Netherlands Enterprise Agency

Archaeological Desk Study

Hollandse Kust (west) Wind Farm Zone

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Hollandse Kust (west) Wind Farm Zone

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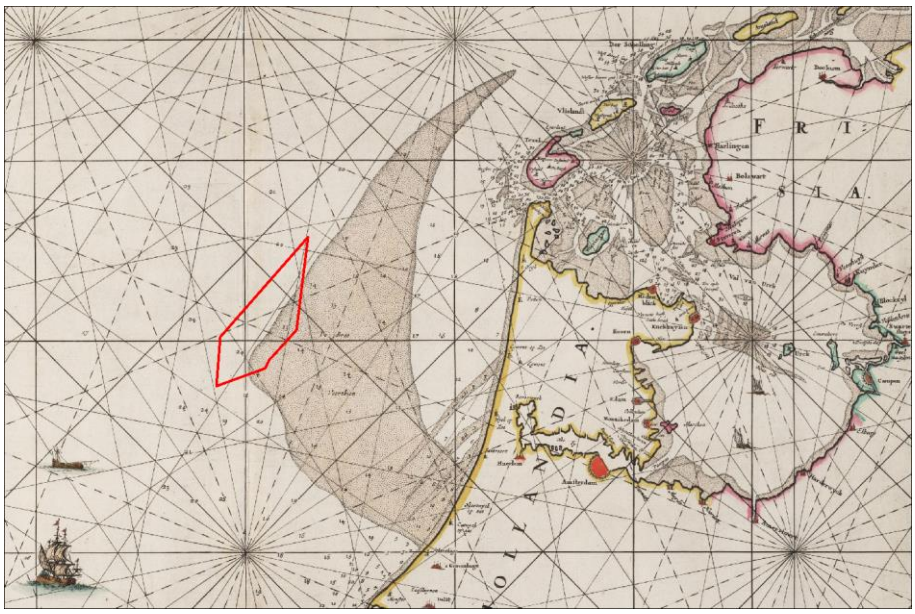
Periplus Archeomare

Archaeological Desk Study

Wind Farm Zone
Hollandse Kust (west)



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At the request of

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Contents

Table 1. Dutch archaeological periods

Period	Time in Years				
Post-medieval / Modern Times	1,500	A.D.	-	Present	
Late medieval period	1,050	A.D.	-	1,500	A.D.
Early medieval period	450	A.D.	-	1,050	A.D.
Roman Times	12	B.C.	-	450	A.D.
Iron Age	800	B.C.	-	12	B.C.
Bronze Age	2,000	B.C.	-	800	B.C.
Neolithic (New Stone Age)	5,300	B.C.	-	2,000	B.C.
Mesolithic (Stone Age)	8,800	B.C.	-	4,900	B.C.
Palaeolithic (Early Stone Age)	300,000	B.C.	-	8,800	B.C.

Table 2. Administrative details

Location:	North Sea	
Toponym Dutch:	Hollandse Kust (west)	
Chart:	1801-01	
Coordinates Geodetic datum: ETRS89 Projection: UTM31N	Centre	E 584 230 - N 5 834 717
	IA_01	E 561228.0 - N 5855632.6
	IA_03	E 556460.6 - N 5830656.3
	IA_04	E 549868.2 - N 5822960.7
	IA_05	E 549138.1 - N 5822251.0
	IA_06	E 547864.6 - N 5819746.5
	IA_07	E 536954.7 - N 5814611.0
	IA_08	E 535232.6 - N 5813800.4
	IA_09	E 537288.5 - N 5826952.9
Depth (LAT):	20.0 to 34.6 meter, average 28.1 meter	
Surface investigation area	392.8 km^2	
Surface investigation area (+buffer 1km)	500 km^2	
Environment:	Tidal currents, salt water	
Area use:	Shipping , fishing	
Area administrator:	Rijkswaterstaat Zee en Delta	
Competent authority	Rijkswaterstaat Zee en Delta	
Advising body	Dutch Cultural Heritage Agency	
ARCHIS-research report (CIS-code):	4636995100	
Periplus-project reference:	18A031-01	
Period	October – December 2018	

Samenvatting (in Dutch)

In opdracht van RVO.nl heeft Periplus Archeomare een archeologisch bureauonderzoek uitgevoerd voor het windpark Hollandse Kust (west). Het gebied met een oppervlakte van 393 km^2 ligt in de Noordzee, 51 km ten westen van Petten.

Tijdens de installatie van windturbines, funderingen en kabels kunnen archeologische waarden (indien aanwezig) worden aangetast. Conform de Erfgoedwet (2016) is het daarom verplicht om archeologisch onderzoek uit te voeren. De eerste stap in het archeologische proces is het bureauonderzoek, dat tot doel heeft de archeologische verwachting voor het gebied te specificeren. De resultaten van het bureauonderzoek worden hieronder samengevat.

Scheepswrakken
In totaal zijn maximaal 23 scheepswrakken bekend binnen het onderzoeksgebied. Het is mogelijk dat hier dubbelingen tussen zitten. Zes wrakken en een onderzeeboot zijn geïdentificeerd. Vier van de wrakken zijn recent en hebben geen archeologische waarde; twee wrakken en de onderzeeboot wel. Van de overige zestien wrakken zijn details, zoals naam, type, jaar van vergaan en exacte locatie, niet bekend. Aanvullend onderzoek is nodig om de archeologische waarde van deze wrakken vast te stellen. Daarnaast kunnen nog onontdekte wrakken aanwezig zijn in het gebied.

Vliegtuigwrakken
Tijdens de Tweede Wereldoorlog zijn vele vliegtuigen neergestort in de Noordzee. De bronnen zijn niet eensluidend als het gaat om het aantal wrakken dat nog vermist is, maar het moeten er minstens honderden zijn. Regelmatig worden in de Noordzee resten aangetroffen door vissers. Het is daarom goed mogelijk dat zich in het onderzoeksgebied nog resten bevinden.

Prehistorie
In situ resten van prehistorische kampplaatsen kunnen verwacht worden in de volgende stratigrafische eenheden:

<u>Boxtel Formatie (Laat Paleolithicum en Mesolithicum)</u>
Laat-paleolithische en mesolithische kampplaatsen en inhumaties worden verwacht op het gevarieerde laat-pleistocene dekzandlandschap dat wordt gekenmerkt door een afwisseling van duinen, ruggen en beekdalen. Archeologische niveaus bevinden zich de top van het Laagpakket van Wierden (dekzand), de Laag van Usselo (binnen de dekzandopeenvolging) en de top van het Laagpakket van Singraven (beekafzettingen). Vooral op plaatsen waar de Formatie van Boxtel is afgedekt door de Basisveen Laag en/of Laag van Velsen worden gave en goed geconserveerde resten verwacht.

<u>Brown Bank Laagpakket</u>
Neanderthaler kampplaatsen kunnen verwacht worden langs de kusten van voormalige zoetwatermeren en -lagunes die zijn ontstaan op de overgang van het Eemien naar het Weichselien. De sedimenten (klei en zand) behoren tot het Brown Bank Laagpakket. Ook het veen van de bovenliggende Woudenberg Formatie kan goed geconserveerde resten bevatten.

Stuwwallen

De stuwwallen in de Yarmouth Roads Formatie kunnen vuurstenen artefacten uit het Paleolithicum bevatten. Het gaat hierbij niet om *in situ* resten, maar om artefacten in de door ijs opgestuwde en vervormde oude rivierzanden. Aan de top van de stuwwallen kunnen *in situ* resten van kampplaatsen en begravingen van Neanderthalers en laat-paleolithische en mesolithische jagers en verzamelaars voorkomen. Alle niveaus met potentieel interessante archeologische resten liggen bedekt onder een minder dan 1m tot 17 meter dikke laag van jongere afzettingen.

Op dit moment is nog weinig bekend over de intactheid van het Pleistocene landschap. Door middel van *subbottom profiler* kan de ligging van geologische lagen (zowel verticaal als lateraal) en de ingebedde archeologische lagen in kaart worden gebracht en laaggrenzen (erosief versus concordant) worden geïnterpreteerd.

Het is onwaarschijnlijk dat de archeologische resten van paleolithische en mesolithische kampplaatsen met voldoende zekerheid kunnen worden geïdentificeerd (gebaseerd op geofysische en geotechnische onderzoeken) om restricties op te leggen aan de ontwikkeling van het windmolenpark. Dit geldt voor alle bovengenoemde archeologische lagen (stuwwallen, Brown Bank Laagpakket en Boxtel Formatie). Daarom zou de focus niet moeten liggen op het opsporen van deze resten, maar op een pragmatisch gebruik van geofysische technieken om beter inzicht te krijgen in (de intactheid) van het pleistocene landschap. Dit kan leiden tot een a) verfijning van het archeologische verwachtingsmodel en b) het aanwijzen van gebieden met een hoge verwachting voor *in situ* prehistorische resten.

Mogelijk kan een de getrapte geogenetische benadering, of delen daarvan, zoals toegepast door Vos et al. (2015), worden geintegreerd in de onderzoeksstrategie voor de HKW WFZ.

Conform de Archeologische Monumentenzorg cyclus (AMZ-cylcus) wordt geadviseerd om een inventariserend veldonderzoek (opwaterfase verkennend) uit te voeren om de archeologische verwachting te toetsen en de aard, omvang, (diepte)ligging, datering, gaafheid en conservering van scheepswrakken, het prehistorische landschap en potentiele archeologische niveaus nader te specificeren. De onderzoeksfasen van de AMZ cyclus worden nader toegelicht in Appendix 1: ‘Phases in maritime archaeological research’ op pagina 67 en het stroomdiagram op pagina 69.

Voor het gebied zal standaard al een geofysische survey worden uitgevoerd met *side scan sonar*, *magnetometer* en *subbottom profiler*. De resultaten van dit onderzoek kunnen (na interpretatie en rapportage van de uitvoerder van het geofysisch onderzoek) gebruikt worden voor een archeologisch analyse.

Op basis van de seismische data zal de uitvoerder van de geofysische survey advies opstellen over de locaties van nog uit te voeren geotechnische boringen om data te verzamelen voor constructiedoeleinden. De archeologische partij kan adviseren of de monsters van de boringen geschikt zijn analyse met betrekking tot het prehistorische landschap en afwegen of dit effect heeft op de voorgenomen werkzaamheden. Als het bevoegd gezag van oordeel is dat aanvullend onderzoek van de boormonsters gewenst is dan word geadviseerd dat de archeologische partij in samenspraak met de RCE een strategie opstelt voor de boor en monsterlocaties. Dit moet wel passen in het programma voor het geplande geotechnisch onderzoek, dat leidend is.

De archeologische analyse van de data dient uitgevoerd te worden door een geofysisch specialist (KNA Prospector Waterbodems). De datakwaliteit van de geofysische onderzoeken moet voldoen aan de eisen voor een archeologisch onderzoek. Om dit te waarborgen wordt geadviseerd om de doelen en eisen aan de archeologische analyse vast tel leggen in een programma van Eisen dat beoordeeld dient te worden door het bevoegd gezag.

Tijdens de installatie van de windturbines en de verbindingskabels kunnen archeologische resten aan het licht komen die volledig begraven lagen of niet als zodanig zijn herkend tijdens de archeologische onderzoeken. Conform de Erfgoedwet (2016) dienen deze vondsten te worden gemeld bij de autoriteiten. Deze meldingsplicht dient opgenomen te worden in het bestek van de aannemer.

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Summary

Periplus Archeomare was assigned by RVO.nl to conduct an archaeological desk study of the Hollandse Kust (west) Wind Farm Zone. The area of 393 km^2 is located in the North Sea, 51 km off the coast of Petten.

The installation of wind turbine foundations, cables and coherent activities may affect archaeological remains in the area, if present. According to the Law on Archaeological Heritage (Dutch: Erfgoedwet 2016) there is a statutory obligation to conduct archaeological research if such is the case. This archaeological desk study is the first step in the archaeological process aiming to establish whether archaeological remains are, or are likely to be, present, and whether these remains could be effected by the development of the planned wind farm. The results are summarized below.

Shipwrecks
A (maximum) total of 23 shipwrecks is known in the area. It is possible that some of these object entries are duplicates. Six ship wrecks and a submarine have been identified. Four of the ship wrecks are recent and have no archaeological value, two ship wrecks and the submarine do have an archaeological value. For the other sixteen wreck reportings, details like names, types and date of sinking are not known, nor are the exact locations. Further research is needed to determine the cultural-historical value of the wrecks and assess whether undiscovered shipwrecks are present.

Plane wrecks
During World War II, many airplanes crashed into the North Sea. Several sources are ambiguous about the number of aircraft still missing, but is at least hundreds. Remains are found on a regular base by fishermen. It is quite possible to expect (remains of) plane wrecks within the research area.

Prehistory
Remains of *in situ* prehistoric camp sites are expected within the context of the following lithostratigraphic units:

Boxtel Formation (Late Paleolithic and Mesolithic)
Late Paleolithic and Mesolithic camp sites and inhumations can occur in the cover sand dunes and ridges (top of Wierden Member and embedded Usselo Bed), and along the valleys of small streams (Singraven Member). The covering Basal Peat Bed and Velsen Bed can contain well-preserved lost objects, intentional depots and dumps.

Brown Bank Member
Remains of Neanderthal camp sites can be expected along the shores of fresh water lakes and beaches of lagoons which developed at the transition from Eemian to Weichselian. The sediments (clay and sand) are part of the Brown Bank Member. Within the peat of the covering Woudenberg Formation well-preserved lost objects, intentional depots and dumps can be encountered.

Ice-pushed ridge
The ice-pushed river sands of the Yarmouth Roads Formation can contain reworked flint artefacts from Lower and Middle Paleolithic times. At the top of the ice-pushed ridge in situ remains of camp sites and inhumations of Neanderthal and Late Paleolithic and Mesolithic hunters and gatherers can be expected. The ice-pushed ridge pre-dates the above-mentioned Eemian, Weichselian and Early Holocene deposits.

All archaeological levels of interest are located under a < 1m to 17 meter cover of Holocene deposits of the Bligh Bank Member possibly preceded by the Naaldwijk Formation.

At this stage little is known about the integrity of the Pleistocene landscape. By means of subbottom profiling the occurrence of geological units (both horizontal as vertical) and archaeological levels herein can be mapped. The character of layer boundaries (erosive or non-erosive) can be interpreted. It is unlikely however that archaeological remains of Paleolithic and Mesolithic camp sites can be identified with sufficient certainty (based on the geophysical and geotechnical surveys) to impose restrictions on wind farm development. This applies to all the above mentioned archaeological levels (Ice-pushed ridge, Brown Bank Member and Boxtel Formation). At this stage focus should therefore not be put on tracing prehistoric camp sites but on a pragmatic employment of geophysical techniques in order to obtain a better insight in (the integrity of) the Pleistocene landscape. The insights gained shall be used to a) refine the archaeological expectancy model and b) allocate areas with a high expectancy for *in situ* prehistoric remains.

Possibly (part of) a geogenetic, staged approach as advocated by Vos et al. (2015) could be implemented in the research strategy for the HKW WFZ.

In accordance with the AMZ cycle it is advised to conduct an exploratory field research (in Dutch '*Inventariserend veldonderzoek opwaterfase*') in order to test and further specify the archaeological expectancy in terms of the character, spacial distribution, integrity and preservation of wreck sites, prehistoric landscapes and potential archaeological levels herein. The phases of the AMZ cycle are explained in Appendix 1: 'Phases in maritime archaeological research' on page 67 and the schematic overview on page 69.

In general an exploratory research comprises a geophysical survey with *side scan sonar*, *magnetometer* and *subbottom profiler*. The resulting data should be archaeologically assessed after the general processing, interpretation and reporting has been performed by the survey contractor.

Based on the processed seismic data the survey contractor will advise on the borehole sample locations to acquire the information on soil parameters needed for construction purposes.

The archaeological contractor will advise whether borehole sample analysis is to be recommended to assess the presence of prehistoric remains and weigh the probability that remains will be affected by the planned activities. Alike the geophysical survey a geotechnical survey including borehole sampling and/or cone penetration tests is part of the archaeological phase of exploratory field research. If the competent authorities decide that an additional research by borehole sample analysis shall be carried out it is advised to consult with the archaeological contractor and the RCE to determine the sample locations and sample strategy. The 'archaeological' sample locations should fit in the program of data acquisition for engineering purposes, which will be the primary objective of the borehole sampling.

The archaeological assessment of the data has to be conducted by a geophysical specialist (KNA prospector Waterbodems). The data quality from the surveys needs to match the demands for this archaeological assessment. To ensure compatibility between the site investigation and the required quality for this assessment it is recommended to define a Program of Requirements (In Dutch: '*Programma van Eisen'*) in accordance with the 'KNA' (the Dutch quality standards for archaeological research), to be authorized by the competent authority.

During the installation of the wind turbines and construction of the cables archaeological remains may be encountered that were fully covered by sediment or not identified as archaeological remains during the geophysical survey. In accordance with the Malta convention incorporated in the Erfgoedwet (2016) it is required to report those findings to the competent authority. This notification for archaeological finds should be included in the specifications or scope of work.

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1 Introduction

Periplus Archeomare was assigned by RVO.nl to conduct an archaeological desk study of the Hollandse Kust (west) Wind Farm Zone. The research area of 393 km^2 is located in the North Sea, 51 km off the coast of Petten.

Figure 1. Location map of the research area

The desk study and reporting were carried out in accordance with the Dutch Quality Standard for archaeological research.[1]

[1] Kwaliteitsnorm Nederlandse Archeologie (KNA waterbodems 4.1).

1.1 Motive

The Dutch government has set ambitious targets for realizing renewable energy and offshore wind energy plays a prominent role in this. Important steps have been taken with the 2013 Energy Agreement for Sustainable Development and the resulting Offshore Wind Energy Roadmap 2023. In line with the policy intentions of the roadmap 2023, Wind Farm Site Decisions have been taken for the wind energy zones Borssele, Hollandse Kust (zuid) and Hollandse Kust (noord).

In March 2018 the second Offshore Wind Energy Road Map was published calling for the deployment of an additional 7,000 MW of offshore wind energy capacity by 2030 to be deployed in the following wind farm zones already designated as such in the National Water Plan: Hollandse Kust (west), Ten noorden van de Waddeneilanden, and IJmuiden Ver.

The Dutch Government has developed a systematic framework under which offshore wind farm zones are designated. Any location outside these wind farm zones are not eligible to receive a permit. Within the designated wind farm zones the government decides the specific sites where wind farms can be constructed using a so-called Wind Farm Site Decision ('Kavelbesluit'). This contains conditions for building and operating a wind farm on a specific site. The Dutch transmission system operator TenneT will be responsible for grid connection.

Winners of the site development tenders will be granted a permit to build a wind farm according to the Offshore Wind Energy Act (Wet windenergie op zee2) and offered a grid connection to the main land. The Ministry provides all relevant site data, which can be used for the preparation of bids for these tenders. This system is expected to contribute to cost savings. This Archaeological Desk Study is part of the site data for Wind Farm Zone Hollandse Kust (West).

In the Law on Archaeological Heritage (Erfgoedwet 2016), emerged from the Malta Convention (1992), incorporated in the Monuments Act through the Archaeological Heritage Act, the protection of the archaeological heritage is regulated. Planned activities, such as the installation of wind turbines and cables in the North Sea, may affect the archaeological values if present. If effects on possible remains are expected, there is a statutory obligation to conduct archaeological research. This process is also outlined in the law "windenergie op zee".

This archaeological desk study for the proposed Wind farm Zone Hollandse Kust (west) is the first step in the archaeological process as part of the so-called *AMZ* cycle. The phases of the AMZ cycle are explained in Appendix 1: 'Phases in maritime archaeological research' on page 67 and the schematic overview on page 69.

1.2 Objective

The objective of this archaeological desk study is to specify the archaeological expectancy for the HKW WFZ. To meet this objective this desk study aims to determine the occurrence and spacial distribution of (potential) archaeological remains, geological and geomorphological units and archaeological horizons embedded in those units. The research area for the desk study is defined as the HKW WFZ plan area plus a 1 km buffer zone.

Based on the outcome of the desk study an assessment will be made whether (possible) remains could be affected by the development of the wind farm and related infrastructure. Where possible, the desk study

aims to give insight into the archaeological value of these (possible) remains in terms of physical quality, scientific value and rarity. Furthermore, recommendations will be made on how to deal with possible archaeological remains.

The archaeological management procedure ('AMZ-cycle') is a defined sequence of steps and decisions within archaeological heritage management in the Netherlands. The procedure is embedded in the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1) as the mandatory workflow for archaeologists. A detailed description of the different phases of archaeological research is included in appendix 1.

1.3 Research questions

For an archaeological desk study, the following research questions are applicable:

- Are there any known archaeological values present within the research area? If so, what is the nature, extent (depth) location and dating of these sites?
- Are there, in addition to any known values, archaeological remains to be expected? If so, what is the nature, extent (depth), location and date of the expected archaeological remains?
- Can the proposed activities in the wind farm zone affect known or expected archaeological values? If so, can an impact on archaeological assets be prevented or restricted by planning adaptation?
- If the archaeological values cannot be saved:
  What kind of further research is needed to determine the presence of archaeological values and their size, location, type and dating to be determined enough to come to a selection decision?

In addition, the following points of attention and questions have been defined by RVO.nl in the scope of work and during the archaeological desk studies of WFZ HKN and HKZ:

- Define an overview of the archaeological aspects on which basis the wind farm zone will be assessed.
- Assess whether there are (indications for) areas with specific archaeological interest (wrecks and prehistoric life) at the Hollandse Kust (west) wind farm zone.
- If present, define expected location, size and dating of the areas with specific archaeological interest.
- Determine the possible effect of the installation of offshore wind farms on the areas with specific archaeological interest.
- Assess possibilities to mitigate the disturbance of areas with specific archaeological interest as a result of installing offshore wind farms.
- Identify whether any further investigations should be carried out from archaeological point of view and make a recommendation on the scope and specifications of these investigations.
- Define requirements for any activity carried out in the wind farm area (investigations or monitoring activities, installation activities, operational activities) that could have an effect on archaeological aspects in the wind farm area.
- What is the expectation of the physical quality of possible archaeological sites and objects?
- Which lithostratigraphic units can be determined and what is their spatial distribution (both horizontal and vertical)?
- Allocate archaeological levels within the lithostratigraphic sequence
- Is it possible to define zones where the (buried) prehistoric landscape is eroded or intact? Are the expected lithostratigraphic boundaries erosive or non-erosive?
- If so, will these zones be affected by the work envisaged?

- Investigate whether human activities could have led to a disturbance of the seabed and archaeological remains therein.
- If present, define the expected intrinsic quality in terms of rarity, research potential, group value and representativeness of the areas with specific archaeological interest.
- Define the expected physical quality in terms of integrity and preservation of the areas with specific archaeological interest.

If, on the basis of this desk study, a connection can be made with other questions from the NoaA 2.0 (national research agenda archaeology), then these must be answered. Given the nature of the research and the often limited possibilities for the identification of archaeological objects, it is not possible to select all the questions in advance. As far as the possible find categories are concerned, there are also various ongoing research programs at universities, with which a relationship can be established.

Possible synergy can be reached in the field of both archaeological remains and prehistoric landscapes, provided the investigations take place in the proximity of the research area of the HKW WFZ. Currently research programs are being carried out by VLIZ (Belgium), Bradford (United Kingdom) and TNO/Deltares (Netherlands) proximate to the Brown Bank area.

2 Methodology

The desk study was conducted in accordance with the Dutch Quality Standard for Archaeology (KNA Waterbodems 4.1, Protocol 4102). This concerns in particular the specifications LS01wb, LS02wb, LS03wb, LS04wb and LS05wb. The study is reported in accordance with specification LS06wb.

In order to comply with the main objectives and answer the research questions, the archaeological desk study is carried out according to the scope of Work as described in the following steps:

- Description of the Area of Interest and determination of the consequences for future use (LS01wb);
- Description of the current usage of the area of Interest (LS02wb);
- Description of the historical situation and possible disturbances (LS03wb);
- Description of the known archaeological features and objects (LS04wb);
- Description of the geological setting within which the archaeological objects are to be found (LS04wb);
- Definition of a specified archaeological expectation (LS05wb).

Based on these components a specified archaeological expectation is defined. It is expressed whether, and if so, which archaeological values can be expected. The properties of these values will be indicated in as much detail as possible.

The results of the study are summarized in chapter three. Based on the results the research questions are answered in chapter four. The study concludes with a summary and recommendation in chapter five.

The research and reporting were conducted by S. van den Brenk, R. van Lil (both senior prospector) and Rens Cassée. The results were approved and authorized by B. Goudswaard (Senior KNA archeoloog).

2.1 Sources

The following sources were consulted for the study:

- Archis III, archaeological database of the Dutch Cultural Heritage Agency
- Databases of Periplus Archeomare
- Dutch Federation for Aviation Archaeology (NFLA)
- Geological Desk Study Hollandse Kust (west) Wind Farm Zone by Arcadis
- Scope of Work Archaeology Studies I II III IV VOF
- Starting points and assumptions part I General V04F
- National Contact Number (NCN) database Rijkswaterstaat
- Rijkswaterstaat Zee en Delta
- Stichting Aircraft Recovery Group 40-45
- The Hydrographic Service of the Royal Netherlands Navy
- *TNO-NITG*; geological borehole data and maps
- UXO-study (REASEuro)
- Scientific publications in the field of (geo)archaeology and geology
- Various sources from the Internet

For a complete overview of the sources and literature see references on page 69.
Words in *italics* and abbreviations are explained in the glossary on page 63.

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3 Results

3.1 Definition of the research area and consequences of future use (LS01wb)

The Hollandse Kust (west) Wind Farm Zone (HKW WFZ) is located 51 kilometres off the west coast of the Netherlands. Active oil and gas production platforms are present within- and in the surroundings of the Wind Farm Zone.

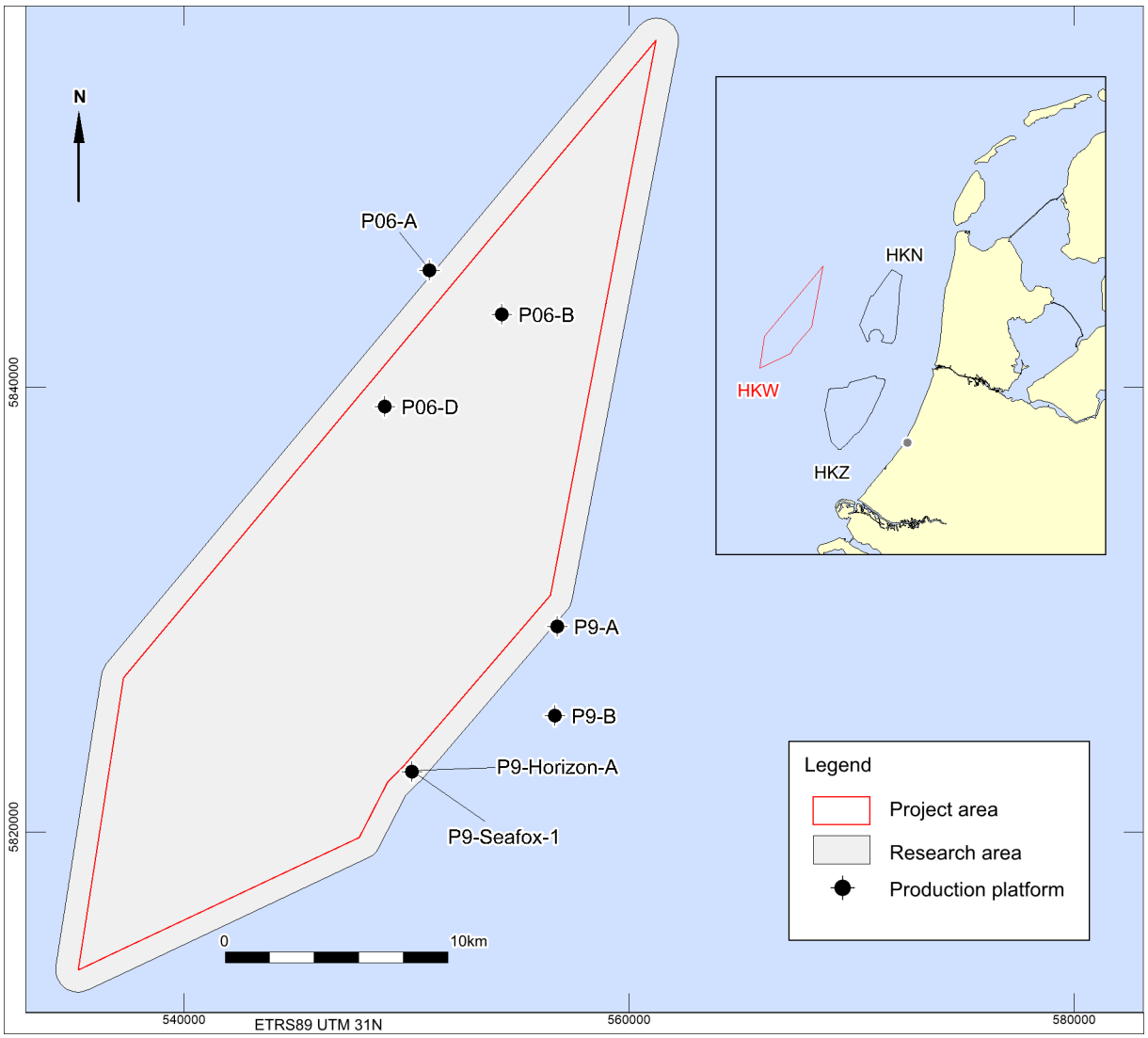


Figure 2. Overview of the research area in relation to the other wind farm zones

The Wind Farm Zone has the following general characteristics, as shown in the table below.

Water depth (LAT)	20.0 to 34.4 meter (LAT)
Mean water depth (LAT)	28.1 m
Distance from shore	51 km from Petten
Total surface area (including maintenance and safety zones within the WFZ)	393 km^2
Total research area desk study (surface area + 1km bufferzone)	500 km^2
Overall Wind Turbine Density	N/A

Table 3. General characteristics of the wind farm zone

The installation of the wind farm is expected to have a direct impact on the seafloor. Foundations need to be installed and trenches are created for the infield cables, which might have an effect on the possible presence of cultural heritage.

In the longer term, wind turbines can cause a change in seafloor morphology due to change of tidal currents. This may cause, in turn buried ship wrecks to emerge at the surface, exposing them to erosion.

Previous research

Parts of the research area have been investigated in the past for archaeological purposes:

- Windfarm and export cables Tromp-Binnen 2008. Archaeological desk study;[2]
- Export cable route HKW 2018. Archaeological desk study.[3]

Figure 3 Area covered by earlier conducted archaeological investigations

The results of this investigation have been incorporated in paragraph 3.5, description of known archaeological values.

[2] Van den Brenk et al, 2008.

[3] Van Lil et al. 2018.

3.2 Description of the current situation (LS02wb)

The water depth within the research area varies from 20.0 to 34.4 meter (LAT), with an average of 28.1 meter (LAT). The figure below shows a colour depth map based on data from the Hydrographic service (25m grid, 2009).

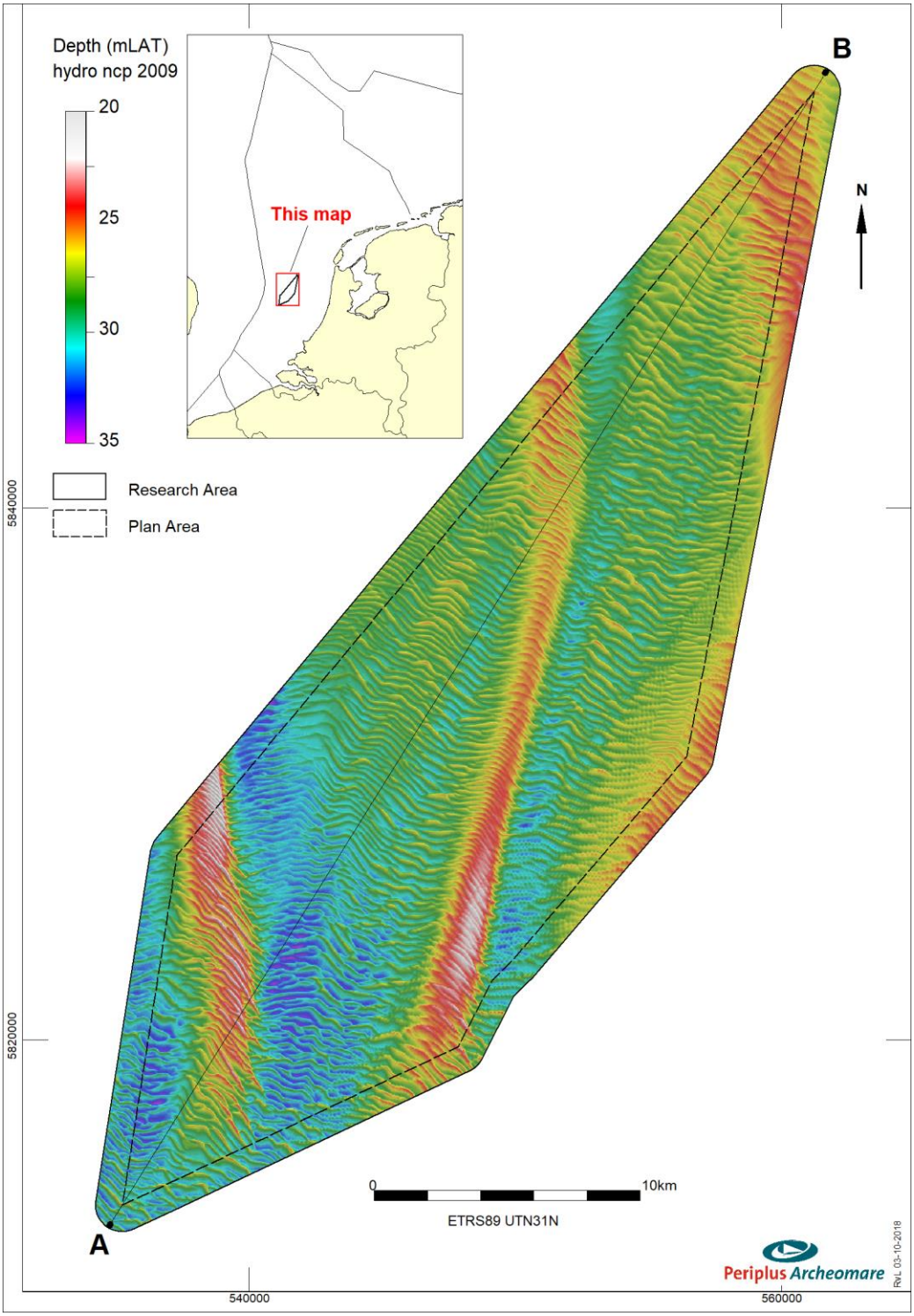


Figure 4. General bathymetry of the seabed (data Hydrographic Survey 2009)

The seabed is characterized by three types of morphological structures. The largest structures are north-south orientated ridges. The ridges vary in width from 1km to 3km and are up to 10m in height. Superposed on those ridges sand waves occur. The sand waves are up to 5m in height; the average

distance between the crests is 300m. The sand wave crest orientation changes from west-east to northwest-southeast at the intersections with the large north-south orientated ridges. Mega-current ripples which developed on top of the sand waves cannot be distinguished due to the grid-scale available (25m), but are nonetheless expected to be present. The ripple height is often less than a few dm; the distance between the current ripple crests is up to 10m.

The large ridges, sand dunes and current ripples have formed in the top layer of mobile sand. The ripples migrate along with tidal currents; the sand dunes typically migrate with a speed of 1 to 10 m/year. The migration rate of sand dunes in the Princes Amalia Wind Farm Zone were recently assessed to be in the order of 4 m/year.[4]

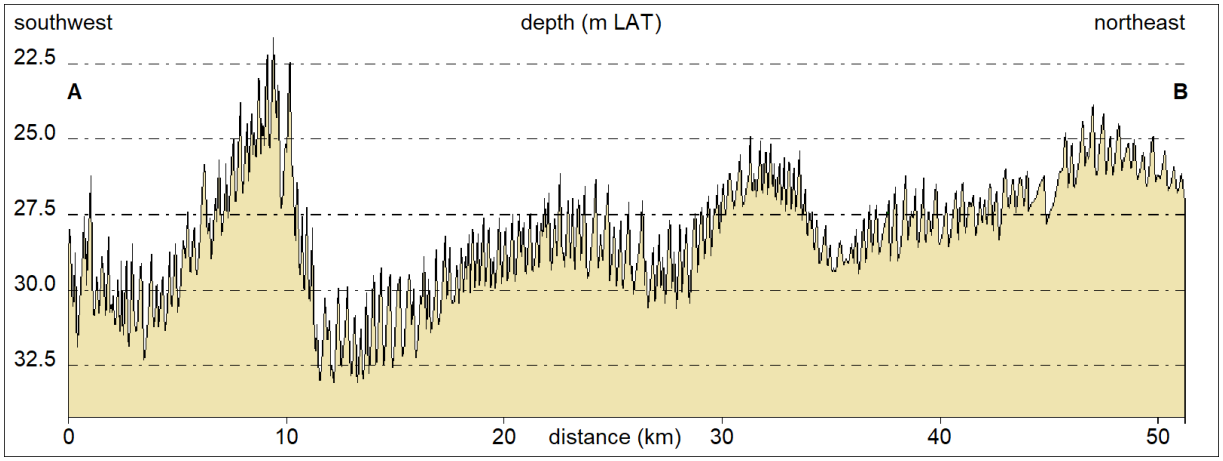


Figure 5. Seabed profile (see profile line figure 4)

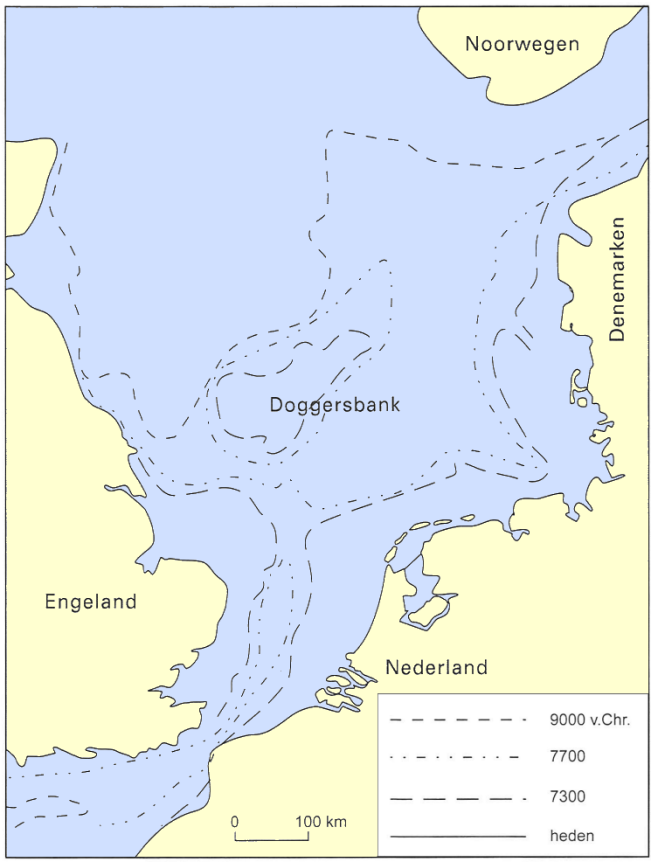
A separate more detailed morphodynamical desk study will be executed for Hollandse Kust (west).

[4] Forzoni 2017.

3.3 Description of the historical situation and possible disturbances (LS03wb)

The North Sea basin formed about 12,000 years ago as an extensive aeolian sand landscape with a tundra climate. At the end of the last Ice Age (ca 11500 years ago), the temperature rose as a result, the northern glaciers melted. The sea level rose and the North Sea basin was gradually filled. The filling of the North Sea plains did occur over the course of 3,500-5,000 years. During this time the landscape changed, from a freezing tundra to a woodland where birch dominated the region, with some alder, hazel, juniper, and pine[5]. During this time, the North Sea rose more rapidly than it does today, therefore, the residents of the area had to leave eventually for higher ground.[6]

The Dogger Bank in the North of the Dutch Continental Shelf is an example of an elevated area. Remnants of the tundra landscape and its inhabitants are regularly found in the nets of fishermen. However, all over the North Sea, remnants are found of hominin occupation of the region. For example, the only known Neanderthal from the Netherlands was found in the North Sea. Moreover, multiple Palaeolithic and Mesolithic artefacts and even human remains have been found within the remains of the North Sea.[12] A number of artefacts have been found in the vicinity of the research area. [7, 8, 9, 10, 11, 12] By 6,000 years ago, the North Sea plains were fully submerged, and the North sea looked very much as it does today.



[5] Van de Noort, 2011.

[6] Gaffney e.a. 2005.

[7] Louwe Kooijmans 1970.

[8] Armkreutz et al. 2016.

[9] Armkreutz et al. 2017.

[10] Armkreutz et al. 2018b.

[11] Momber, G. & J.H.M. Peeters 2017.

[12] Peeters, J.H.M. & K.M. Cohen, 2014.

Figure 6. Reconstruction of the historical coast lines in the North Sea basin

Due to the sea level rise the ancient landscapes drowned. These landscapes are depicted through geophysical and geotechnical engineering. Recently, for example, on the basis of seismic data from the oil industry a prehistoric landscape was reconstructed near the east coast of England.[13] Authors concluded that a large part of the Southern North Sea contains an in-situ prehistoric landscape.

Shipping

The earliest evidence of shipping in the North Sea dates from the Neolithic. For example, evidence of this can be found in prehistoric Rhineland burials. In this region the access of tin was limited and was therefore considered a luxury good. It had to be imported from other regions. One of such regions is South-West Britain.[14] It can be seen the other way around as well, Alpine jade axe heads have been sporadically found across the British Isles. Since this age, there is an increase of shipping in the North Sea with a few well-documented historical peaks. During Roman times, the North Sea and in particular the Channel served as connecting bridge for the empire. From the Early and High Middle Ages new centres of power arose along the North Sea coast. Furthermore, the raids of the Vikings should also be mentioned in this context. From the late Middle Ages, the international trade and the shipbuilding industry developed so that the North Sea was a stepping stone for global shipping routes. In all periods, ships were lost at sea. Ship wrecks are the traces of the maritime past and this can be preserved under favourable storage conditions in sediment. Obviously, the possible existing wreck site only occupy a very small area of the total research area.

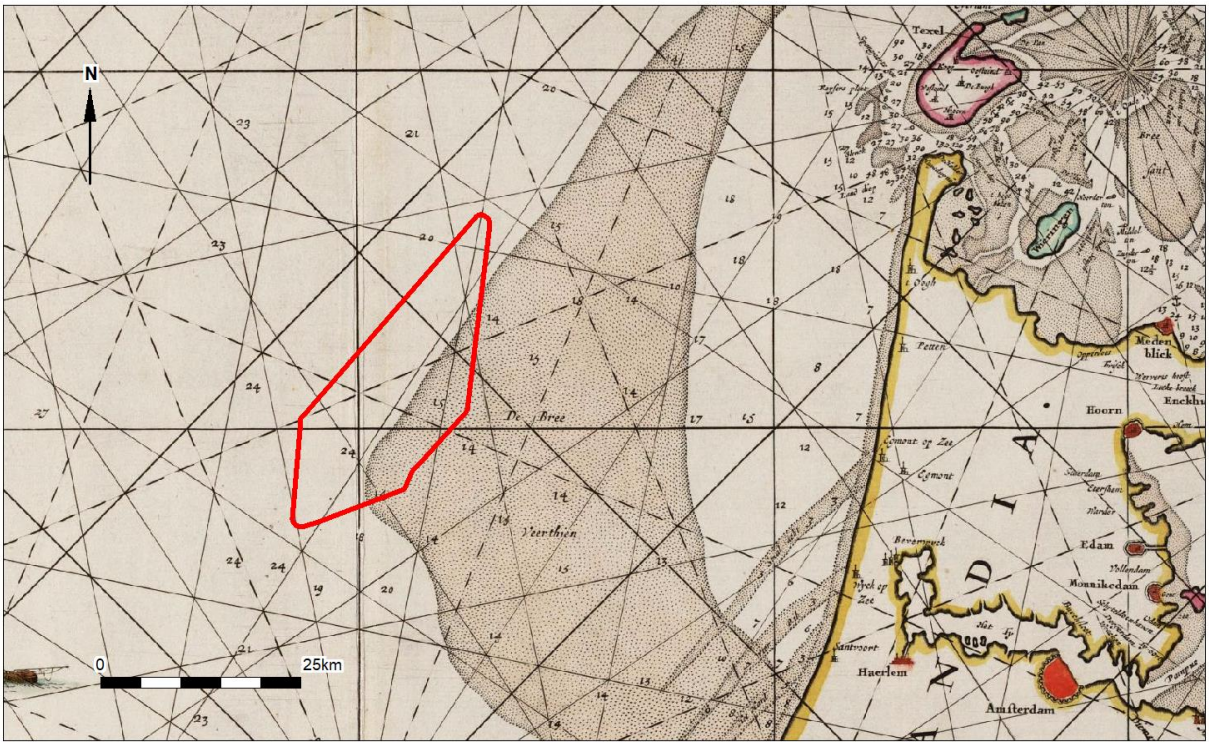


Figure 7. Research area on the historical map of 1675 (Pascaert de Wit, 1675)

[13] Project 'North sea paleo-landscapes' of the University of Birmingham

[14] Van de Noort, 2011

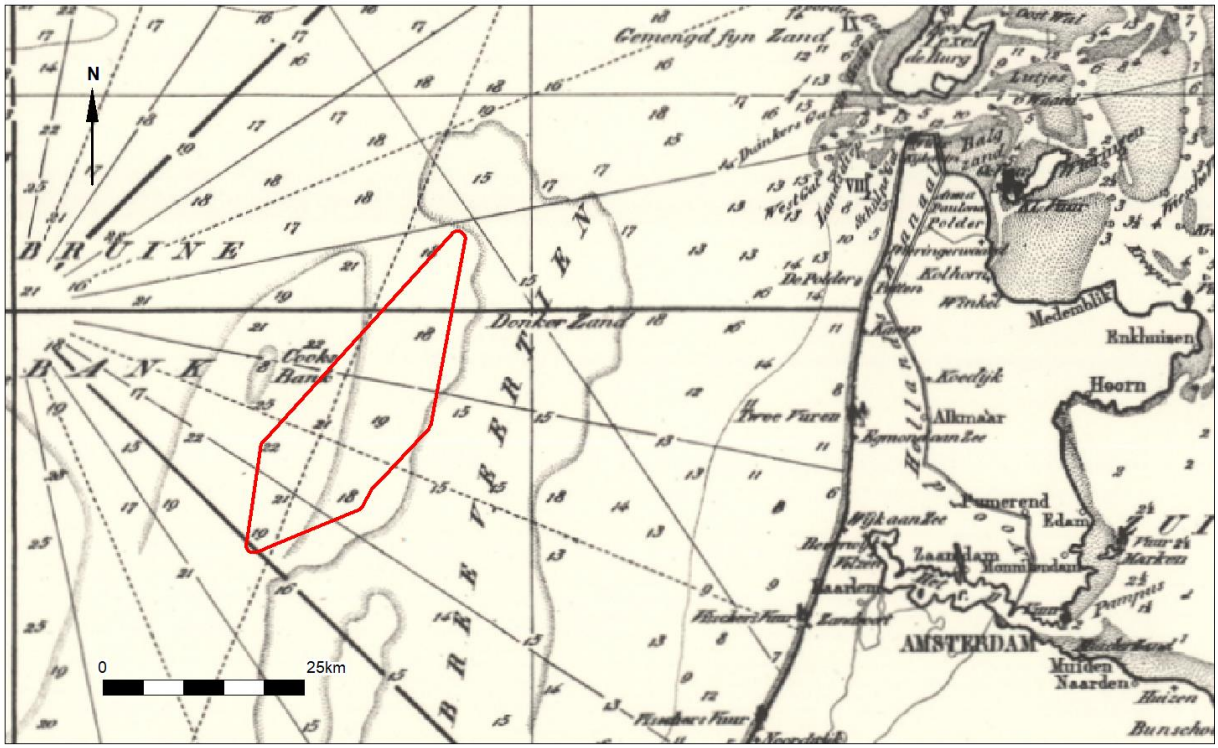


Figure 8. Research area on the historical map of 1852 (Jacob Swart, 1852)

Known disturbances of the seabed in the research area

In the past, parts of the seabed within the research area have been disturbed by trenches for cables and pipelines, and installations of platforms. The initial depth of burial of the cables is unknown, but should be a minimum of 1 meter according to the environmental permits. It is however expected that the cables are laid at a depth of 2 meters up to a maximum of 5 meters below the seabed. This also applies to the pipelines in the area.

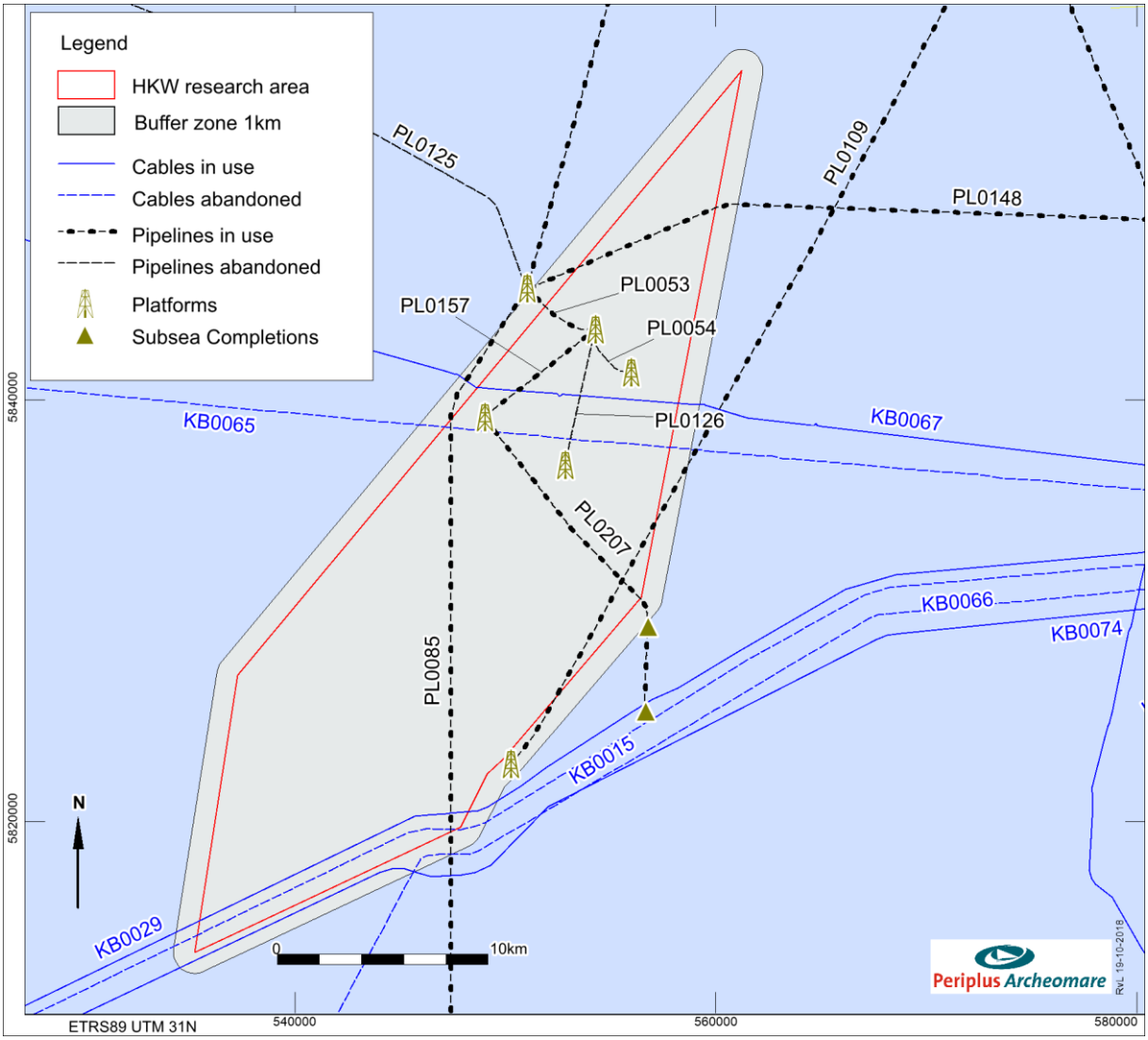


Figure 9. Known seabed disturbances within the research area

Number	Operator	Route	Type	Status
PL0125	Wintershall Noordzee B.V.	P2-NE tot P6-A	Gas 10 inch	Abandoned
PL0053	Wintershall Noordzee B.V.	P6-B to P6-A	Gas 3/12 inch	Abandoned
PL0054	Wintershall Noordzee B.V.	P6-C to P6-B	Gas 3/12 inch	Abandoned
PL0157	Wintershall Noordzee B.V.	P6-D to P6-B	Gas 12 inch	In use
PL0148	Wintershall Noordzee B.V.	Q4-A to P6-A	Gas 14 inch	in use
PL0126	Wintershall Noordzee B.V.	P6-S to P6-B	Gas 6 inch	Abandoned
PL0207	Wintershall Noordzee B.V.	P9-B to P6-D	Gas 6/8 inch	In use
PL0085	Wintershall Noordzee B.V.	P12-SW to P6-A	Gas 3/12 inch	In use

Table 4. Listing of pipelines through the research area

Number	Route	Type	Installation	Status
KB0015	Beverwijk (NL) to Lowestoft (GB)	Fibre Optic	Trenched	in use
KB0029	Lowestoft (GB) to Egmond (NL)	Fibre Optic	Trenched	in use
KB0065	Egmond (NL) to Lowestoft (GB)	Coax	Partially trenched	Abandoned
KB0066	Veurne (B) to Egmond (NL)	Fibre Optic	Trenched	Abandoned
KB0067	Egmond (NL) to Winterton (GB)	Fibre Optic	Trenched	in use
KB0074	Castricum (NL) to Whitesand (GB)	Fibre Optic	Trenched	in use

Table 5. Listing of cables through the research area

Platform	Type	Status	Remarks
P6-B	Production platform	In use	
P6-C	Production platform	Abandoned	Removed
P6-D	Production platform	In use	
P9-Horizon-A	Production platform	In use	
P9-Seafox-1	Production platform	In use	

Table 6. Listing of platforms in the research area

Locations and status of cables and pipeline are based on the database of Rijkswaterstaat (September 2018). This may differ from the as-built data from the operators

Disturbances by fishery

Within the area, seabed disturbances may occur due to fishery, especially trawling.

3.4 Description of geological data (LS04wb)

The archaeological prospect for (pre)historic settlements is strongly related to the geogenese of the plan area. The geogenese is reflected by the lithostratigraphic units present, the character of layer boundaries (erosive vs non-erosive) and indications for the development of soils within the sediments in prehistoric times. Therefore geophysical and geological data are an important source to answer questions with respect to the nature, age, depth and location of occurrence, integrity and preservation of the archaeological remains which are to be expected within the plan area.

Arcadis conducted (in corporation with Geo-Engineering.org) a geological desk study for the HKW WFZ.[15]
A geological model was constructed based on borehole data extracted from the DINOloket and NLOG databases together with information from neighbouring wind farms and geological maps. Further available seismic data of the northern part of the wind farm zone has been researched and assessed.

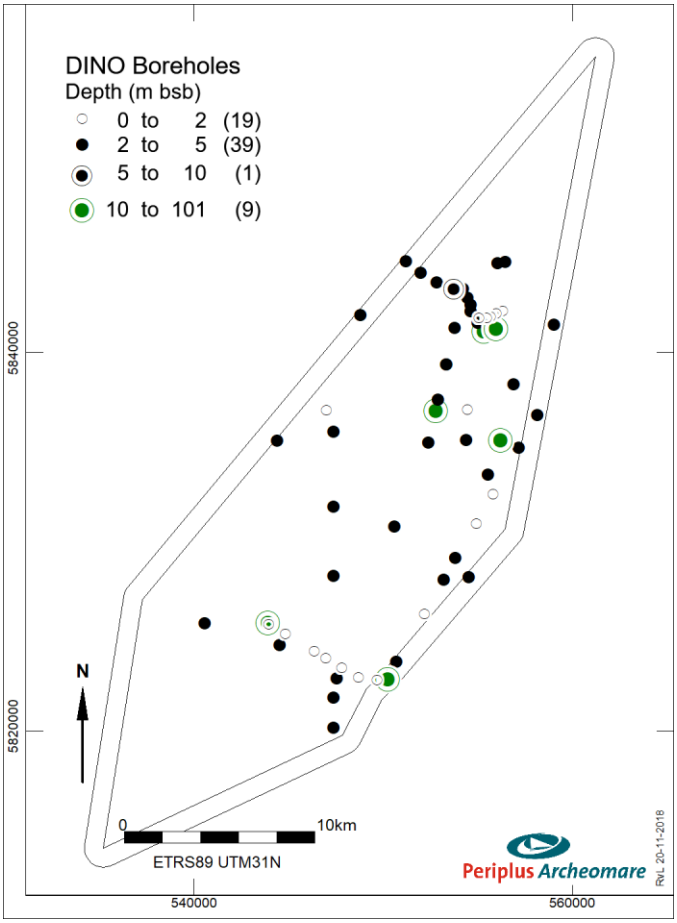


Figure 10. DINO-boreholes in the research area

Within the 498 sq. km HKW research area 68 boreholes are registered in the DINO-database, which equals an average of 1 borehole per 7.3 sq. km. The borehole density in the area is significantly less than onshore. Within a random picked 10 x 10 km square in the province of Noord-Holland we found 1363 boreholes in DINO which equals a density of 1 borehole per 0.073 sq. km. In other words the borehole density onshore in the Netherlands is some 100 times higher than in the research area. Also the boreholes are not uniformly distributed over the research area (see figure 10). The former indicates that the accuracy and precision of the geological maps is limited, although the maps are drawn by tying-in seismic data with borehole data.

[15] Thal 2018.

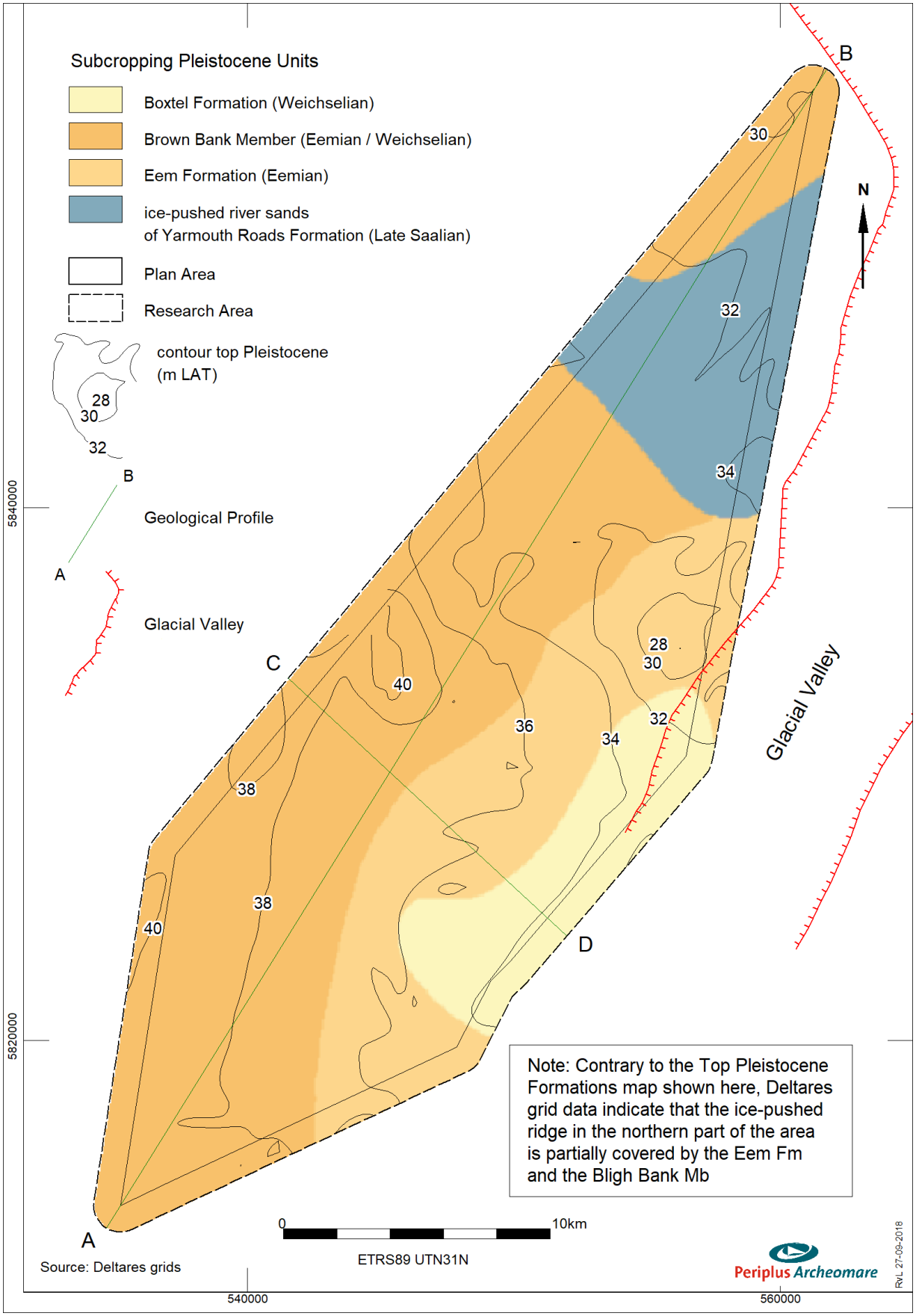


Figure 11. Sub cropping Pleistocene units

In 2017 Deltares conducted a geological study for the Hollandse Kust (zuid) WFZ.[16] On request Deltares provided Periplus with grid models (MSL) of a) the depth at which the (modelled) formation boundaries occur within the North Sea area and b) the thicknesses of these units. The grids available comprise the Pleistocene Eem, Kreftenheye and Boxtel Formation and the Holocene Naaldwijk Formation and Bligh Bank Member. The grids of the Drente Formation and Drachten Formation are not available. For this study we combined the Deltares data with the Top Pleistocene Formations map (see figure 11).[17]

The depth of the top of the Pleistocene units is shown as contour-lines projected on the lithostratigraphy (figure 11), and as a separate colour-scaled image (figure 12). The depth of the Pleistocene varies from 40m LAT in the south of the research area to 31m LAT in the north. The peak of an elevated Pleistocene area just north-east of the centre of the research area reaches 27m LAT. Figure 12 reflects the Pleistocene landscape as found to date. It is not known to what extent the original morphology has altered due to erosion.

[16] Forzoni 2017.

[17] Laban 2004.

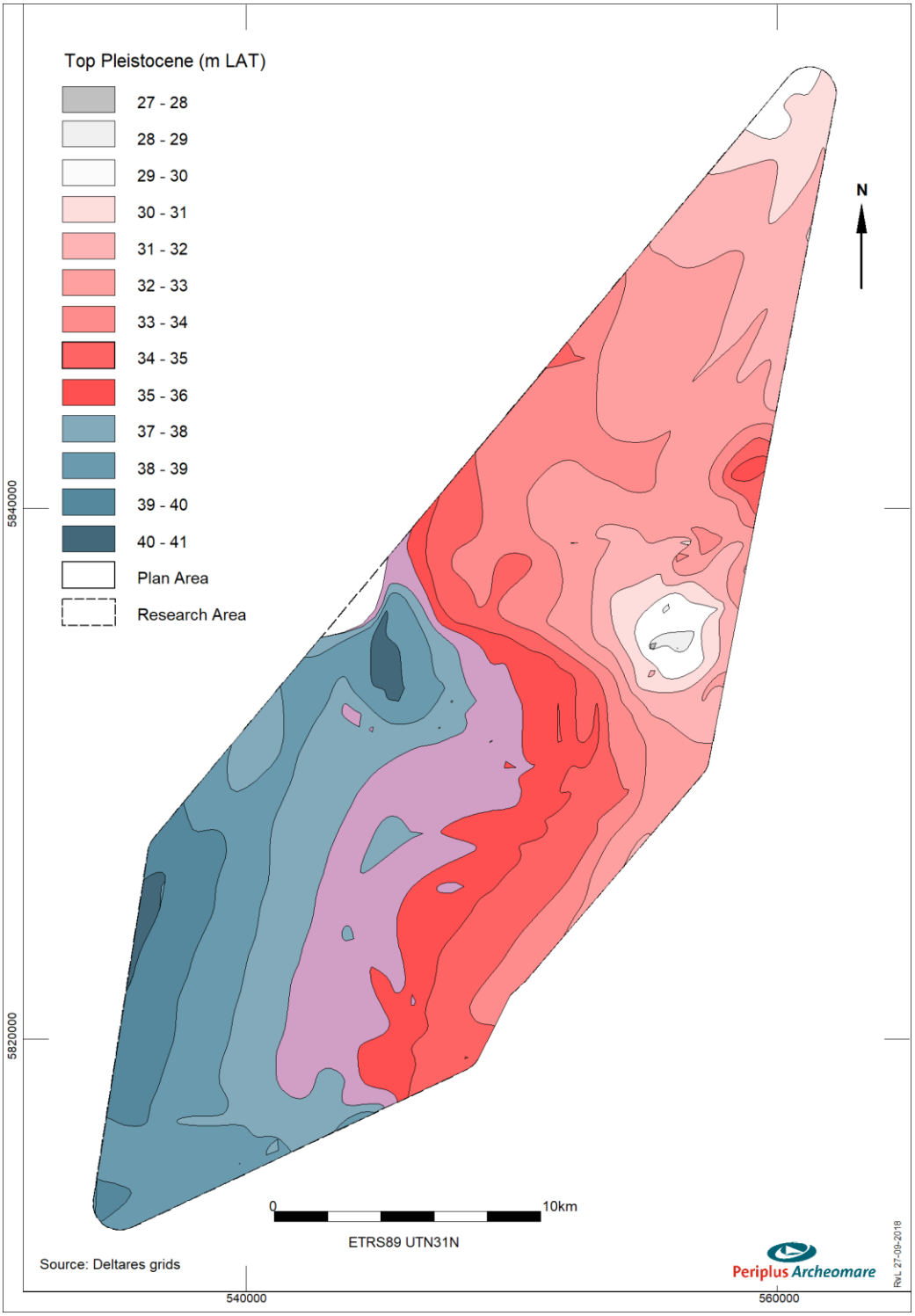


Figure 12. Top Pleistocene sequence (mLAT)

Within the boundaries of the research area four sub cropping Pleistocene units have been mapped:

- Ice-pushed deposits
- Eem Formation
- Brown Bank Member
- Boxtel Formation

The lithostratigraphic units will be discussed in more detail below.

Ice pushed deposits

In the northern part of the research area the Yarmouth Roads Formation is mapped.[18] It is important to note that the river sands of this unit are not in their original position of deposition. During the Late Saalian sediments of the Yarmouth Roads Formation were pushed and lifted to the surface in front of, and alongside the southward moving glaciers. This process led to the formation of ice-pushed ridges which contain the 'old' river sands. For a clear geogenetic understanding the unit could (or perhaps should) be a classified as glacial deposits of the Drente Formation. Onshore the deposits contained ice-pushed ridges have not been attributed to a lithostratigraphic unit. The deposits are labelled NN (*deposits, not formally classified or unknown; probably ice-pushed*').[19] The ice-pushed ridges constituted distinct morphological elements in the Early Holocene landscape.

Eem Formation

The Eem Formation predominantly consists of shell bearing fine sands deposited in an open marine environment during the Eemian interglacial (warm) period.[20]

Brown Bank Member (Eem Formation)

At the end of the Eemian period brackish and fresh water clays were deposited in lagoons and lakes which remained in the glacial basins during regression of the Eemian sea. These lake and lagoonal deposits have separately been classified as the Brown Bank Member within the Eem Formation. The Brown Bank Member was previously referred to as Brown Bank Bed or Brown Bank Formation. Zagwijn describes the unit as follows: '*The Brown Bank Formation is of fresh-water origin except for its lowermost layers, which are marine in some places. It was deposited in a lagoon or a lake. Underlying these beds there are marine shelly sands which contain a fauna characteristic of the Eemian. These sands are rarely absent. …The base of these sands is flat in the south (at about 46 to 47.5 m below the present sea-level) and more sloping in the north.' [21]* The description of Zagwijn refers to a north-south profile located 20 kilometres west of the HKW WFZ.

Zagwijn mapped the transition between the shell bearing marine sands of the Eem Formation and the overlying laminated fresh water clays is found around 40m below sea-level.[22] Deltares' grid data indicate that in the southern part of the research area the base of the Brown Bank Member indeed is located at -40m LAT.

Contrary to the Top Pleistocene Formations map displayed in figure 11, the Deltares data indicate that the ice-pushed ridge in the northern part of the area is partially covered by the Eem Formation and Bligh Bank Member. The top of the Brown Bank Member is in the north-eastern part of the area located around 31m to 32m LAT. The marine sands appear to wedge out on the flanks of the ice-pushed ridge.

Woudenberg Formation

In the Early Weichselian cooling climate peat was locally deposited on top of the clayey Brown Bank Member. At is base the peat is often rich in wood remains; at the top moss is a major constituent.

[18] Cameron 1984; Laban 2003; Laban 2018 (pers. comm.)

[19] e.g. DINOloket borehole sample B26C0384.

[20] Eemien: interglacial period between 130,000 and 115,000 years ago.

[21] 'south' and 'north' refer to the southern and northern part of the North Sea area.

[22] Reference plane is not specified.

Kreftenheye Formation

The Kreftenheye Formation consists of fluvial deposits of the Rhine which were deposited during the Weichselien.[23] In the warmer summer periods peak discharges of melt water resulted in the transport of fast amounts of sand and gravel to the North Sea area. There are no indications that the Kreftenheye Formation is present in the research area of the HKW WFZ.

Boxtel Formation (Weichselian)

The Boxtel Formation consists of terrestrial sediments deposited during the latest ice age, the Weichselian, and Early Holocene. The unit most probably contains aeolean deposits of the Wierden Member (cover sands) and loamy stream deposits of the Singraven Member. Apart from loam (=silt) the Singraven Member can contain sand, clay and peat. The occurrence of the Boxtel Formation is limited to thin layer in the south-eastern part of the research area, where it overlies marine sediments of the Eem Formation. The maximum thickness is 1m.

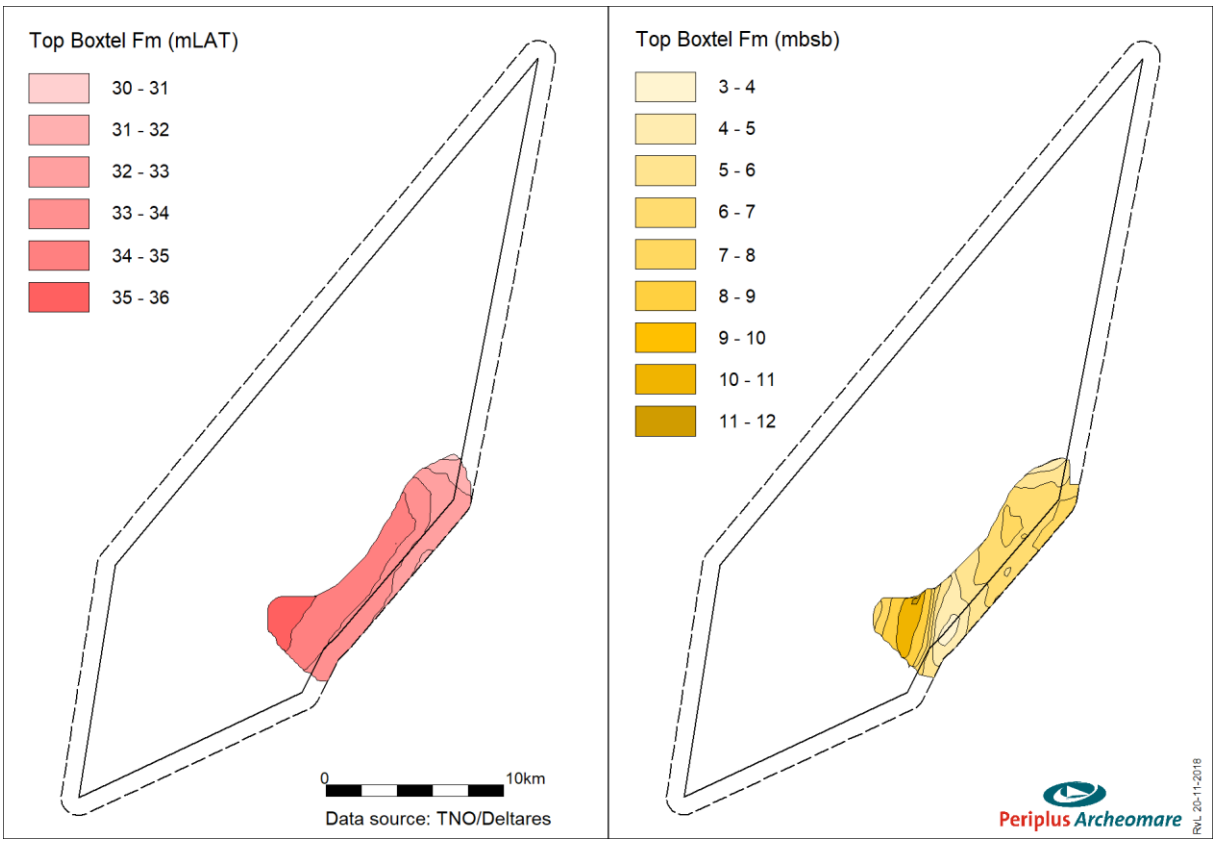


Figure 13. Top Boxtel Formation in meters LAT (left) and in meters below seabed (right)

The top of the Boxtel Formation is located between -31m and -36m LAT. The Boxtel Formation is covered by a sequence Holocene deposits, which varies in thickness from 4m to more than 12m in the southern part.

Basal Peat Bed and Naaldwijk Formation (Holocene)

Along the Dutch coast Pleistocene units are in places covered by Holocene tidal deposits (clay and fine sand). These layered and laminated tidal deposits are part of the Wormer Member within Naaldwijk

[23] Weichselien: ice age which lasted from 115,000 till 12,000 years ago.

Formation. The earliest clastic deposits are those of the Velsen Bed. The Velsen Bed consists of firm humic clay, sometimes containing considerable amounts of Hydrobia shells.

Information on the composition of the Holocene deposits is contra dictionary. The 1984 'Seabed sediments and Holocene geology' map of the Flemish Bight contains a sub map of the distribution of Early Holocene sediments in the area. This map indicates that the Elbow Formation is present in major part of the research area (see figure 14). In the northern part of the research area this unit reaches a thickness of over 5m.

Cameron and Laban described the Elbow Formation as follows:

'The Elbow Formation (Oele, 1969) has a maximum thickness off 12m but mostly between 2 and 6m thick, and comprises fine- or even very fine-grained bluish-grey muddy sands with interbedded clay. The Formation has a characteristic nearshore Spisula subtruncata bivalve assemblage (Spaink, 1973). A basal discontinuous early Boreal peat bed with intercalations of wind-blown or fluviatile sand is up to 1m in the north-west, but is present only locally in in the Dutch sector. There is evidence of a stratigraphic hiatus before deposition of the marine sands of the overlying Bligh Bank Formation.'

The Elbow Formation is an old name. According to the current classification, the unit includes the Basal Peat Bed and Wormer Member (=lower part of Naaldwijk Formation) with the Velsen Bed at its base. The Elbow Formation has been incorporated in the geological report of Arcadis as the Naaldwijk Formation.[24]

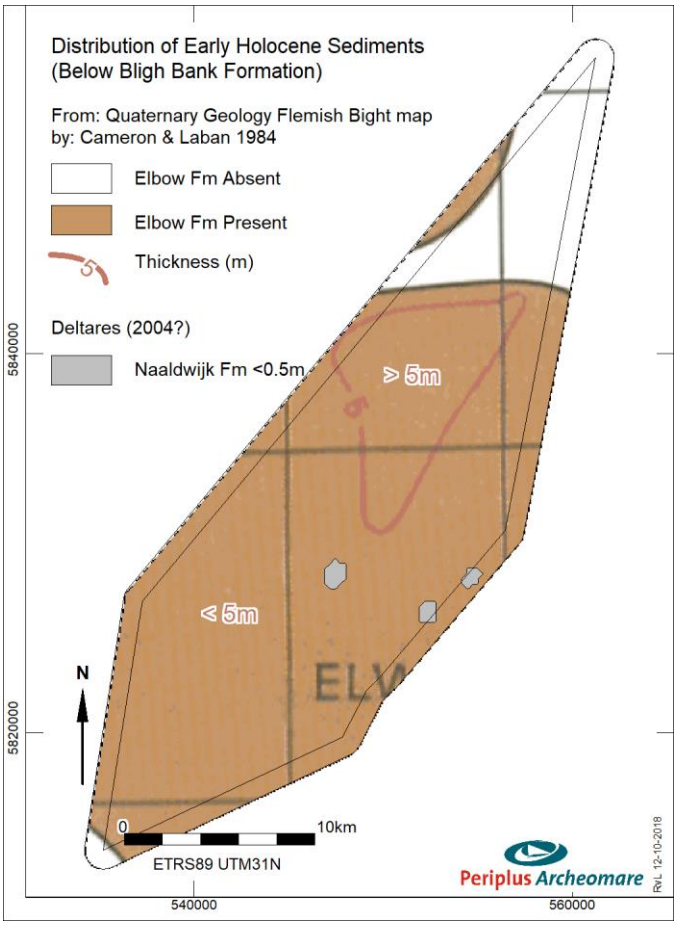


Figure 14. Distribution of Early Holocene sediments (Cameron & Laban 1984)

[24] Thal 2018.

The 2004 Deltares grid data suggest that the Naaldwijk Formation is virtually absent in the research area. Only in the southern part of the area some very thin small patches are present. The discrepancy between the Deltares' data (2004) and the mapped Elbow Formation by Cameron and Laban (1984) is not understood. The Basal Peat Bed (Nieuwkoop Formation) and Velsen Bed (Naaldwijk Formation/Wormer Member) both mark the Early Holocene transgression in the area. The presence of the Basal Peat Bed is a clear indication that the underlying Pleistocene landscape and possible archaeological remains contained herein might be intact. However, additional information is needed to conclude on the occurrence of Early Holocene peat and clay sub crops in the research area.

Bligh Bank Member

The Bligh Bank Member is a mobile sand layer in which sand dunes and mega-ripples have developed. This unit consists of marine, medium- or fine to medium-grained, clean, yellow-brown sands with local mud laminae. The formation often has a more gravelly structure towards the base. The thickness of the Bligh Bank Member ranges from less than 1 to over 17 meters at the crests of the sand dunes.

Geological profiles

A geological map of the research area provides insight in the lateral distribution of lithostratigraphic units present in the area (see figure 11). Below, two geological profiles illustrate the vertical distribution of those units.

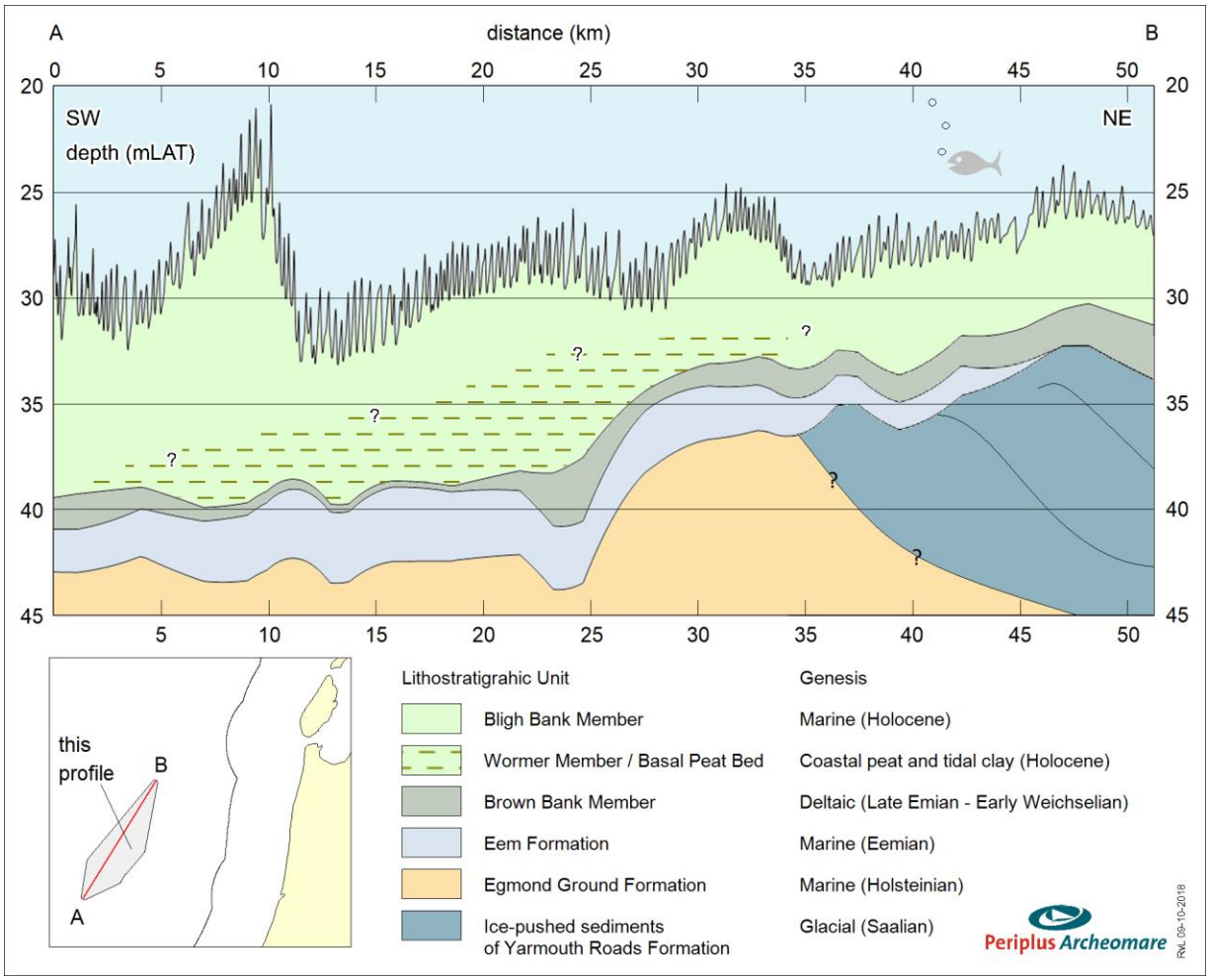


Figure 15. Geological profile (southwest-northeast)

Analogue to the Flemish Bight Map (Cameron and Laban, 1984) the ice-pushed Yarmouth Road Formations forms the top of the Pleistocene sequence on the Top Pleistocene Formations map (Laban 2003). However, grid data suggest that the Brown Bank Member and Eem Formation (Deltares 2004) are (partially) present in the area where the ice-pushed river sands of the Yarmouth Roads Formation have been mapped. As the Yarmouth Roads Formation ice push event took place before deposition of the Eem Formation, it looks like that either the Yarmouth Roads Formation is overlain by the Eem Formation and Bligh Bank Member (as shown in the profile), or that the grid data do not reflect the actual geological constellation and the Yarmouth Roads Formation is indeed the unit sub cropping below the Holocene cover, as Cameron and Laban suggested.

The question marks in figure 15 indicate that the extent of the ice-pushed deposits is not known. Possibly the unit extents to the point where the base of the Eem Formation drops from 37m to 43m LAT. The Holocene unit covering the Pleistocene sequence is mapped as Bligh Bank Member. As discussed before it cannot be excluded that Pleistocene units locally are covered by the Basal Peat Bed, Velsen Bed or Wormer Member and the Bligh Bank Member.

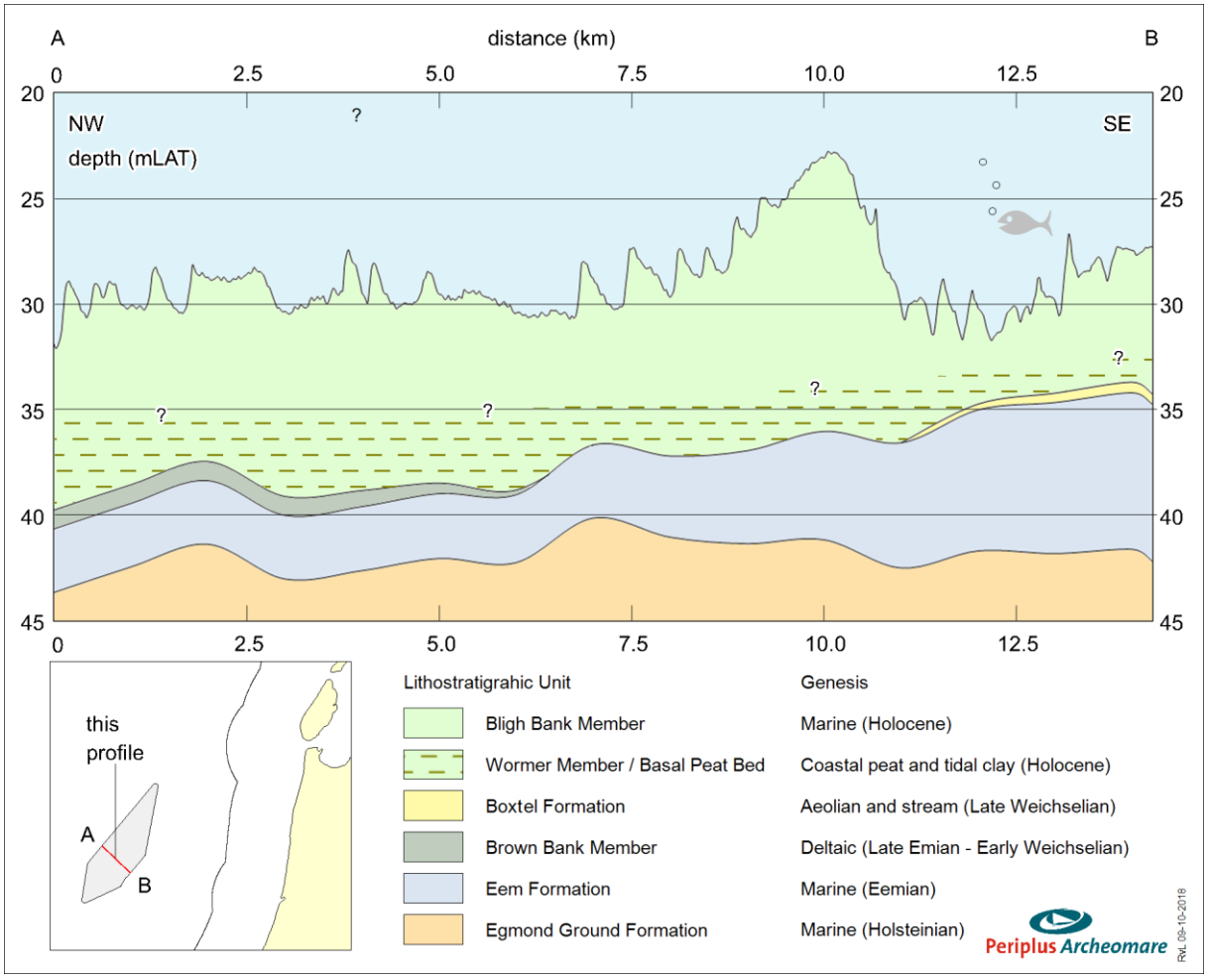


Figure 16. Geological profile (northwest-southeast)

The top of the Pleistocene landscape in meters below seabed is shown in figure 17. The elongated north – south orientated areas in which the Pleistocene units are located at more than 10m below sea bed coincide with the large sand ridges which can clearly be seen on multibeam images (see figure 4).

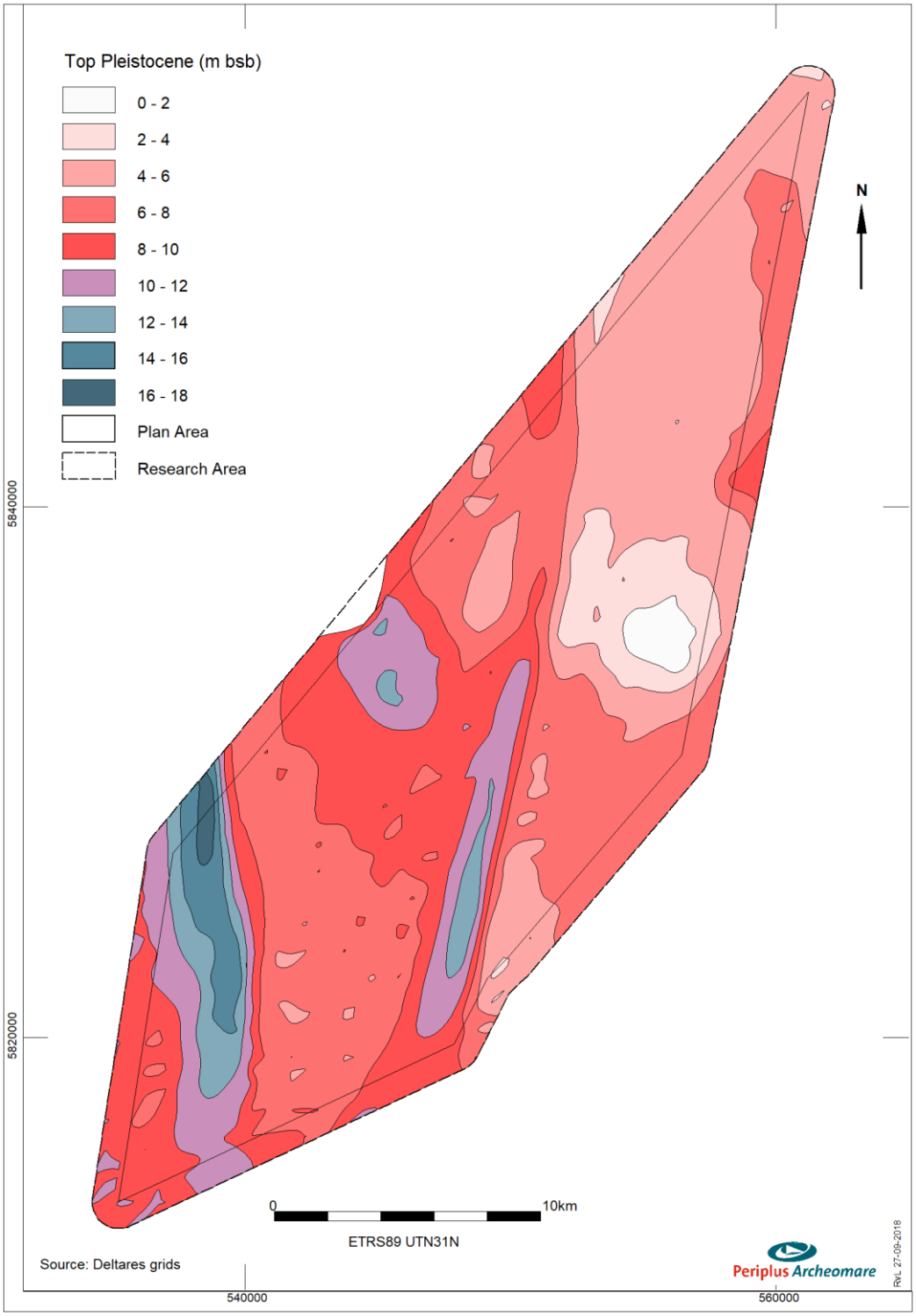


Figure 17. Top Pleistocene (m below seabed)

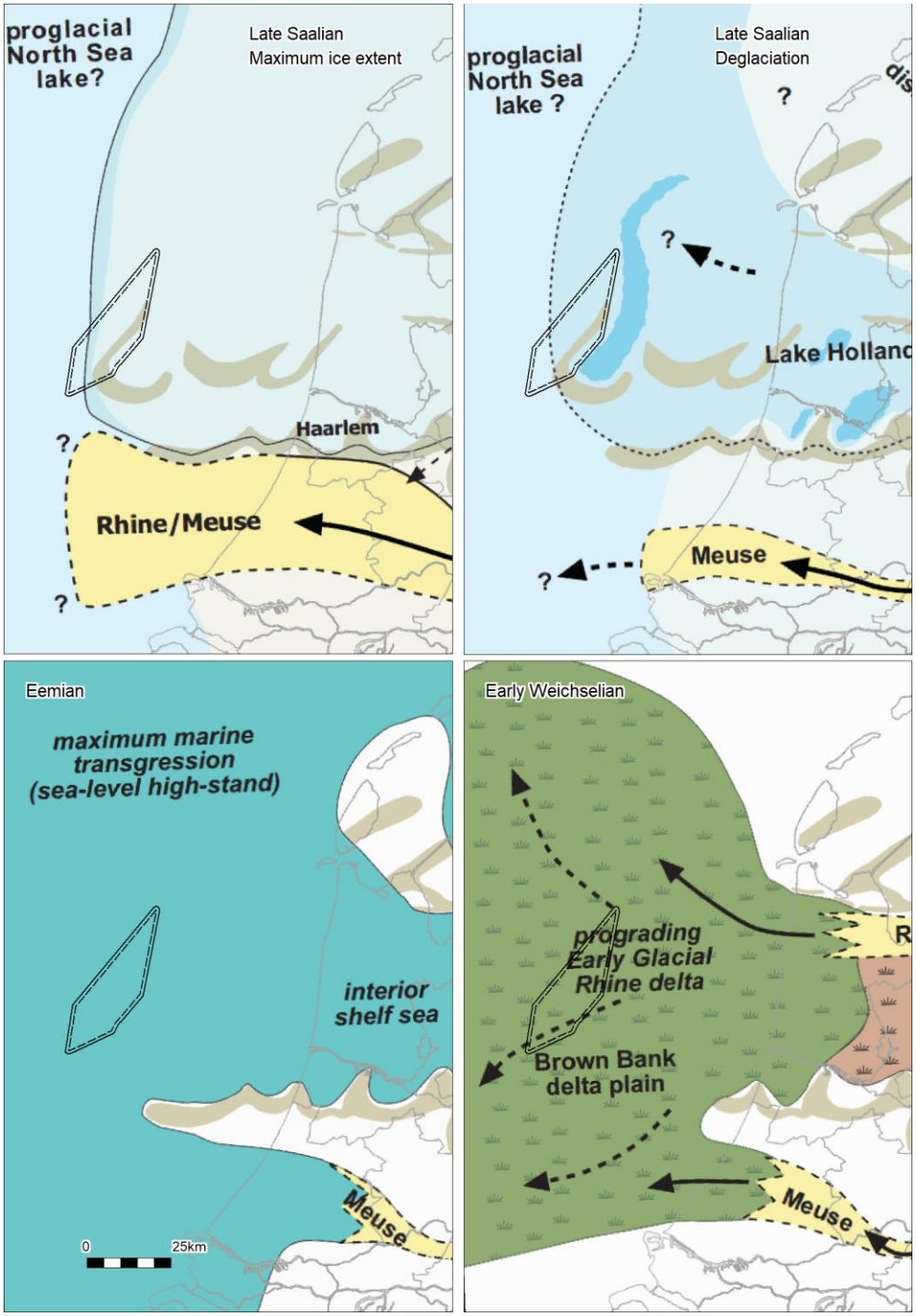


Figure 18. Palaeogeographic maps (Peeters 2015)

3.5 Description of known archaeological values (LS04wb)

The former National Service for Archaeological Heritage (ROB, now Dutch Cultural Heritage Agency or RCE) in collaboration with Rijkswaterstaat and TNO NITG have developed a comprehensive archaeological map of the continental shelf based on geological and archaeological observations[25] (see figure below).

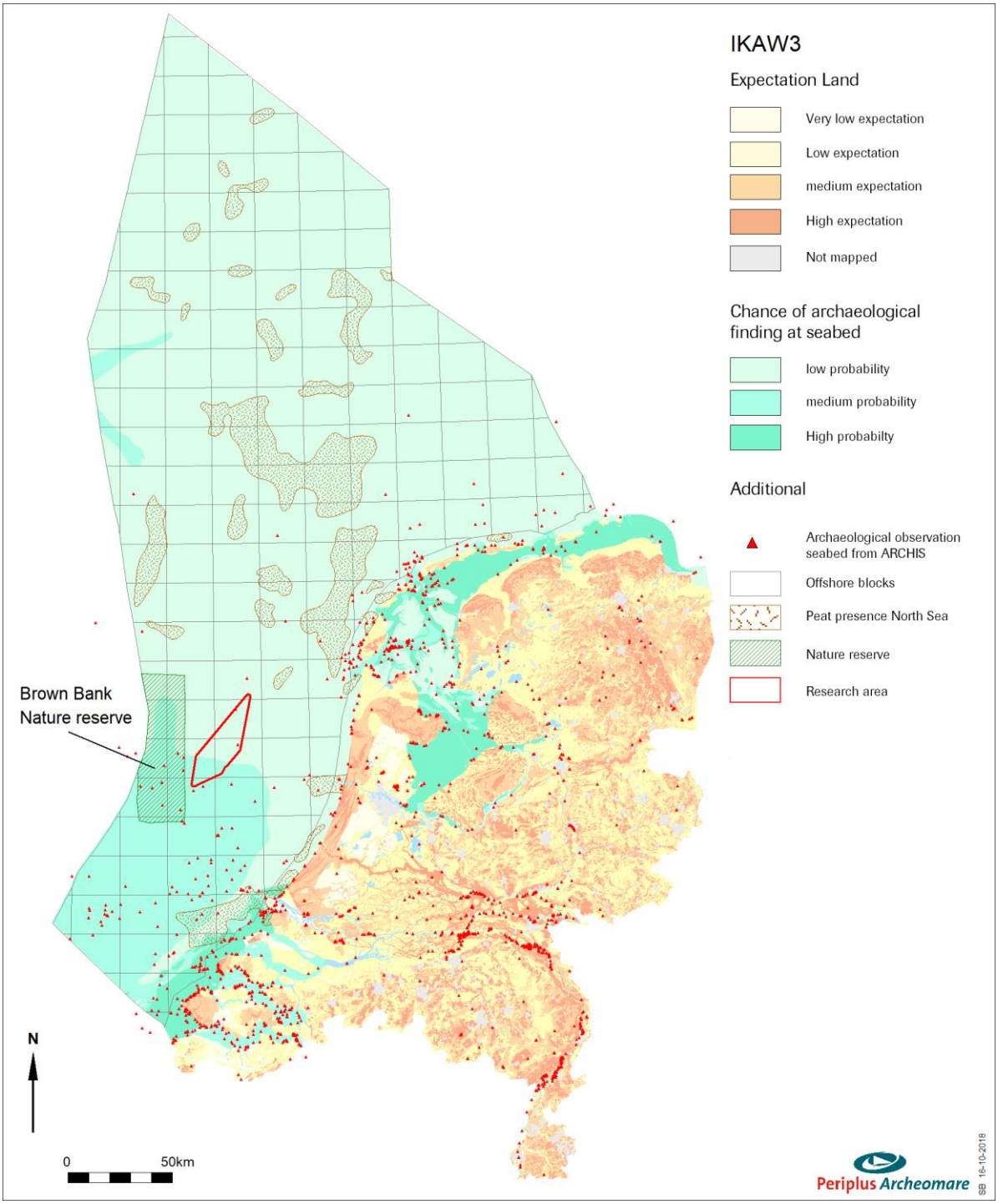


Figure 19. Overview indicative map of archaeological values (IKAW)

This global map presents the chance of presence of well-preserved shipwrecks (and often a ship's discovery of high archaeological value) for the Dutch part of the Continental Shelf. However, this map has

[25] IKAW 3e generatie, RCE 2008

a very limited use, partly due to the large scale of 1: 500,000. In addition, the degree of conservation is closely related to geology and morphology. The idea here is that in channel deposits or regions with soft sediment, a wreck quickly sinks into the seabed and therefore remains in good condition. In other areas with harder top sediments the chance of a find is not necessarily lower, but the chance to find a well-preserved ship with the cargo and equipment still intact is considerably less.

The map also indicates areas where peat and clay are preserved. This cover with clay / peat only refers to the possible location of Pleistocene deposits on / near the seabed. Where Holocene clay or peat is eroded Pleistocene layers with artefacts and fauna fossils may be present. The presence of early Holocene sediments could indicate the presence of a well preserved prehistoric landscape. West of the research area lies the nature reserve Brown Bank, a shoal known for its palaeological and prehistorical finds.

Research in the last decade has shown that the probability of encountering prehistoric residues in the North Sea is much greater than originally thought. The archaeological map for the Dutch continental shelf is therefore being revised. In 2016, an indicative model of the archaeological potential of the North Sea was published by Deltares.[26] A detail of this map is shown in figure 20 The expectancy for prehistoric remains is closely related to the lithostratigraphic units which are discussed and outlined in previous paragraphs.

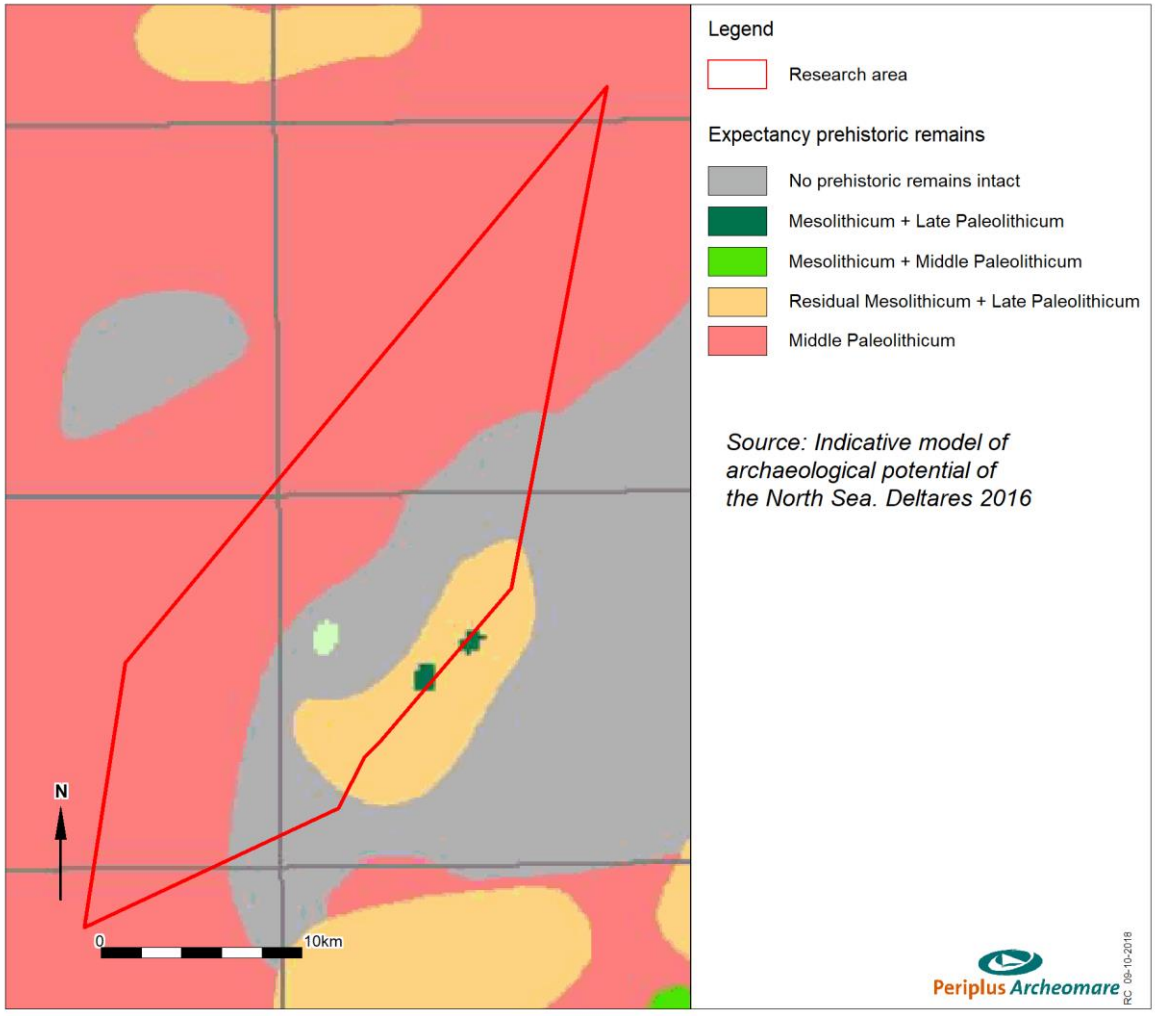


Figure 20. Expectancy of prehistoric remains

[26] Vonhögen et al, 2016.

For instance the expectancy for Middle Palaeolithic remains indicated in red coincides with the occurrence of the Brown Bank Member, the expectancy for residual Mesolithic and Late Paleolithic remains indicated in beige coincides with the occurrence of the Boxtel Formation and the expectancy for Mesolithic and Late Paleolithic remains indicated in dark green coincides with the Naaldwijk Formation (with the Velsen Bed at its base).[27] It should however be stressed that the Naaldwijk Formation is found in borehole samples and a more widespread occurrence cannot be excluded and is even considered to be probable.

It should however be stressed that figure 20 offers a two dimensional view. The occurrences of the Eem Formation and the Brown Bank Member are not limited to the area indicated in grey but extend underneath the Boxtel Formation (beige) and Velsen bed (dark green). This means that Middle Paleolithic remains are also to be expected in those areas.

Based on figure 20 it is clearly visible that there is an expectancy for prehistoric remains in 3 major areas:

a) Middle Paleolithic (*in situ)* remains in the north western half;
b) Late Palaeolithic and Mesolithic (residual) remains the south-eastern part;
c) No intact prehistoric remains in between a) and b).

It is important to bear in mind that the occurrences and boundaries of the lithostratigraphic units mapped are based on a limited amount of geological data. The occurrences and boundaries should therefore not be considered definite, but an indication of the of what is to be expected in the area and a framework for further research.

Details research area

Figure 21 shows a detailed map of the research area and the officially known archaeological finds in the surrounding area. ARCHIS III is the official database of the National Cultural Heritage Agency in which all archaeological findings and observations in the Netherlands and territorial waters are stored. The database contains more than 95,000 locations (mainly land-based) where archaeological observations have been made.

[27] Occurrence Naaldwijk Fm according to Deltares grids (2004).

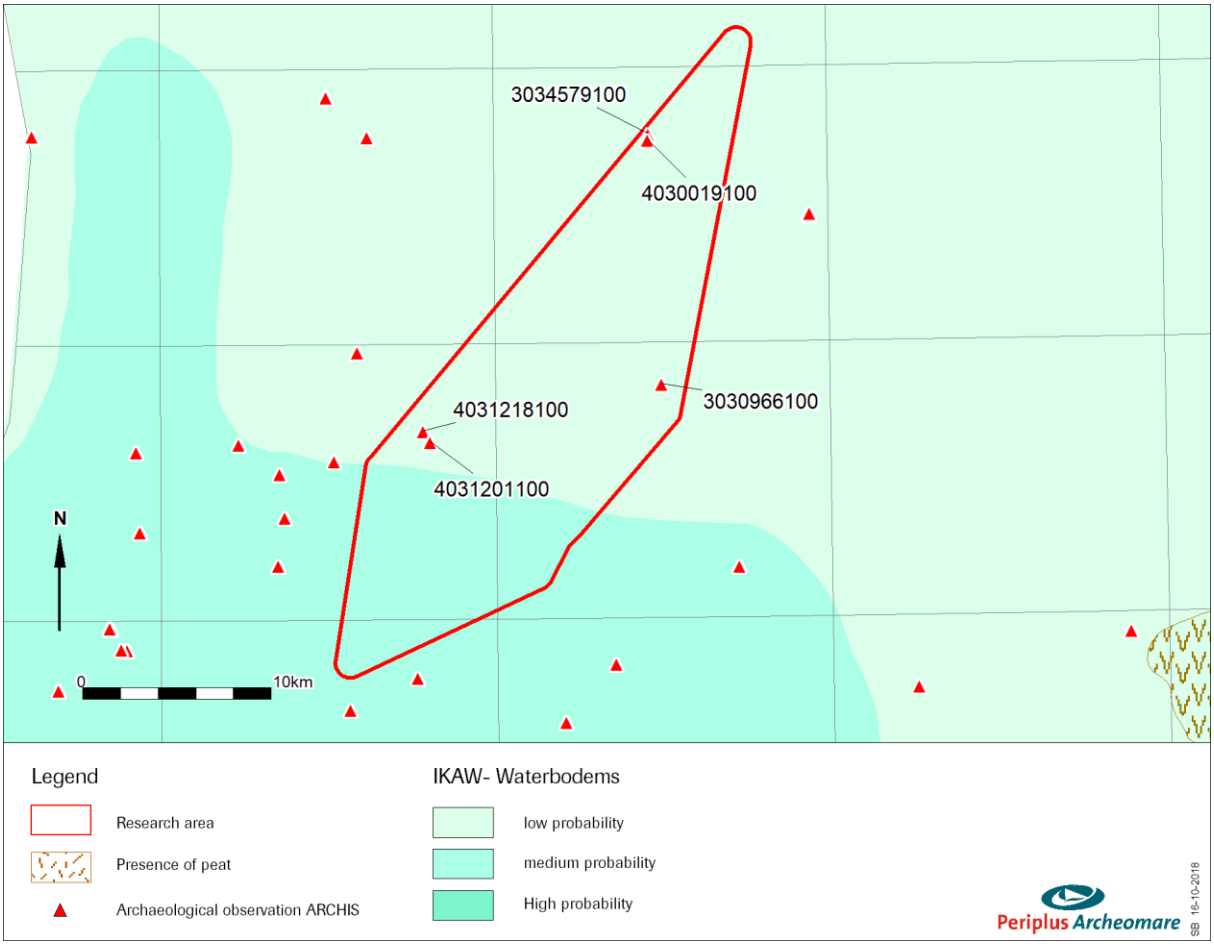


Figure 21. Detail indicative map of archaeological values (IKAW)

The following observations fall within the research area of the wind farm zone.

ARCIS case	NCN	Description
3034579100	9299	French submarine Doris, sunk may 1940
4030019100	2120	French submarine Doris, sunk may 1940
3030966100	9226	Wooden wreck remains
4031218100	2064	Shipwreck, Toponym Paaswrak II
4031201100	2056	Shipwreck, Toponym Paaswrak I

Table 7. Listing of knows archaeological observations from ARCHIS

The two observations of the submarine Doris are probably a duplicate entry. The observations will be discussed in more detail in the next paragraph on known objects and ship wrecks.

The offshore archaeological expectation is related to the geogenese of North Holland. In prehistoric times the shoreline was intermitted by a fast inlet near Bergen aan Zee.[28] Behind the shoreline Bergen tidal basin developed with coastal dunes, branching tidal channels and creeks, mud flats, tidal marshes and fens. From the hinterland the basin was fed with fresh water from the Vecht, Eem and smaller tributaries. Around 2100 BC the basin size diminished. In the Late Neolithic seasonal exploitation of levees and splay deposits took place. Pleistocene outcrops and creek ridges were exploited permanently. In the Bronze Age farmsteads arise on beach barriers and former tidal marsh and creek deposits. Numerous sites are known

[28] Zijverden 2017.

in the West Frisian area. Due to the presence of the Bergen inlet the Pleistocene deposits are relatively deep seated in the HKW windfarm zone.

Plane wrecks

During World War II, many airplanes crashed into the North Sea. Several sources are ambiguous about the number of aircraft still missing. It is at least hundreds[29]. Remains are found on a regular basis by fishermen. No finds are known around and within the research area, but remains can be expected.

Shipwrecks

In general, when a sinking ship ends up on the seabed, the tidal currents will create scouring around the wreck, and bury it down to a level of a harder surface within the sedimentary sequence. The thicker the layer of loose material, the more the ship will be packaged therein and will be retained. Especially in areas where the sediments have a high clay content the wreck remains will be sealed and well preserved. In more sandy areas this effect is much smaller. Uncovered wooden parts may be effected by a naval shipworm (*Teredo Navalis*).

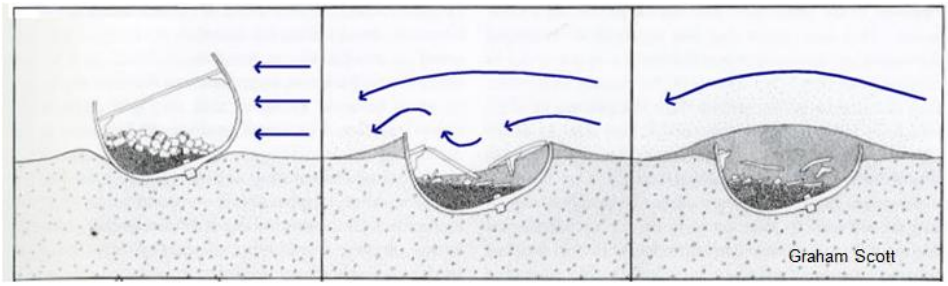


Figure 22. Example of wreck site formation (Graham Scott)

Known objects and shipwrecks

For a listing of known objects and shipwrecks within the research area, the united NCN database is consulted[30].

The National Contact Number (NCN)

The NCN database combines the data from three governmental databases:

- The Dutch Continental Shelf and Westerschelde wrecks register from The Hydrographic Service of the Royal Netherlands Navy.
- The SonarReg92 object database of Rijkswaterstaat
- The ARCHIS database (the official archaeological database of the Ministry of Cultural Heritage)

Additional information of known wrecks and background information was retrieved from various sources and online databases on the Internet like wrecksite.eu and marhisdata.nl. A total of 39 known wrecks and objects is known within the research area. The map and tables on the next pages show all known observations in the research area.

[29] Dutch Federation of Aviation Archaeology

[30] With permission of P. de Boer,Rijkswaterstaat Zee en Delta

NCN type	Known
Shipwreck remains	23
Cable	2
Anchor	1
Wellhead	10
Other (obstruction)	3
Total	**39**

Table 8. Observations of known objects

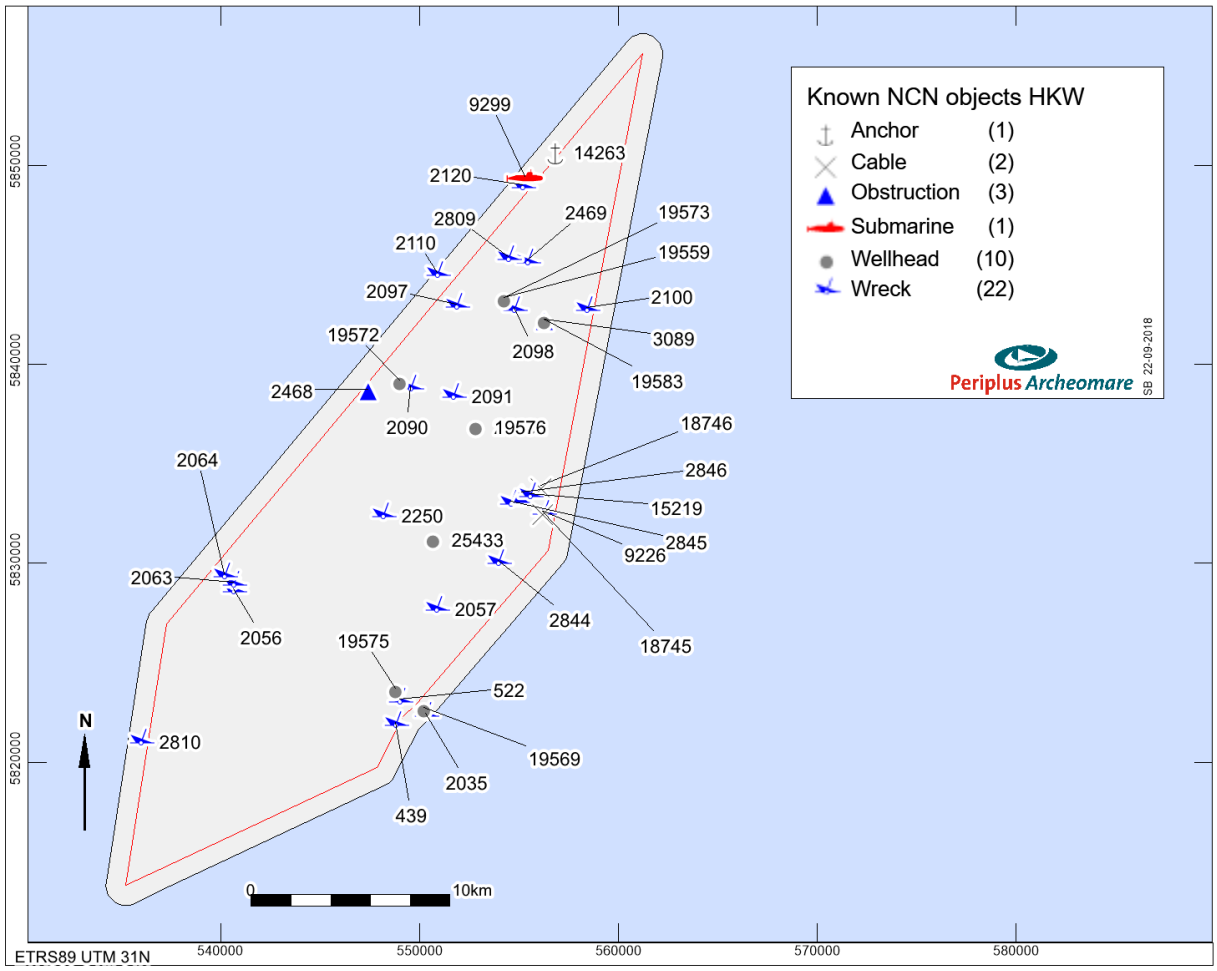


Figure 23. Overview of known objects and contacts in the research area

Ship wrecks

A (maximum) total of 23 ship wrecks is known in the area. It is possible that some of these object entries are duplicates (for example: the submarine is listed twice). This is due to differences and overlaps of the different databases.

NCN	DHY	Easting	Northing	Description	identified	Arch. value
439	3444	548806	5821993	Wreck yacht Regina, 13x3x2 meter, sunk 01-05-2008 after collision	Yes	None
522	522	549026	5823162	Wreck DHY 522. Duikteam Zeester: Wreck of coast vessel, sunk 1980, standing right up, superstructure is gone, close to platform	Yes	None
2035	2221	550310	5822477	Wreck DHY 2221. Unknown small wreck found 1959, not confirmed since	No	Unknown
2056	2247	540651	5828702	Wreck DHY 2247. Duikteam Zeester: "Paaswrak 1", close to the Brown bank. Identified as Norwegian cargo ship Biaritz from 1920, sunk 1940	Yes	Unknown
2057	2248	550864	5827791	Wreck DHY 2248. Duikteam Zeester: Wreck Dutch fishing trawler Stellendam 4, sunk 1969	Yes	None
2063	2255	540648	5829062	Wreck DHY 2255, Unknown wreck found 1970	No	Unknown
2064	2256	540173	5829482	Wreck DHY 2256. Duikteam Zeester: SS Paris, built in 1922, sunk 1939	Yes	Unknown
2090	2283	549558	5838909	Wreck DHY 2283. Unknown wreck found 1946	No	Unknown
2091	2284	551689	5838477	Distributed remains of wreck DHY 2284	No	Unknown
2097	2291	551880	5843043	Wreck DHY 2291 Unknown wreck found 1961	No	Unknown
2098	2292	554776	5842849	Wreck DHY 2292. Duikteam Zeester: so- called Boezemwrak close to platform	No	Unknown
2100	2294	558429	5842871	Wreck DHY 2294. Mast reported 1898, not confirmed since	No	Unknown
2110	2304	550906	5844640	Wreck DHY 2304. Wreck reported 1946, not confirmed since	No	Unknown
2120	2315	555194	5849035	Wreck DHY 2315. Duikteam Zeester: **Submarine** Doris	Yes	High
2250	2468	548152	5832498	Wreck DHY 2468. Unknown wreck reported 1984	No	Unknown
2469	2852	555440	5845241	Wreck debris	No	Unknown
2809	3427	554452	5845413	Wreck DHY 3427. Unknown wreck reported with sonar 1997	No	Unknown
2810	3428	535978	5821107	Distributed remains of wreck	No	Unknown
2844	3498	553958	5830158	Wreck DHY 3498	No	Unknown
2845	3499	554572	5833117	Wreck DHY 3500. Wreck debris reported 2014	No	Unknown
9226	0	556213	5832620	Wooden wreck remains, discovered in 2002. ARCHIS wng 47163	No	High
15219	0	555554	5833512	Norwegian cargo vessel Nordfrakt, sunk 25-10-1992, dimensions 76x12x2m. RWS SR 11968	Yes	None
9299	0	555298	5849442	French **submarine** Doris, sunk mei 1940, cannon salvaged in 2003. ARCHIS wng 48181 (probably duplicate entry with NCN 2120)	Yes	High

Table 9. Overview of the known ship wrecks in the research area

Six wrecks have been identified, four of them are recent wrecks and have no archaeological value. Two sites are reported as the French submarine Doris which is of historical value. NCN 9299, reported in ARCHIS is probably at the wrong location, the actual position is presented by NCN 2120.

For sixteen wreck reportings, details like names, types and date of sinking are not known, nor are the exact locations. Further research is needed to determine the cultural-historical value.

Below, a number of available images of the different wrecks are presented.

Figure 24. ROV –photograph of the yacht Regina (NCN 439), sunk in 2008 (source RWS ZD)

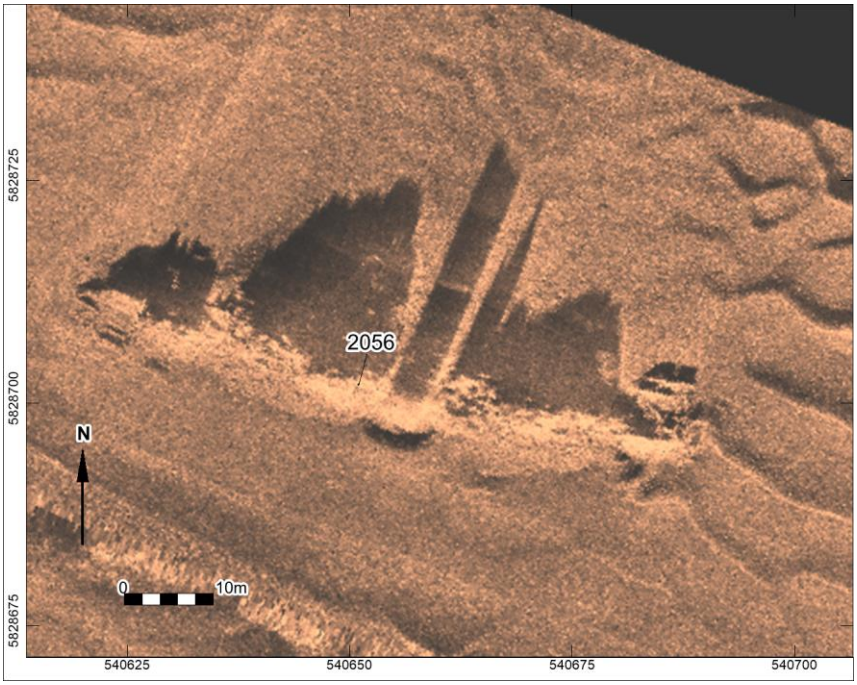


Figure 25. Side scan sonar image of NCN 2056, SS Biaritz. (source: Hydrographic Service)

NCN 2056 has been identified by the North Sea Divers as the wreck of the Biaritz. This was a passenger ship made by the Fred Olson line, built in 1922. It sunk in 1940 because it run over a sea mine or was hit by a torpedo from the German submarine U-14 (there are multiple sources that claimed that one of these caused the ship to sink). What is sure is when the ship sunk, of the 57 people on board only 21 were saved.

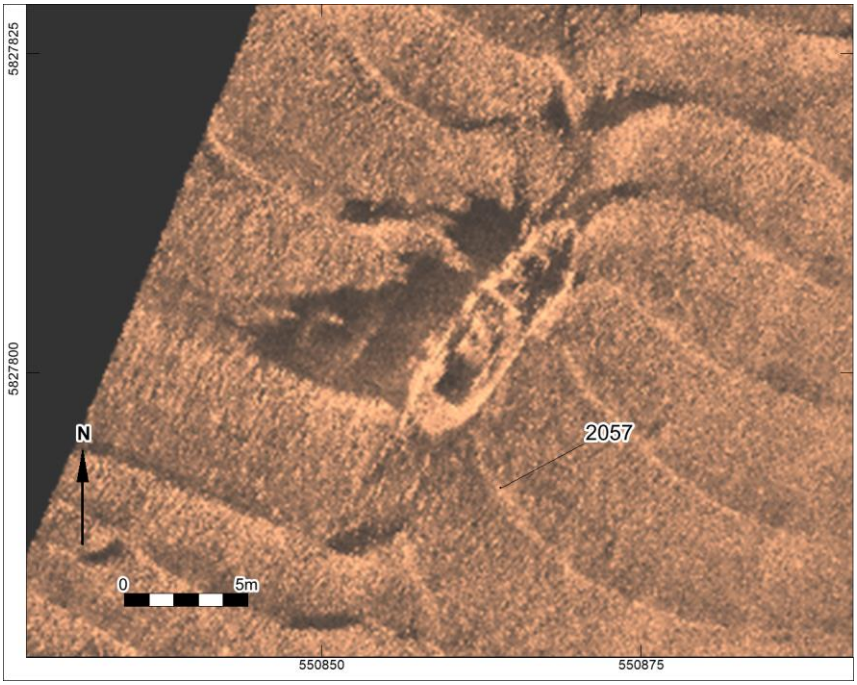


Figure 26. Side scan sonar image of NCN 2057, wreck of Dutch fishing trawler Stellendam 4, sunk 1969 (source: Hydrographic Service)

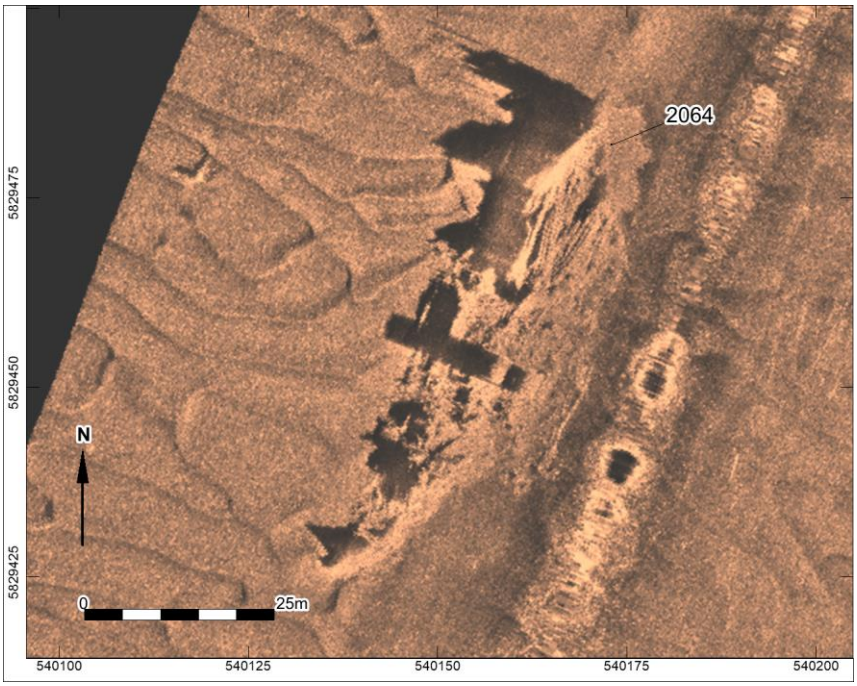


Figure 27. Side scan sonar image of NCN 2064, wreck of SS Paris (source: Hydrographic Service)

NCN 2064 has been identified by the North Sea Divers as the wreck of the SS Paris, Fred Olsen line , built in 1922, sunk in 1939 by a mine.

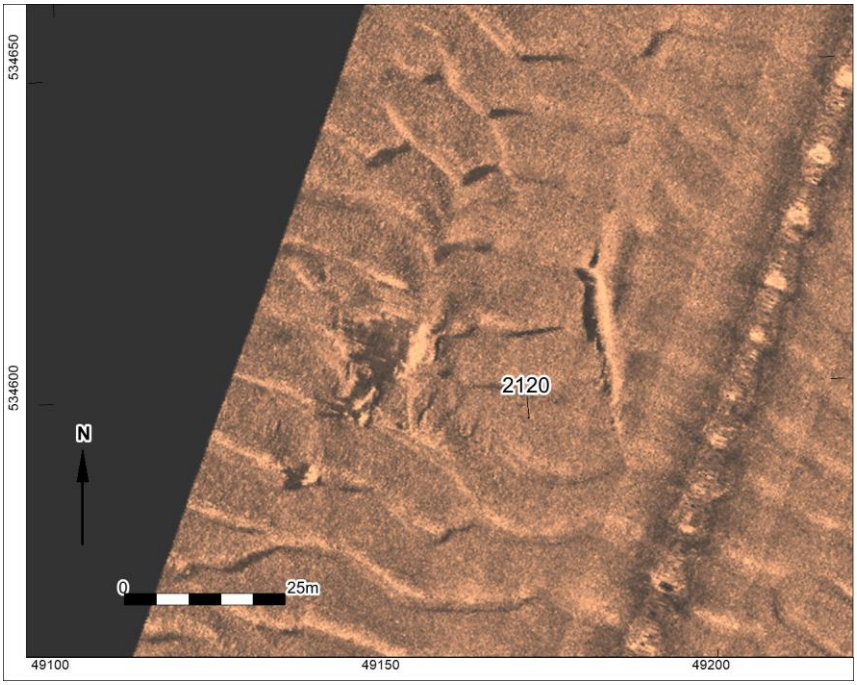


Figure 28. Side scan sonar image of NCN 2120, wreck of the submarine Doris (source: Hydrographic Service)

NCN 2120 (and probably NCN 9299) has been identified as the submarine Doris. This was a Circé-class submarine of the French Navy in in service from 1928 until the day she sunk. By the beginning of the Second World War this type of submarine was already obsolete. The submarine and her crew were part of the 10th French Submarine flotilla. The 10th was relocated to England in order to reinforce the British Royal Navy. During the crossing of the Chanel, Doris suffered damage to the gas compressor. As a result of this, the submarine was unable to dive. Despite this crippling malfunction the submarine was ordered to patrol the North Sea. On the 8th of May five British and seven French submarines, including the Doris, departed to carry out their patrol. Within 48 hours the Doris was torpedoed by the German submarine U-9, and sunk. Doris and her entire crew were lost.[31]

After being sunk, the wreck of the Doris was lost for decades, until 2003 when two Dutch sport divers discovered the ship 30 miles from the Dutch coast. A commemoration ceremony was held on the 16th of July in 2004, above the wreck of the submarine. The ceremony was organized by the French Navy and was held by vice-admiral d'Arbonneau, whose father was captain of the Doris.[32]

[31] https://www.uboat.net/articles/index.html?article=58

[32] https://www.digibron.nl/search/detail/012dc68d44e9816b8b1bb871/herdenking-ondergang-franse-onderzeeer

Figure 29. Photograph of the Doris (source: wrecksite.eu)

NCN 15219 has been identified as the wreck of the Nordfrakt, build in 1973. While on its voyage from Szczecin (Poland) to the Belgium port of Antwerp, the ship encountered bad weather. Due to the heavy seas and a displacement of the cargo the ship sunk on the 25th of October in 1992. Its six crew members were saved by helicopter. Salvage operations to pump out the cargo, lead concentrate, from the wreck began in January 1993 and in March of that year, salvers started to cut up the wreck and remove it in pieces.[33] The ship has no archaeological value. It is unclear, however, how much of the ship is left on the seafloor. Wreck debris is reported in the direct vicinity of the original wreckage location. This debris may still form a possible obstruction.

[33] http://wwz.cedre.fr/en/Resources/Spills/Spills/Nordfrakt

Other known objects

Next to the 23 ship wreck reportings, sixteen other objects have been reported in the area, which are listed below.

NCN	Nlhono	Type	R95	Easting	Northing	Description
2468	2849	Obstruction	10	547407	5838757	Foul ground
2846	3500	Obstruction	5	555128	5833583	Manmade object.
3089	-	Obstruction	5	556255	5842276	Manmade object, probably wellhead. RWS SR 1016
14263	-	Anchor	5	556822	5850739	Anchor and chain, length 82 m. RWS Sr 11072
25432	100543	Wellhead	5	552819	5836933	Wellhead P06-S-01
25433	100650	Wellhead	5	550669	5831259	Wellhead P09-07
25434	100875	Wellhead	5	552838	5836933	Wellhead P06-10
18745	-	Cable	5	556203	5832620	Piece of cable. RWS SR 1042, survey 2002
18746	-	Cable	5	556113	5833907	Piece of cable. RWS SR 1043, survey 2002
19559	100403	Wellhead	5	554262	5843360	Wellhead P06-03
19569	100507	Wellhead	5	550241	5822755	Wellhead P09-HORIZON-A-08-SIDETRACK1
19572	100761	Wellhead	5	549013	5839202	Wellhead P06-D-01
19573	100534	Wellhead	5	554269	5843354	Wellhead P06-B-04, same location as NCN 19559
19575	100417	Wellhead	5	548797	5823713	Wellhead P09-02
19576	100617	Wellhead	5	552845	5836956	Wellhead P06-S-01, same location as NCN 25432
19583	100409	Wellhead	5	556266	5842284	Possible Wellhead P06-01

Table 10. Listing of other known objects in the area

Figure 30. ROV images of NCN 3089, a possible wellhead (source RWS ZD)

None of the objects has an archaeological value, but they can form obstructions.

A complete list of all 39 known wrecks and objects with descriptions within the research area is enclosed in appendix 3.

3.6 Specified archaeological expectancy (LS05wb)

Shipwrecks

The area has a high expectation for shipwrecks from all periods. A (maximum) total of 23 shipwrecks is known in the area. Six ship wrecks and a submarine have been identified. Four of the ship wrecks are recent and have no archaeological value, two ship wrecks and the submarine do. For the other sixteen wreck reportings, details like names, types and date of sinking are not known, nor are the exact locations. Further research is needed to determine the cultural-historical value of the wrecks and assess whether undiscovered shipwrecks are present.

Plane wrecks

The area has a high expectation for plane wrecks from the Second World War. Several sources are ambiguous about the number of aircraft still missing. It is at least hundreds[34].

Prehistory

During the last ice ages the research area was exposed due to very low sea levels. In those times the landscape was occupied by hunters and gatherers. Therefore archaeological remains are to be expected in the top of Pleistocene formations. The archaeological expectancy is discussed below by means of the geogenese of the area and lithostratigraphic units present. As discussed in the section on ship wrecks, also for the Pleistocene landscape applies that our specific knowledge is limited, because major part of the area has not been investigated by detailed geophysical surveys or the analysis of high quality borehole samples.

Formation	Member / Bed	Lithology	Age	Arch. Expectancy*	Period
Southern Bight	Bligh bank	sand	Holocene	I, IV	Historical periods
Naaldwijk	Wormer	clay and sand		I	
	Velsen	humic clay	Early Holocene	II	Mesolithic
Nieuwkoop	Basal Peat	peat		II	
Boxtel	Singraven	sand, loam, clay and peat	Weichselian and Early Holocene	II and III	Late Paleolithic and Mesolithic
	Wierden	fine sand		III	
Woudenberg		peat	Eemian and Early Weichselian	II	Middle Paleolithic
Eem	Brown Bank	humic clay and silt	Eemian and Early Weichselian	II and III	Middle Paleolithic
		sand and clay	Eemian	IV	
Yarmouth Roads (ice-pushed)		sand and clay	Pre-Saalian and Saalian (ice-push event)	II, III and IV	Early Paleolithic to Mesolithic
Drente	Uitdam	sand, silt and clay	Saalian	II and III	Middle Paleolithic
	Schaarsbergen	sand		II	
	Gieten	gravelly clay, loam, and sand with cobbles and boulders		III	

Table 11. Classification of archaeological expectancy

[34] Dutch Federation of Aviation Archaeology

*

Archaeological Expectancy	
I	Ship wrecks and shipping related objects; air planes from World War I and II
II	Lost or dumped objects including flint and bone hunting gear, fish weir, fish traps and dugout boats
III	Camp sites and inhumations
IV	Artefacts in reworked context

Archaeological levels are contained in the stacked sequence of Pleistocene and Holocene units. The relationship between the archaeological levels and the lithostratigraphic units is summarized in the table 11.

Moraine, melt water lakes and outwash plains (Late Saalian)

The presence of the Drente Formation is not certain. If this unit is present remains of Neanderthal sites can be expected. Of special interest are gradients within the prehistoric landscape such as moraine hills, shores of lakes and river sides, which might have been used for the installation of camp sites.

Ice-pushed ridges (Late Saalian)

Ice-pushed ridges constitute profound morphological phenomena in the prehistoric landscape. The ice-pushed ridge in the northern part of the research area dates back to the Late Saalian. Onshore numerous prehistoric settlements have been found in the context of ice-pushed ridges. Therefore archaeological remains from the Middle Paleolithic (Neanderthal sites), Late Paleolithic and Mesolithic are to be expected in the top of ice-pushed deposits. Within the sequence of ice-pushed (pre)Saalian river deposits Early and Middle Paleolithic flint artefacts can occur. Quarries in the onshore ice-pushed ridge of the Utrechtse Heuvelrug revealed artefacts of early hominids which are over 150,000 years old.[35]

The ice-pushed ridge in the northern part of the research area is covered by younger sediments. However, the lateral and vertical distribution of those younger sediments is uncertain. The cover can therefore solely consist of the Bligh Bank Member, but can also consist of all, or part of the units post-dating the Saalian epoch. Those units include the Eem Formation, the Brown Bank Member, the Woudenberg Formation, the Boxtel Formation, the Basal peat Bed and the Naaldwijk Formation.

The top of the unit mapped by Cameron and Laban in the northern part of the research area is located at -31m to -35m LAT; 4 to 6m below the seabed. South of this area a Pleistocene high is observed. The top this high is located at -27m LAT; <1m below seabed. Here the Eem Formation is mapped. It cannot be excluded that this Pleistocene high in fact is part of the ice-pushed ridge. A clear indication that the ridge extent further south is provided by palaeogeographic maps.[36] The north-west flank of the ice-pushed ridge mapped by Peeters runs parallel to the south-eastern border of the HKW WFZ.

Open sea (Eemian)

The Eem Formation consists predominantly of marine sand deposited in the Eem Sea during the Eemian interglacial (warm) period.[37] Within the sandy marine deposits no archaeological remains are expected.

The top of the Eem Formation is expected at depths varying from 27m to 37m LAT and less than 1m to more than 10m below the seabed.

[35] Rhenen Industry.

[36] Peeters 2015.

[37] Eemien: interglacial which lasted from 130,000 till 115,000 years ago.

Lagoons, lakes and fens (Eemian to Early Weichselian)

The Brown Bank Member at the top of the Eem Formation consists of lacustrine fresh water and coastal marine brackish water deposits of silty clay. At the end of the Eemien the sea regressed and the Brown Bank clays were deposited. This layer can contain Middle Palaeolithic artefacts from, or remains of Neanderthal who in this period populated the Netherlands and the North Sea area. Little archaeological research has been done into this often deep-seated stratigraphical unit. Camp sites are expected to be intact and well preserved, especially when the remains are contained in a clayey context and covered by peat of the Woudenberg Formation and/or cover sands of the Wierden Member (Boxtel Formation). The Woudenberg Formation can contain dumps from close-by camps, lost hunting gear and intended depositions. The available geological information does not suffice to assess whether the Late Eemian to Early Weichselian facies of sandy lagoonal beaches and/or clayey shores of lakes and fens is present.

The top of the Bligh Bank Member is expected at depths varying from 30m to 40m LAT and 3m to 16m below the seabed.

Cover sand landscape (Late Weichselian and Early Holocene)

The camp sites of Late Paleolithic and Mesolithic hunters and gatherers are found in a cover sand landscape with ridges and dunes and valleys formed by small streams. Stream valleys offered fresh water, a large variety of plant species and ample opportunities for hunting. Camps were installed along the borders of those valleys. The remains of sites can be encountered in the context of sandy, loamy, clayey or peaty beak deposits of the Singraven Member. The lithological context of settlements found at the dunes and ridges comprises well sorted non-calcareous fine cover sand of the Wierden Member. Both Singraven and Wierden Member are part of the Boxtel Formation.

Late Paleolithic and Mesolithic remains are expected at two distinct levels within the cover sand sequence. The first is a paleosol found in between two cover sand layers Late Paleolithic remains of camp sites of reindeer hunters are to be expected. The paleosol is a charcoal rich layer called the Usselo Bed, which has been formed during the Bølling and Allerød interstadials. The second level is the top of the cover sand sequence. The sandy dunes and ridges often display a well-developed podzol, if not eroded. Due to the low carbonate content presence of oxygen in the pores of the sand the preservation conditions for organic remains (wood, bone, etcetera) is a priori not so good in cover sands. The preservation of organic remains is therefore highly dependent on the timing of the water table rising above the archaeological level.
If the Boxtel Formation is covered by the Basal Peat Bed or the Velsen Bed the integrity and conservation of archaeological remains is expected to be high. Considering our limited knowledge of prehistoric sites in the North Sea area such well-preserved finds would *a priori* be worth preserving. Archaeological markers consist of flint and bone artefacts, burnt nuts and seeds and charcoal. Zones of interest are locations where the top of the cover sands and river dunes (if present) are not eroded. The presence of the Basal Peat Bed and Velsen Bed indicate that underlying Boxtel Formation and possible archaeological remains herein could be intact.

Peat and humic clays

The Basal Peat Bed and Velsen Bed themselves can also contain archaeological remains. These remains include dumped waste from nearby camp sites, lost hunting gear or intentional (e.g. ritual) depositions. Due to the low levels of oxygen and wet conditions both organic and anorganic remains might be very well preserved.

Site characteristics

The expected camp sites of hunters and gatherers are generally small (a few sq. m), although larger settlements (up to approximately 2,000 sq. m) can occur in case the site repeatedly or for prolonged period of time was occupied. Sites are characterized by the presence of concentrations of charcoal, flint artefacts, bone remains, burnt seeds and nuts, natural stones and artefacts of bone or horn. Inhumations can occur. The density of finds (debris of flint processing) can vary from low to high.

Physical Quality

It is not known to what extent erosion has affected the integrity of the Pleistocene landscape and embedded remains of prehistoric settlements. The presence of the Basal Peat Bed and/or Velsen Bed provides an indication for an intact Pleistocene landscape, although it should be noted that erosion could have taken place prior to the deposition of peat and clay, leading to degradation or even annihilation of prehistoric remains. The ice-pushed ridges experienced even two full-marine periods which could have led to erosion: the Eemian and Holocene. If the *in situ* prehistoric remains did not suffer from erosion, the very rapid Early Holocene 'drowning' of the Pleistocene landscape and local deposition of a peat and/or clay cover offered perfect conditions for the conservation of both organic and inorganic remains. In this situation well-preserved sites of high physical quality can occur.

Occurrence and special distribution

The occurrence and spacial distribution of the Late Saalian ice pushed-ridges, Early Weichselian lagoons, lakes and fens and the Late Weichselian wind-blown dunes and stream valleys in the research area is not known. Surely the available geological maps of the Flemish Bight Map (1984), the Top Pleistocene Formation map and Deltares' grid data (2004) and palaeogeographic maps (2015) provide an indication, but the actual situation can only be established through subbottom profiling in combination with borehole sample analysis. The depth below the seabed of the Pleistocene landscape ranges from less than 1m in the central north-eastern part of the research are to nearly 16m locally in the southwestern part.

4 Synthesis

Based on the results of the data analysis the research questions are answered.

- *Are there any known archaeological values present within the research area? If so, what is the nature, extent (depth), location and dating of these sites?*
  A (maxium) total of 23 ship wreck locations are reported in the NCN database. Four recent ship wrecks are not considered to be of archaeological value. Three wrecks (including a WWII submarine) are likely to be of high archaeological/historical value. The actual archaeological value however, can only be established by an archaeological investigation performed in accordance with the Dutch Quality Standard by a BRL4000 certified company, which – for these three wrecks – is not the case. The archaeological value of the remaining 16 wrecks is unknown.
- *Are there, in addition to any known values, archaeological remains to be expected? If so, what is the nature, extent (depth) location and date of the expected archaeological remains?*
  The area may contain more undiscovered shipwrecks, remains of shipwrecks or remains of airplanes from the Second World War. Apart from wrecks archaeological remains of Paleolithic and Mesolithic camp sites of hunters and gatherers can be encountered. These sites are characterized by the presence of flint and bone artefacts, burnt nuts and seeds, charcoal and hunting gear.
- *Can the proposed activities in the wind farm zone affect known or expected archaeological values? If so, can an impact on archaeological assets be prevented or restricted by planning adaptation?*
  This question can only be answered once the area has been geophysically investigated and when the cultural historic value of the objects in the area has been determined.

  If the archaeological values cannot be saved:

  - *What kind of further research is needed to determine the presence of archaeological values and their size, location, type and dating to be determined enough to come to a selection decision?*
    Further research is to be performed within the framework of the standardized sequence of phases of maritime archaeological research as defined in the Dutch archaeological management procedure (Dutch: 'AMZ Cycle'). The research strategy is further determined by the type of archaeological remains which, based on the archaeological expectancy outlined in section 3.6 of this report, are to be expected. In summary the expectancy is two-fold comprising plane and ship wrecks on one hand and prehistoric remains on the other. The first phase after the archaeological desk study is an exploratory field research. This field research comprises a geophysical survey. The methods employed include multibeam echo sounder, side scan sonar and magnetometer to trace and map wrecks and shipping related objects. A subbottom profiler is used to assess the potential for prehistoric remains by mapping the top of the buried Pleistocene landscape, identify seismostratigraphic units and correlate those units with the expected lithostratigraphic units (and potential archaeological remains herein), and determine the locations at which archaeological levels have been affected by erosion.
  - *What are the possible effects of the installation of offshore wind farms on the areas with specific archaeological interest?*
    Archaeological values can be affected by human activities which result in a disturbance of the seabed. Direct disturbances are caused by cable-lay-trenching operations and the installation of wind turbines. Scouring adjacent to the foundations of the wind turbines is considered to be an indirect disturbance which might lead to the exposure of wrecks and erosion of the prehistoric landscape.

- *What are the possibilities to mitigate the disturbance of areas with specific archaeological interest as a result of installing offshore wind farms?*
  In general, a buffer or safety zone of 100 meters around an archaeological object or an object with an archaeological expectation is to be defined in which seabed disturbing activities are not allowed.[38] If additional research shows that the object has no archaeological value, the location and the buffer zone can be omitted. The identification and mapping of camp sites from the Paleolithic and Mesolithic is, due to their limited size and depth of burial, in practice troublesome. Mitigating measures to preserve those sites can therefore only be effected by excluding areas which are considered to have a high probability for containing those sites.

- *Should further investigations be carried out from archaeological point of view and what are the recommendations on the scope and specifications of these investigations?*
  Additional research in the form of a geophysical survey is standard in the process of archaeological investigations. (in Dutch: *Inventariserend veldonderzoek opwaterfase*). The scope and specifications for this geophysical survey are to be recorded in a mandatory Program of Requirements (PvE). Typical requirements include restrictions about the maximum range and minimum frequency of the side scan sonar, survey speed and line spacing.

- *What are the requirements for any activity carried out in the wind farm area (investigations or monitoring activities, installation activities, operational activities) that could have an effect on archaeological aspects in the wind farm area?*
  In general, a buffer or safety zone of 100 meters around an archaeological object is to be defined in which no activities such as trenching or anchoring are allowed. This applies only for objects with an archaeological expectation. If additional research shows that the object has no archaeological value, the location and the buffer zone can be omitted, and the objects may be removed during a debris clearance campaign. Additional prospection will provide further insight in the lateral and vertical distribution of geological units and the archaeological levels contained herein, thus offering the information needed to assess whether prehistoric remains will be affected by the planned activities and whether mitigating measures can to be taken.

  What is the expectation of the physical quality of possible archaeological sites and objects?
  The physical quality of wreck sites is expected to be high in case these wrecks are covered with sediments. If wooden ship wrecks are exposed at the seafloor biological deterioration by the naval shipworm could result in a lowering of the level of preservation. Moreover these wrecks are subject to demolishment by anchors and fishing nets which will result in a lowered integrity of the wreck site.

  In situ prehistoric remains are expected to be buried under a cover of Holocene deposits. Because the archaeological levels are not exposed at the seabed, remains will not be affected by fishing nets, anchoring and shipworm. It is not known to what extent erosion has affected the integrity of the Pleistocene landscape and embedded remains of prehistoric settlements. The presence of the Basal Peat Bed and/or Velsen Bed provides an indication for an intact Pleistocene landscape, but erosion could have taken place prior to the deposition of peat and clay, leading to degradation or even annihilation of prehistoric remains. The ice-pushed ridge experienced even two full-marine periods which could have led to erosion: the Eemian and Holocene. If the *in situ* prehistoric remains did not

[38] Beleidsregels ontgrondingen in Rijkswateren, see http://wetten.overheid.nl/BWBR0028498/

suffer from erosion, the very rapid Early Holocene 'drowning' of the Pleistocene landscape and local deposition of a peat and/or clay cover offered perfect conditions for the conservation of both organic and inorganic remains. In this situation well-preserved sites of high physical quality can occur.

- *Which lithostratigraphic units can be determined and what is their spatial distribution (both horizontal and vertical)?*
  The following units have been determined:

Unit	**Top** in m below sea bed	**Occurrence**	**Environment**	**Remark**
Southern Bight Fm - Bligh Bank Mb	0	Total area	Open marine	Mobile layer exposed at seabed Medium to poorly sorted, fine to coarse sand, carbonate and shell-rich, sparse clay and silt laminae, locally with gravel
Naaldwijk Fm - Wormer Mb - Velsen Bed	< 16	Uncertain	Tidal Brackish	Laminated very fine sand and clay with detritus and shell fragments; Brackish water humic stiff clay with juvenile shells
Nieuwkoop Fm - Basal Peat Bed	< 16	Uncertain	Coast	Peat
Boxtel Fm - Singraven Mb - Wierden Mb	3 - 12	Southeast	Beak and Wind-blown	Loam, clay, fine to coarse sand and peat; Very fine well sorted non-calcareous cover sands
Woudenberg Fm	< 16	Uncertain	Lake and Fen	Peat
Eem Fm - Brown Bank Mb	3 - 16	North, West and South	Lagoonal and Lake	Laminated fine sand, silt and clay; humic with plant remains
Eem Fm	1 - 17	Total area	Open marine	Fine to medium shell-bearing sand
Ice pushed ridge	0 - 8 ?	North and possibly Southeast	Glacial	Fine to coarse river sand of Yarmouth Roads Formation
Drente Fm - Gieten Mb - Uitdam Mb	?	Uncertain	Glacial and Lake	Moraine: very poorly sorted boulder clay and boulder sand (Gieten); laminated fine sand, silt and clay, varves (Uitdam)

Table 12. Sequence of lithostratigraphic units in the research area

- *What are the archaeological levels within the lithostratigraphic sequence?*
  The table below presents the specified expectation

Formation	**Member / Bed**	**Archaeological remains**	**From**	**In situ**
Southern Bight	Bligh Bank	reworked flint and bone artefacts	LPALEO - NEO	no
Naaldwijk	Velsen	lost objects, dumps	LPALEO- MESO	yes
Nieuwkoop	Basal Peat	lost objects, dumps	LPALEO- MESO	yes
Boxtel Fm	Singraven	camps sites and inhumations; lost and dumped objects	LPALEO- MESO	yes
	Wierden	camps sites and inhumations; lost and dumped objects	LPALEO- MESO	
Woudenberg		lost objects, dumps	MPALEO	yes

Formation	Member / Bed	Archaeological remains	From	In situ
Eem	Brown Bank	camps sites Neanderthal; flint artefacts	MPALEO	yes
		reworked flint and bone artefacts	MPALEO	no
Ice pushed ridge	Top unit	camps sites and inhumations; lost and dumped objects	MPALEO - MESO	yes
	Within unit	Reworked flint artefacts	LPALEO - MPALEO	no
Drente	Gieten	camps sites Neanderthal; flint artefacts	MPALEO	yes
	Uitdam	camps sites Neanderthal; flint artefacts	MPALEO	yes

Table 13. Archaeological levels within the lithostratigraphic units

- *Is it possible to define zones for windfarms where the (buried) prehistoric landscape is eroded or intact? Are the expected lithostratigraphic boundaries erosive or non-erosive?*
  No, the data available do not contain information from which can be deduced if the (buried) prehistoric landscape is intact. Well preserved valuable sites however are to be expected in areas where the prehistoric landscape is covered by sediments deposited in an environment where erosion is limited, such as peat of the Woudenberg Formation and Basal Peat Bed and humic clays of the Velsen Bed. A subbottom profiling survey could supply (part of) the information needed to map the occurrence of the above-mentioned units and provide with information on the zones where the prehistoric landscape is expected to be intact.

- *If so, will these zones be affected by the work envisaged?*
  Archaeological levels found at shallow depths could be affected by trenching activities in the course of cable lay operations, but also anchoring. Deeper lying archaeological levels can be affected by the installation of foundations for the wind turbines such as monopoles. After installation scouring in the vicinity of those foundations might affect archaeological levels.

  Based on the subbottom profiling data a geological framework will provide an insight in the stacked sequence of submerged Pleistocene landscapes. The outcome of this geological investigation is used to refine the model for the expected archaeological remains (wrecks of ships and planes and prehistoric camp sites) in the area.

- *Could human activities have led to a disturbance of the seabed and archaeological remains therein?*
  Yes. In the past, several cables and pipelined were trenched in the area, and boreholes drilled to explore and produce hydrocarbons present in deep-seated geological strata. Furthermore, fishing activities using trawls may have damaged archaeological remains at the seabed surface.

- *What is the expected intrinsic quality in terms of rarity, research potential, group value and representativeness of the areas with specific archaeological interest?*
  With respect to the planes and ship wrecks this question can only be answered when the characteristics (type, size, age, inventory, load, etc.) and archaeological value of the objects in the area have been determined. In the process of valuation of archaeological sites the physical quality in terms of integrity and preservation of those sites shall be assessed first (see answer to question below). At this stage three wrecks with a presumed high archaeological value are present, although to date no formal valuation of the sites has not been carried out. A further 16 wrecks with an unknown

archaeological value are present in the area. Additional research is required to obtain additional information on these wreck site and map undiscovered plane wrecks and maritime objects.

The intrinsic quality of prehistoric remains is *a priori* high, because:

- prehistoric finds (especially *in situ* finds) are extremely rare in the North Sea area (hence: high score on 'Rarity');
- little is known of the humans that occupied the North Sea area in prehistoric times, which means that almost any find is likely to contribute in filling the gaps in our knowledge (hence: high score on 'Information value');
- Paleolithic and Mesolithic sites onshore often are found in rural areas where archaeological levels are exposed. Artefacts are contained in the ploughed top layer and located above groundwater level. Because of this the physical quality and the context of the site within the landscape is often affected; such contrary to the North Sea area where remains of high physical quality can be contained within a continues sequence of stacked landscapes (hence: high 'Context value').

According to the Dutch archaeological management procedure (Dutch: 'AMZ Cycle') subsequent steps shall be taken assess the occurrence and value of archaeological in the area. A description and flow chart of the AMZ Cycle is included as Appendix 1. The first step, an archaeological desk study, has been carried out. The next step is an exploratory field research. For the Hollandse Kust West area it is advised to carry out a geophysical survey by means of side scan sonar, multibeam echo sounder, subbottom profiler and magnetometer and a geotechnical works including borehole sampling and cone penetration testing.

- *What is the expected physical quality in terms of integrity and preservation of the areas with specific archaeological interest?*
  The physical quality of prehistoric settlements in the North Sea area is to a large extent dependent on the integrity of archaeological levels. The chance that these levels have deteriorated due to erosion or human activities is considerable. On the other hand archaeological remains are expected to be well-preserved under water. Therefore if the archaeological levels have not been altered by natural or human causes, prehistoric settlements of high physical quality are to be expected.

  The porous non-calcareous wind-blown covers sand of the Wierden Member do not provide optimum conditions for the preservation of organic materials. Onshore the remains of a person buried in prehistoric times in cover sand have often vanished completely overtime, leaving little more than a dark shadow amid the yellow sand. Remains can be well-preserved (even organic remains) if the site submerged below the ground-water level. Within the context of clay (e.g. Brown Bank Member and Velsen Bed) or peat (e.g. Woudenberg Formation and Basal peat Bed) both organic and inorganic materials are expected to be well-preserved contributing to the physical quality of the remains.

  As stated in the answers to previous questions no sites are known in the area yet and additional research is needed to test if the stacked sequence of prehistoric landscapes - and archaeological levels herein - is present and preserved intact. Thus the archaeological expectancy for prehistoric remains is tested and further specified.

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5 Summary and recommendations

Within the investigated area of the wind farm zone there is a high expectation for the presence of (remains of) ship wrecks and WWII plane wrecks. *In situ* remains of Paleolithic and Early Mesolithic camp sites and inhumations might be present.

The wind farm area has not been investigated by detailed geophysical surveys. The area may contain more undiscovered shipwrecks or remains of shipwrecks.

Shipwrecks

A (maximum) total of 23 shipwrecks is known in the area. It is possible that some of these object entries are duplicates. Six ship wrecks and a submarine have been identified. Four of the ship wrecks are recent and have no archaeological value, two ship wrecks and the submarine do have an archaeological value. For the other sixteen wreck reportings, details like names, types and date of sinking are not known, nor are the exact locations. Further research is needed to determine the cultural-historical value of the wrecks and assess whether undiscovered shipwrecks are present.

Plane wrecks

During World War II, many airplanes crashed into the North Sea. Several sources are ambiguous about the number of aircraft still missing, but is at least hundreds. Remains are found on a regular base by fishermen. It is quite possible to expect (remains of) plane wrecks within the research area.

Prehistory

Remains of *in situ* prehistoric camp sites are expected within the context of the following lithostratigraphic units:

Boxtel Formation (Late Paleolithic and Mesolithic)

Late Paleolithic and Mesolithic camp sites and inhumations can occur in the cover sand dunes and ridges (top of Wierden Member and embedded Usselo Bed), and along the valleys of small streams (Singraven Member). The covering Basal Peat Bed and Velsen Bed can contain well-preserved lost objects, intentional depots and dumps.

Brown Bank Member

Remains of Neanderthal camp sites can be expected along the shores of fresh water lakes and beaches of lagoons which developed at the transition from Eemian to Weichselian. The sediments (clay and sand) are part of the Brown Bank Member. Within the peat of the covering Woudenberg Formation well-preserved lost objects, intentional depots and dumps can be encountered.

Ice-pushed ridge

The ice-pushed river sands of the Yarmouth Roads Formation can contain reworked flint artefacts from Lower and Middle Paleolithic times. At the top of the ice-pushed ridge in situ remains of camp sites and inhumations of Neanderthal and Late Paleolithic and Mesolithic hunters and gatherers can be expected. The ice-pushed ridge pre-dates the above-mentioned Eemian, Weichselian and Early Holocene deposits.

All archaeological levels of interest are located under a < 1 meter to 17 meter cover of Holocene deposits of the Bligh Bank Member possibly preceded by the Naaldwijk Formation.

At this stage little is known about the integrity of the Pleistocene landscape. By means of subbottom profiling the occurrence of geological units (both horizontal as vertical) and archaeological levels herein can be mapped. The character of layer boundaries (erosive or non-erosive) can be interpreted. It is unlikely however that archaeological remains of Paleolithic and Mesolithic camp sites can be identified with sufficient certainty (based on the geophysical and geotechnical surveys) to impose restrictions on wind farm development. This applies to all the above mentioned archaeological levels (Ice-pushed ridge, Brown Bank Member and Boxtel Formation). At this stage focus should therefore not be put on tracing prehistoric camp sites but on a pragmatic employment of geophysical techniques in order to obtain a better insight in (the integrity of) the Pleistocene landscape. The insights gained shall be used to a) refine the archaeological expectancy model and b) allocate areas with a high expectancy for *in situ* prehistoric remains.

Possibly (part of) a geogenetic, staged approach as advocated by Vos et al. could be implemented in the research strategy for the HKW WFZ.[39]

In accordance with the AMZ cycle it is advised to conduct an exploratory field research (in Dutch '*Inventariserend veldonderzoek opwaterfase*') in order to test and further specify the archaeological expectancy in terms of the character, spacial distribution, integrity and preservation of wreck sites, prehistoric landscapes and potential archaeological levels herein. The phases of the AMZ cycle are explained in Appendix 1: 'Phases in maritime archaeological research' on page 67 and the schematic overview on page 69.

In general an exploratory research comprises a geophysical survey with *side scan sonar*, *magnetometer* and *subbottom profiler*. The resulting data should be archaeologically assessed after the general processing, interpretation and reporting has been performed by the survey contractor.

Based on the processed seismic data the survey contractor will advise on the borehole sample locations to acquire the information on soil parameters needed for construction purposes.

The archaeological contractor will advise whether borehole sample analysis is to be recommended to assess the presence of prehistoric remains and weigh the probability that remains will be affected by the planned activities. Alike the geophysical survey a geotechnical survey including borehole sampling and/or cone penetration tests is part of the archaeological phase of exploratory field research. If the competent authorities decide that an additional research by borehole sample analysis shall be carried out it is advised to consult with the archaeological contractor and the RCE to determine the sample locations and sample strategy. The 'archaeological' sample locations should fit in the program of data acquisition for engineering purposes, which will be the primary objective of the borehole sampling.

The archaeological assessment of the data has to be conducted by a geophysical specialist (KNA prospector Waterbodems). The data quality from the surveys needs to match the demands for this archaeological assessment. To ensure compatibility between the site investigation and the required quality for this assessment it is recommended to define a Program of Requirements (In Dutch: '*Programma van Eisen'*) in accordance with the 'KNA' (the Dutch quality standards for archaeological research), to be authorized by the competent authority.

[39] Vos 2015.

During the installation of the wind turbines and construction of the cables archaeological remains may be encountered that were fully covered by sediment or not identified as archaeological remains during the geophysical survey. In accordance with the Malta convention incorporated in the Erfgoedwet (2016) it is required to report those findings to the competent authority. This notification for archaeological finds should be included in the specifications or scope of work.

List of figures

List of tables

Glossary and abbreviations

Terminology	Description
AMZ	Archeologische Monumenten Zorg (Dutch archaeological management procedure)
CPT	Cone penetration test
Ferrous	Material which is magnetic or can be magnetized, and well known types are iron and nickel
Holocene	Youngest geological epoch (from the last Ice Age, around 10,000 BC. To the present)
In situ	At the original location in the original condition
KNA	Kwaliteitsnorm Nederlandse Archeologie (Norm of quality for the Dutch archaeology branch)
LSwb	Specifications of protocols defined in the KNA
Magnetometer	Methodology to measure deviations from the earth's magnetic field (caused by the presence of ferro-magnetic = ferrous objects)
Multibeam	Acoustic instrument that uses different bundles or beams to measure the depth in order to create a detailed topographic model
NoaA	Nationale Onderzoeksagenda Archeologie (national research agenda archaeology)
Pleistocene	Geological era that began about 2 million years ago. The era of the ice ages but also moderately warm periods. The Pleistocene ends with the beginning of the Holocene
PvE	Programma van Eisen (Program of Requirements)
RCE	Rijksdienst voor het Cultureel Erfgoed (Cultural Heritage Agency)
ROV	Remotely Operated Vehicle
Side scan sonar	Acoustic instrument that registers the strength of reflections of the seabed. The resulting images are similar to a black / white photograph. The technique is used to detect objects and to classify the morphology and type of soil
Current ripples	Asymmetrical wave pattern at the seabed caused by currents. The steep sides of the ripples are always on the downstream side.
Subbottom profiler	Acoustic system used to create seismic profiles of the sub surface.
Trenching	Construction of a trench for the purpose of burying a cable or pipeline
Vibrocore	A special drilling technique where a core tube is driven by means of vibration energy in the seabed. In addition, the core tube is provided with a piston so that the bottom material in the core tube remains in place.

References

Literature

- Amkreutz, L., H. Peeters & B. Smit, 2016. De Noordzee: verdronken steentijd. In: L. Amkreutz, F. Brounen, J. Deeben, R. Machiels, M.F. van Oorsouw & B. Smit (red.): Vuursteen verzameld. RCE, Amersfoort (Nederlandse Archeologische Rapporten 50), 226-228
- Amkreutz, L., M. Niekus, D. Schiltmans & B. Smit, 2017. Meer dan bijvangst! De prehistorische archeologie van de Noordzee. Cranium 34(1):34–47
- Amkreutz et al. 2016 (Cranium).
- Amkreutz, L., A. Verpoorte, A. Waters-Rist, M. Niekus, V. van Heekeren, A. van der Merwe, H. van der Plicht, J. Glimmerveen, D. Stapert & L. Johansen, 2018b. What lies beneath ... Late Glacial human occupation of the submerged North Sea landscape. Antiquity 92(361), 22-37.
- Momber, G. & J.H.M. Peeters 2017. Postglacial human dispersal and submerged landscapes in North-West Europe. In: G. Bailey, J. Harff & D. Sakallariou (eds), Under the Sea: Archaeology and Palaeolandscapes of the Continental Shelf. Cham, Springer, 321-334.
- Peeters, J.H.M. & K.M. Cohen, 2014. Introduction to North Sea submerged landscapes and prehistory. Netherlands Journal of Geosciences 93, 1-2, 3-5
- Busschers, F.S., C.W. Dubelaar, J. Stafleu en D. Maljers, 2010: Lithological and sand grain-size variability in the three-dimensional GeoTOP model of Zuid-Holland, Delft.
- De Mulder, E. e.a., 2003: *De ondergrond van Nederland*, Groningen.
- Deeben, J., D.P. Hallewas & Th.J. Maarleveld, 2002: Predictive modelling in Archaeological Heritage Management of the Netherlands: the Indicative Map of Archaeological Values (2nd Generation), Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek 45, 9-56.
- Forzoni, A., Vermaas, T., Mesdag, C., Hijma, M., de Lange, G. and de Kleine, M., 2017. Geological study Hollandse Kunst (west) Wind Farm Zone).
- Gaffney, V.L., K. Thomson en S. Fitch, 2005: The Archaeology and geomorphology of the North Sea, Kirkwall.
- Hessing, W.A.M., 2005: Het Nederlandse kustgebied, in: Bechert, T en W.J.H. Willems (red.), De Romeinse rijksgrens tussen Moezel en Noordzeekust, 89-102.
- Hijma, M., 2009: From river valley to estuary, The early-mid holocene transgression of the Rhine-Meuse valley, The Netherlands, Netherlands Geographical Studies 389, Utrecht.
- Huizer, J. en H.J.T. Weerts, 2003: Formatie van Maassluis, In: Lithostratigrafische Nomenclator van de Ondiepe Ondergrond, Geologische Dienst Nederland (DINOloket).
- IMAGO projectgroep, 2003: Eindrapportage IMAGO: Samenvatting en conclusies, RDIJ rapport 2003-13a.
- Kramer, E. e.a., 2003 (red.): Koningen van de Noordzee, 250-850, Leeuwarden / Nijmegen.
- Laban, C. 2004: Top Pleistocene Formations map. Netherlands Institute of Applied Geoscience TNO. Department of Geo Marine and Coast. Utrecht.
- Louwe Kooijmans, L.P., 1970-1971. *Mesolithic Bone and Antler Implements from the North Sea and from the Netherlands*.- Berichten van de Rijksdienst voor het Oudheidkundig Bodemonderzoek, 20-21: 69-70.
- Maarleveld, Th. J. en E.J. van Ginkel, 1990: Archeologie onder water, het verleden van een varend volk, Amsterdam.
- Maarleveld, TH.J. , Almere 1998: Archaeological heritage management in Dutch waters: exploratory studies.
- REASeuro, 2018. UXO Desk Study – Unexploded Ordnance. Site Data Hollandse Kust (west) Wind Farm Zone (HKW WFZ)
- Rieu, R., van Heteren, S., van der Spek, J.F., and de Boer, P.L., 2005: Development and preservation of a Mid-holocene Tidal-Channel Network Offshore the Western Netherlands. Journal of Sedimentary Research, 75-3, p 409-419.

- Rijsdijk, K.F, S. Passchier, H.J.T. Weerts, C. Laban, R.J.W. van Leeuwen & J.H.J. Ebbing, 2005: Revised Upper Cenozoic stratigraphy of the Dutch sector of the North Sea Basin: towards an integrated lithostratigraphic, seismostratigraphic and allostratigraphic approach. Netherlands Journal of Geoscience 84-2, p 129-146
- Schüttenhelm, R.T.E.and Laban, C. 2005. Heavy minerals, provenance and large scale dynamics of seabed sands in the Southern North Sea.
- Thal, J., Socko, L., Feldmann, S, Brock, J. P. (2018). Geological Desk Study for the Hollandse Kust (west) Wind Farm Zone. Arcadis Nederland B.V. and Geo-Engineering.org GmbH, 180017. Netherlands Enterprise Agency. (RVO.nl).
- Van de Noort, R., 2011. North sea archeaeologies: A maritime biograph, 10,000 BC to AD1500. Oxford university press.
- Van den Brenk, S., B.E.J.M. van Mierlo en W.B.Waldus, 2008. Archeologisch bureauonderzoek aanleg windturbinepark Tromp-Binnen en kabelroutes naar de Nederlandse kust. Periplus Archeomare rapport 08A014.
- Van Lil, R. en van den Brenk, S., 2014. Windturbinepark Q4 en kabelroute naar de Nederlandse kust. Periplus Archeomare rapport 14A021
- Van Lil, R. en van den Brenk, S., 2018. Net op Zee Hollandse kust (Noord) and (west Alpha), offshore export cable routes. Periplus Archeomare report 18A013-01 (English)
- Verhart, L., 2005: Een verdronken land. Mesolithische vondsten uit de Noordzee, in: Louwe Kooijmans, L.P. e.a. (red.), de Prehistorie van Nederland, 157-160.
- Vonhögen-Peeters, L.M., S. van Heteren and J.H.M. Peeters, 2016. Indicatief model van het archeologische potentieel van de Noordzeebodem. Deltares rapport 209133-000.
- Vos, P.C., F.P.M. Bunnik, K.M. Cohen and H. Cremer, 2015: A staged geogenetic approach to underwater archaeological prospection in the Port of Rotterdam (Yangtzehaven, Maasvlakte, The Netherlands): A geological and palaeoenvironmental case study for local mapping of Mesolithic lowland landscapes. Quaternary International 367, 4-31, Utrecht.
- Waasdorp, J.A., 1999: Van Romeinse soldaten en Cananefaten, Den Haag.
- Zijverden, W.K. van, 2017: After the deluge, a palaeogeographical reconstruction of bronze age West-Frisia (2,000-800 BC), Leiden University dissertation, Leiden.

Atlases and Maps

- GeoTOP-model Laag van Wijchen en Hollandveen Laagpakket
- Globale Archeologische Kaart van het Continentale Plat
- Noordzeeatlas

Sources from the Internet

- Dienst der Hydrografie (www.hydro.nl)
- Dutch Federation of Aviation Archaeology (www.nfla.nl)
- Geologische Dienst Nederland - Data Informatie Nederlandse Ondergrond (www.dinoloket.nl)
- Noordzeeloket (www.noordzeeloket.nl)
- North sea paleolandscapes, University of Birmingham (http://www.iaa.bham.ac.uk)
- Olie en Gasportaal (www.nlog.nl)
- Stichting Aircraft recovery Group 40-45 (http://www.arg1940-1945.nl)
- Stichting Infrastructuur Kwaliteitsborging Bodembeheer (SIKB.nl)
- Stichting Maritiem Historische Databank (http://www.marhisdata.nl/)

Various sources

- Archis III, archeologische database Rijksdienst voor het Cultureel Erfgoed
- Databases Periplus Archeomare

- KNA Waterbodems 4.1
- Nationaal Contactnummer Nederland (NCN)
- SonarReg92, objectendatabase Rijkswaterstaat Zee en Delta

Appendix 1. Phases of maritime archaeological research

The Dutch Quality Standard for Archaeology (KNA Waterbodems, version 4.1) describes all procedures and requirements for the archaeological research process. Below a brief description of the steps involved:

1) **Desk study**
   The purpose of a desk study is to collect and report all available historical data, geological information and information about disturbances in the past. The result is an archaeological expectation map or model.
   The desk study may be expanded with an analysis of sonar and multibeam data, if available.

   IF the outcome of the desk study shows that there is a risk of occurrence of archaeology, then the next phase must be carried out:

2) **Exploratory field research (opwaterfase)**

   a) **Geophysical survey**
   In order to test the archaeological expectation, a geophysical survey is carried out. The type of survey depends on the type of expected objects, local geology and expected depth of the objects below the seafloor. In practice, the research usually consists of a side scan sonar survey, if necessary, supplemented with multibeam echo sounder recordings, subbottom profiling and magnetometer measurements. The requirements of the survey are based on the desk study and should be included in a program of requirements which must be approved by the competent authorities.

   IF potential archaeological objects are found, then the next phase (**3**) must be carried out.

   b) **Geotechnical survey**
   In order to reconstruct prehistoric landscapes and refine and test the archaeological expectation related to those landscapes a geotechnical survey can be carried out. A geotechnical survey comprises penetration tests (CPT's) and/or bottom sampling (*vibrocore*, Acqualock, Begemann, grab sampling, etcetera). The sample strategy and sample locations are based on the geological constellation of the area and interpreted subbottom profiling data. The requirements of the survey shall be listed in a program of requirements which must be approved by the competent authorities.

3) **Exploratory field research (onderwaterfase verkennend)**
   The suspected sites are investigated by specialized divers in order to identify the objects. The requirements of the underwater research are included in a program of requirements which must be approved by the competent authorities.

   IF as site is identified as an archaeological object or structure then the next phase must be carried out:

4) **Appreciative field research (onderwaterfase waarderend)**
   The archaeological remains at the site are thoroughly investigated and mapped by a specialized archaeological diving team and samples are collected for additional research. Then a decision will be made whether the archaeological remains are worth preserving. If the latter is the case, then there are two possibilities: either the remains can be preserved in situ (adjustment of plans) or the next phase will be conducted:

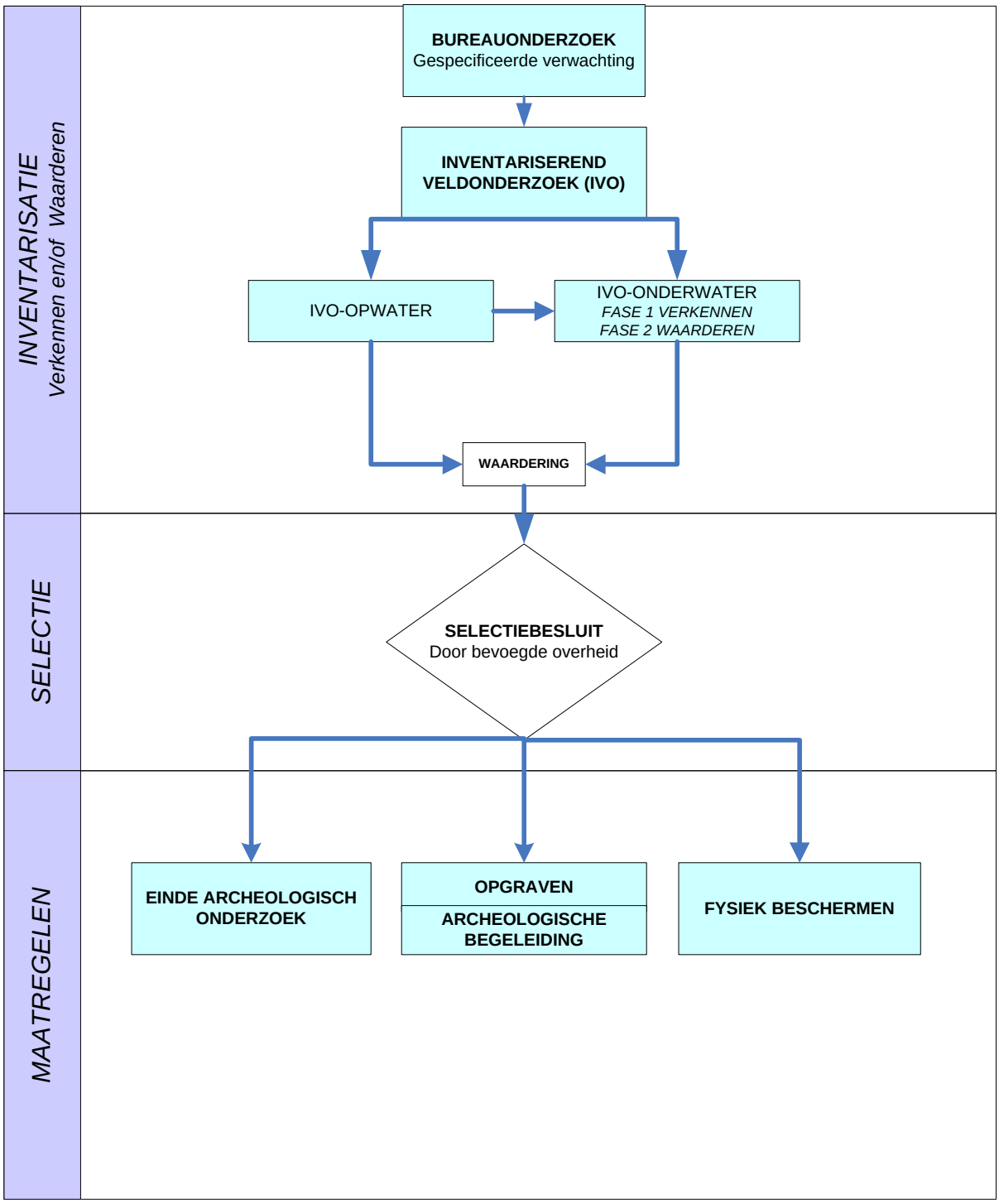
5) Archaeological excavation

The archaeological remains are excavated under supervision of a senior maritime archaeologist. All remains need to be documented, registered and conserved. The requirements of the underwater research are included in a program of requirements which must be approved by the competent authorities.

The phases described above contain a number of decision points that are dependent on the detected archaeological objects. The figure on the next page shows these moments schematically.

Schematic overview KNA Waterbodems version 4.1

(in Dutch)



Appendix 2. Archaeological and geological periods and time scale

CHRONOSTRATIGRAFIE				ARCHEOLOGISCHE PERIODE				
SERIE	ETAGE - CHRONOZONE		TIJD	TIJDPERK				DATERING
Holoceen	**Laat Subatlanticum**		**1150 n. Chr**					
	Vroeg Subatlanticum		0	Nieuwe tijd		C		1850
			450 v. Chr			B		1650
	Subboreaal		3700			A		1500
	Atlanticum		7300	Middeleeuwen	Laat	B		1250
	Boreaal		8700			A		1050
	Preboreaal		9700		Vroeg	D		900
Pleistoceen	Weichselien	Laat Glaciaal	Jonge Dryas			C		725
			Allerød			B		525
			Oude Dryas			A		450
			Bølling	Romeinse tijd		Laat		270
						Midden		70 n. Chr.
		Pleniglaciaal L	Late Glacial Max			Vroeg		15 v. Chr.
				Prehistorie	Metaaltijden	IJzertijd	Laat	250
			Denekamp				Midden	500
		Pleniglaciaal M					Vroeg	800
			Hengelo			Bronstijd	Laat	1100
							Midden	1800
		Pleniglaciaal V	Moershoofd				Vroeg	2000
					Steentijd	Neolithicum	Laat	2850
		Vroeg Glaciaal	Odderade				Midden	4200
							Vroeg	4900/5300
			Brørup			Mesolithicum	Laat	6450
							Midden	8640
			Amersfoort				Vroeg	9700
						Paleolithicum	Laat B	12.500
	Eemien		126.000				Jong	16.000
	Saalien		236.000				A	35.000
	Oostermeer		241.000				Midden	250.000
	onbenoemd		322.000					
	Belvédère		336.000				Oud	
	onbenoemd		384.000					
	Holsteinien		416.000					
	Elsterien		463.000					

Appendix 3. Listing of all known objects within the research area.

				ETRS89 UTM31N			
NCN	Nlhono	Type	R95	Easting	Northing	Survey datum	Description
439	3444	Wreck	5	548806	5821993	20080509	Wreck yacht Regina, 13x3x2 meter, sunk 01-05-2008 after collision
522	5	Wreck	25	549026	5823162	20140908	Wreck DHY 522. Duikteam Zeester: Wreck of coast vessel, sunk 1980, standing right up, superstructure is gone, close by platform
2035	2221	Wreck	500	550310	5822477	20090409	Wreck DHY 2221. Unknown small wreck found 1959, not confirmed since
2056	2247	Wreck	25	540651	5828702	20140908	Wreck DHY 2247. Duikteam Zeester: "Paaswrak 1", close to the Brown Bank. Norwegian cargo ship Biaritz from 1920, sunk 1940
2057	2248	Wreck	25	550864	5827791	20140908	Wreck DHY 2248. Duikteam Zeester: Wreck Dutch fishing trawler Stellendam 4, sunk 1969
2063	2255	Wreck	20	540648	5829062	20070811	Wreck DHY 2255, Unknown wreck found 1970
2064	2256	Wreck	25	540173	5829482	20140908	Wreck DHY 2256. Duikteam Zeester: SS Paris, built in 1922, sunk 1939
2090	2283	Wreck	1000	549558	5838909	-	Wreck DHY 2283. Unknown wreck found 1946
2091	2284	Wreck	5	551689	5838477	20140907	Distributed remains of wreck DHY 2284
2097	2291	Wreck	500	551880	5843043	-	Wreck DHY 2291 Unknown wreck found 1961
2098	2292	Wreck	25	554776	5842849	20070811	Wreck DHY 2292. Duikteam Zeester: Boezemwrak close to platform
2100	2294	Wreck	1000	558429	5842871	-	Wreck DHY 2294. Mast reported 1898, not confirmed since
2110	2304	Wreck	1000	550906	5844640	-	Wreck DHY 2304. Wreck reported 1946, not confirmed since
2120	2315	Wreck	25	555194	5849035	20140907	Wreck DHY 2315. Duikteam Zeester: Submarine Doris
2250	2468	Wreck	100	548152	5832498	20070811	Wreck DHY 2468. Unknown wreck reported 1984
2468	2849	Obstruction	10	547407	5838757	20070811	Foul ground
2469	2852	Wreck	5	555440	5845241	20140907	Wreck debris
2809	3427	Wreck	5	554452	5845413	20140907	Wreck DHY 3427. Unknown wreck reported with sonar 1997
2810	3428	Wreck	50	535978	5821107	20140908	Distributed remains of wreck
2844	3498	Wreck	50	553958	5830158	20081129	Wreck DHY 3498
2845	3499	Wreck	50	554572	5833117	20140908	Wreck DHY 3500. Wreck debris reported 2014
2846	3500	Obstruction	5	555128	5833583	19971015	Manmade object. RWS ROV images available
3089	-	Obstruction	5	556255	5842276	15-10-97	Manmade object, probably wellhead. RWS SR 1016
9226	-	Wreck	5	556213	5832620	-	Wooden wreck remains, discovered in 2002. ARCHIS wng 47163
9299	-	Submarine	1	555298	5849442	-	French submarine Doris, sunk mei 1940, cannon salvaged in 2003. ARCHIS wng 48181
14263	-	Anchor	5	556822	5850739	13-10-00	Anchor and chain, length 82 m. RWS Sr 11072
15219	-	Wreck	5	555554	5833512	16-10-92	Norwegian cargo vessel Nordfrakt, sunk 25-10-1992, dimensions 76x12x2m. RWS SR 11968
25432	100543	Wellhead	5	552819	5836933	-	Wellhead P06-S-01
25433	100650	Wellhead	5	550669	5831259	-	Wellhead P09-07
25434	100875	Wellhead	5	552838	5836933	-	Wellhead P06-10
18745	-	Cable	5	556203	5832620	01-01-02	Piece of cable. RWS SR 1042, survey 2002
18746	-	Cable	5	556113	5833907	18-04-02	Piece of cable. RWS SR 1043, survey 2002
19559	100403	Wellhead	5	554262	5843360	-	Wellhead P06-03
19569	100507	Wellhead	5	550241	5822755	-	Wellhead P09-HORIZON-A-08-SIDETRACK1
19572	100761	Wellhead	5	549013	5839202	-	Wellhead P06-D-01

				ETRS89 UTM31N			
NCN	**Nlhono**	**Type**	**R95**	**Easting**	**Northing**	**Survey datum**	**Description**
19573	100534	Wellhead	5	554269	5843354	-	Wellhead P06-B-04, same location as NCN 19559
19575	100417	Wellhead	5	548797	5823713	-	Wellhead P09-02
19576	100617	Wellhead	5	552845	5836956	-	Wellhead P06-S-01, same location as NCN 25432
19583	100409	Wellhead	5	556266	5842284	-	Possible Wellhead P06-01

NCN: Nationaal Contactnummer Nederland
Nlhono nr. From the Dutch Hydrographic Service
R95: Accuracy (in m) for the location

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The information in this document is valid at the time of publishing (see month/year). Updates will be published on the website https://offshorewind.rvo.nl/ at the relevant sitemap (Hollandse Kust (zuid)/Hollandse Kust (noord)/Hollandse Kust (west)), General Information, submap Revision Log and Q & A. In the Revision Log is indicated which versions are the latest and what the changes are in relation to previous versions. The documents can be found at the relevant sites, indicated in the Revision Log.

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