these charts require considerable interpolation. In smaller areas, the coverage is improved through the use of multibeam sonar.¹⁴⁷ This method provides a more or less accurate relief image of the sea floor. Since some sections of the pilot area are not included in the more detailed multibeam recordings, those that were recorded in these sections were not taken into consideration. They are, however, available for more detailed research in smaller areas.¹⁴⁸

There are a number of studies that can be conducted to help refine the map material for the period starting from prehistory through to the late Middle Ages. For example, the GeoTOP model discussed above contains much more information than merely a description of the upper Pleistocene strata.¹⁴⁹ For the Western Wadden Sea, there are also descriptions of more than 5,000 core samples available (RIJP archive), which can be used to refine the models presented here. These have not yet been included because they were only recently rediscovered.¹⁵⁰

Furthermore, a focused core survey has started, based on the data analysed in this study, in order to provide information for the areas where few or no core samples have yet been taken. In this regard, Optical Stimulated Luminescence (OSL) dating may provide more insight into the Holocene sand layer. Research as part of the EU-financed MACHU project has indicated that OSL dating also works for sand that has been deposited under water.¹⁵¹

The known underwater cultural heritage resources can also provide an indication of the possible presence of other objects. The known resources in the Western Wadden Sea area are fairly limited up to the late Middle Ages; however, this does not mean that nothing has been found over the past few decades. Nevertheless, important objects with very old provenance are often found at greater depths, without context, through the process of dredging or sand and gravel mining.¹⁵² By educating the workers in this industry and making it easier to report finds, it

may be possible to gain a better insight into the occurrence of prehistoric artefacts such as hand axes or frames from late medieval ships.¹⁵³

There are also several studies under way that deal with the spatial structure and use of maritime cultural landscapes in prehistory, the Roman era and the early Middle Ages.¹⁵⁴ These studies will certainly result in new insights that can lead to a better understanding of the geological landscape and human use. Once we add more historical data to the geological models, we will gain a better understanding of the culture landscape during the various periods. The integration of historical geographic studies on land and those from a maritime perspective may also provide additional knowledge.

2.10 Conclusion

'In situ should be considered the first option' is a mantra constantly heard in cultural heritage management. What does it mean? More specifically, what does it mean for underwater cultural heritage objects? To answer this question, it is, firstly, important to look at what we mean by 'in situ' and, thus, the place of 'primary' deposition: the environment in which sites were created and can still be found. Objects are purposely or accidentally left behind, although it is not always easy to determine the reasons behind distribution patterns. However, if we do, we will understand the area better from an archaeological and historical-geographical perspective. Landscapes are formed by the interaction of natural and human processes. Understanding these processes is the key to the biography of a place. With that information we can look further than merely those archaeological sites that are already discovered (the 'known resources') and take the step to predicting the chances of cultural heritage being found in other places and zones of the seabed. To do so, we need a lot of validated information as a basis with which to work. From this basis, we can add non-validated information, which can also yield a treasure of information, although this – often highly subjective – information should never be confused with data retrieved systematically by well-planned research projects.

¹⁴⁷ See also the Burgzand monitoring report (Brenk & Manders 2014).

¹⁴⁸ Since 2002, the wrecks in the Burgzand area have been monitored using high-resolution multibeam sonar on an annual basis. This research has led to many new insights about the behaviour of the sea floor in this area and around the wrecks in particular (Brenk & Manders 2014).

¹⁴⁹ The upper 50 m. The entire area is divided into cuboids of 50 m x 50 m wide and 50 cm thick.

¹⁵⁰ The analogue core descriptions from the archive of RWS in Harlingen (the RIJP archive) are currently being validated by Deltares and will then be added to the DINO database.

¹⁵¹ Manders, Os & Wallinga 2009.

¹⁵² A frame of a clinker-built vessel was identified at the Wreck Museum (Wrakkenmuseum) on Terschelling, which dendrochronological dating placed in the fourteenth century (after 1321 AD). It was found many years ago at a great depth (under the sand) by a sand dredger. The exact position it lay in is not known. RING 2009.

¹⁵³ A start was made with the publication of the pamphlet, 'Herkennen van archeologische vondsten uit waterbodems' ('Recognizing archaeological finds from water beds'), which was a collaboration between the RCE and RWS (Houkes & Caspers 2013).

¹⁵⁴ See, for example, Jansma et al. 2014 and Lanen (2015 (1) and (2)).

Seabeds are often very dynamic, especially in the Netherlands. A constant flow of natural processes that shape the seabed as well as human action that has significantly adapted the area have been ongoing for centuries. This high level dynamic was the reason why the Dutch waters were initially not included in the predictive mapping (IKAW), while later attempts did not have reliable outcomes. It was for this reason that a project to develop a more dynamic map began (4D: x, y, z and time). After initially focusing on creating an Indicative Map for the Western Wadden Sea, another direction was taken. This was not only to avoid assuming the responsibility of the municipalities, but also to focus on providing maps that offered an insight into the quality and quantity of heritage in the area.

This led to the birth of the Historical Geomorphological Map Set (HGMS). Some of the data sets necessary for establishing the HGMS were readily available, requiring no additional editing, while others required long searches and intensive editing to make them suitable for use. The project has, subsequently, been able to include data that had not been available until recently, and even to produce new data, primarily by combining different data sets. The map set can serve as a foundation for the drawing up of policy maps by municipalities and provinces. However, it can also be used to answer academic research questions.

The Historical Geomorphological Map Set consists of three groups of maps. The first group is made up of maps that were created using objective measurement data. The second is made up of combinations of maps from the first group. The third group of maps provides insight into human activity and land use in the area – including the maritime landscape – in the various historical periods. Hopefully, these maps and the accompanying acquisition of new knowledge will complement the map set that is available in the MACHU GIS, and also as a package that can be downloaded for use in internal systems. Their use will further improve our knowledge of the Western Wadden Sea area.

However, expert judgement will still be required, in addition to the data sets collected. Insight into what has happened in the past can only be gained through a combination of quantifiable data, current knowledge about a specific area and/or a specific period, logical reasoning and historical interpretation. This combination of data and specific expertise can aid in predicting the likelihood of finding heritage buried in the floor of the Western Wadden Sea. Systematic processing of the data and the clear separation of systematic (or 'objective') and incidental ('subjective') observations will help to identify the gaps in our knowledge. These gaps can then be distilled into fundamental

research questions and added to national and international research agendas.

Setting priorities is an essential element in the management of underwater cultural heritage. Where can the sea floor be disturbed without damaging the historical and archaeological record? Which heritage is sufficiently important to be preserved and protected, and which is not? Where is active management necessary to preserve heritage, and where is this unnecessary due to the lack of threats? Choices will have to be made based on 'hard' numbers and 'soft' impressions. The data provided will offer the ammunition for well-founded mitigation strategies aiming to preserve our underwater cultural heritage.

To conclude, the Historical Geomorphological Map Set for the Wadden Sea is a product that is intended to help policymakers and other parties in the field of cultural heritage management. The method improves the decision-making process pertaining to the management of underwater cultural heritage. In doing so, it complements the methods used in desktop studies.¹⁵⁵ By giving the system a modular structure based on sound theory and method, the system can be expanded (for management and scientific reasons) and made more precise without having to replace it. Due to its structure, it does require some expert judgement, primarily when new data sets are added and when policy or value maps are produced.¹⁵⁶

The Historical Geomorphological Map Set for the Wadden Sea, moreover, can also serve as a sound basis for academic research, since each data set has been validated and summarized, taking into consideration the manner in which the data were collected, when it was collected, the original purpose of the data, the reason for the collection and the processing that the data set has undergone.

By understanding the place – by being able to read the landscape from past but also from current perspectives (including management) – we can make better use of the opportunities the area offers us in terms its archaeological, historical and cultural resources. We will then also be better equipped and better prepared to mitigate against threats caused by changes.

¹⁵⁵ http://www.sikb.nl/doc/archeo/Protocol%204002%20Bureauonderzoek%204_0_definitief.pdf (accessed 29-01-2017).

¹⁵⁶ This also facilitates the entrepreneurship and client-orientation that are guiding

principles in the current archaeological system. After all, it allows good, expert companies to distinguish themselves from the competition.