Netherlands Enterprise Agency

Site Studies Wind Farm Zone Hollandse Kust (zuid)

Unexploded Ordnance (UXO) desk study

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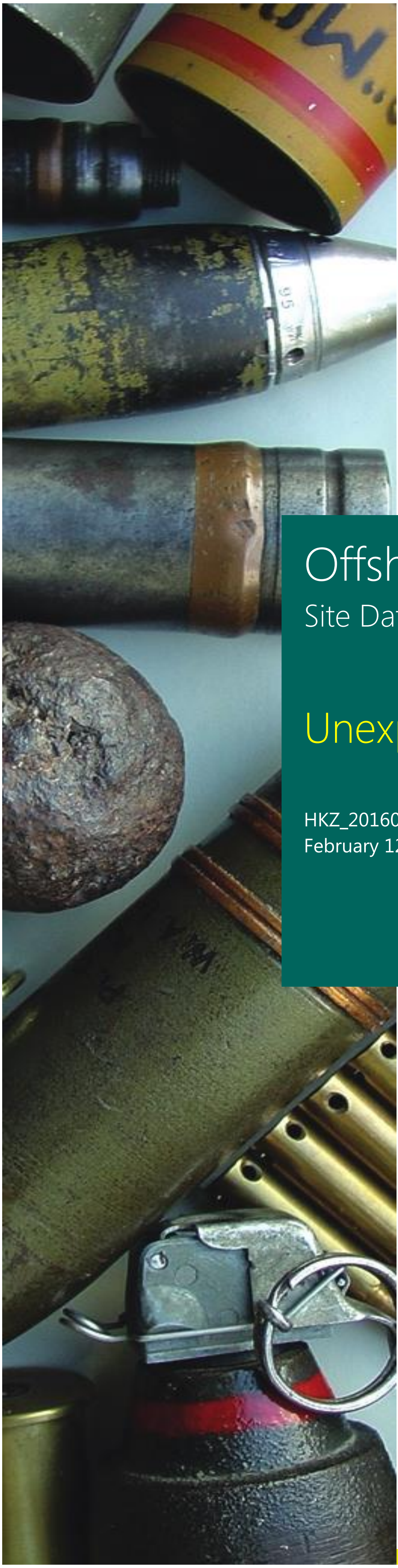

Offshore wind energy Netherlands

Site Data Hollandse Kust (Zuid) wind farm zone

Unexploded Ordnance (UXO) - Desk Study

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Site data Hollandse Kust (Zuid) wind farm zone
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SUMMARY

In 2013 more than 40 organisations and the Government entered into the Energy Agreement for Sustainable Growth (Energieakkoord voor Duurzame Groei). An important part of this agreement includes scaling up of offshore wind power development. The Ministry of Economic Affairs presented a road map outlining how the Government plans to achieve its offshore wind goals in accordance with the time line agreed upon in the Energy Agreement.

The road map sets out a schedule of tenders offering 700 MW of development each year in the period 2015 – 2019. 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 zee), a SDE+ grant 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 UXO study is part of the site data for Wind Farm Zone Hollandse Kust (Zuid).
The UXO desk study consists of a historical research and a UXO risk assessment.

Historical research
The Hollandse Kust (Zuid) wind farm zone and its surrounding areas were the scene of many war related activities in World War I and World War II. Due to the following facts the entire Hollandse Kust (Zuid) wind farm zone is to be considered a UXO risk area:

- The Hollandse Kust (Zuid) wind farm zone is located just north of the main flight path of Allied bomber raids. As a consequence a large number of aircrafts are crashed in the North Sea and many bombs were dropped in the North Sea.
- In World War I and II a large number of naval mines was deployed in the North Sea. Minefields were laid by submarines, ships and aircrafts. In World War I and II a total of five known minefields were (partly) located within the Hollandse Kust (Zuid) wind farm zone. The presence of mines due to secret offensive mine laying operations cannot be ruled out. Of the mines that were laid in WWII, only around 10% - 25% were cleared after the war[1]. There are no records of minesweeping activities after WWI, so recovery numbers are likely to have been even lower [19].
- The Allied air force attacked (German) ships and convoys on a regular basis. During these attacks bombs, torpedoes, rockets and cannons were used. The Allied airplanes were attacked by German fighters and Flugabwehrkanone (FLAK) from FLAK-ships and coastal FLAK-batteries.
- Since April 2005 eight UXO [17] were encountered by fisherman within the Hollandse Kust (Zuid) wind farm zone.
- In the post-war period the seabed was intensively used. Due to intensive fishing (trawling) UXO may have been moved unintentionally, but a large number of UXO were moved on purpose. Until 2005 most of the UXO that were encountered in fishing nets were simply put overboard, often in the direct vicinity of known shipwrecks. These locations were normally avoided because of the risk of damaging the fishing nets, thus forming a gathering place of remnants of war.

[1] Assumption of the Royal Netherlands Navy, based upon three independent sources.

Based upon the described source material the following UXO are likely to be encountered:

- Naval mines;
- Bombs;
- Depth charges;
- Naval mine destruction charges;
- Torpedoes;
- Artillery shells.

UXO risk assessment

The UXO likely to be encountered can be sensitive to hard jolts, change in water pressure, movement and accelerations with an amplitude > 1 m/s^2. Within the Hollandse Kust (Zuid) wind farm zone several intrusive activities will be conducted. These activities may cause a UXO to detonate. Because of the often large calibre UXO, a detonation will have a devastating effect on nearby vessels, equipment, foundations, crew members and surroundings. Therefore a detonation forms an intolerable risk.

The possible presence of UXO in the area, however, is no constraint for offshore wind farm related activities. With proper UXO Risk Management the risks can be reduced to a level that is as low as is reasonably practicable (ALARP).

The duty of health and safety law is to eliminate the risk if possible or reduce it to a level that is ALARP. The level of ALARP can only be determined during the design and engineering phase of the wind farm development.

Recommendations

To manage UXO related risks recommendations are given for the preparation phase, execution phase and the operational phase of the wind farm development.

<u>Preparation phase</u>

- A geophysical (bathymetric) survey is recommended in preparation for a dedicated UXO survey, consisting of at least a high resolution multibeam and side scan sonar. The multibeam generates high quality and high resolution data of the seabed. This data will be used for morphologic research and assessment of the movement of sand waves. The side scan sonar must be able to identify objects > 1 m. The generated data is used to identify objects, debris, debris fields and wrecks. Optional the additional conduction of sub bottom profiler can be considered.
- It's recommended to provide this UXO-Desk Study to the contractor of the geophysical survey.
- An awareness training (or kick-off meeting) before conducting the geophysical survey is recommended.
- It is recommended to conduct an intrusive and/or non-intrusive survey (depending on the local conditions) at each CPT/bore hole and sample location.
- It's recommended to train and certify the key personnel managing the geotechnical investigations to the level "Basic OCE" according to the Dutch Law as outlined in "Werkveld Specifiek Certificatie Schema – Opsporen Conventionele Explosieven (WSCS-OCE)".
- During the metocean measurements potential UXO risks occur. To constrain these risks an awareness training (or kick-off meeting) before conducting the measurements is to be recommended.
- As regards the Met mast installation, intrusive activities will be conducted. Before installation, the area effected by the intrusive activities has to be cleared from UXO. The clearance operations have to be conducted by a certified UXO clearance company.

- It is highly important to assess the mobility of sand waves (banks and ridges) by comparing current bathymetry results with historic data. Thereafter the effects of the mobility of sand waves on the burial depth of UXO need to be determined.
- It is possible that ship- and airplane wrecks need to be removed in order to construct the wind farm. From most wrecks, wreck remains and foul areas specific information lacks. It is recommended to investigate the known wrecks to gather additional information.

Execution phase

- It is recommended to reassess the UXO related risks based on the first draft of the design for the wind farm. Possibly adaptations in the design can be made to mitigate a part of the risks. For the remaining (intolerable) risks a detailed UXO risk mitigation strategy needs be worked out. The required risk mitigation actions will include surveying and safe removal of UXO within a further to assess part of the wind farm zone. The size of the survey area will be determined in the detailed UXO mitigation strategy.
- Prior to the search operations a detailed dedicated UXO survey has to be developed. The information gathered during the geophysical survey is to be used as input for the survey plan.
- Because the validity of the collected data (geophysical survey) is limited in time, it's recommended to minimize the time lapse between the survey and the actual installation works.
- The UXO survey plan needs to address the following subjects:
    - the elevation differences of the seabed;
    - the maximal burial depth of UXO;
    - the types and calibres of UXO (e.g. German GC or Kathy naval mines, with limited ferromagnetic materials);
    - locations of wrecks and wreck remains;
    - Elements and objects disruptive to the UXO survey data such as cables and pipelines.
    - Etc.
- In view of the possibility of UXO migration and variations in burial depth it is recommended to conduct the UXO search and removal operations at short notice prior to the construction activities. The validity of the collected magnetometer survey data in regards to tidal streams, mobility of sand waves and seabed usage has to be taken into account when planning the survey and construction operations. Time lapse between project phases has to be limited as much as possible.

Operational phase

- Because of tidal streams, mobility of sand waves and seabed usage, the possibility that UXO are moved within the wind farm zone after completion of the construction activities has to be taken in to account.
- It is recommended to write a maintenance and monitoring plan. This plan needs to provide safe working protocols for future maintenance operations and a monitoring strategy. To constrain this risks an awareness training (or kick-off meeting) before conducting maintenance operations is also recommended.

SAMENVATTING

In 2013 hebben meer dan 40 organisaties het Energieakkoord voor Duurzame Groei gesloten. Een belangrijk deel van dit akkoord is de opschaling van de off shore wind energie ontwikkeling.
Het Ministerie van Economische Zaken heeft een plan van aanpak van de Rijksoverheid gepresenteerd voor de uitvoering van het Energieakkoord.

Het plan van aanpak presenteert een tender schema met ieder jaar 700 MW aan off shore windenergie ontwikkeling in de periode 2015-2019. De Nederlandse overheid heeft een raamwerk ontwikkelt waarin offshore wind gebieden worden aangewezen. Locaties buiten deze wind gebieden kunnen geen vergunning ontvangen. Binnen de aangewezen windgebied bepaalt de regering de kavels waar wind projecten kunnen worden geconstrueerd middels een kavelbesluit. Een kavelbesluit bevat de voorwaarden voor het bouwen en exploiteren van een wind project op een specifieke locatie. De Nederlandse netbeheerder TenneT zal verantwoordelijk worden voor de netaansluiting.

De winnaars van de tenders ontvangen een vergunning om een windproject te bouwen conform de Wet Windenergie op zee, een SDE+ beschikking, en worden een netaansluiting naar het land aangeboden. Het ministerie van Economische Zaken verzorgt alle relevante site data, die nodig is voor de voorbereiding van het tender bod. Deze UXO studie is onderdeel van de site data voor het windgebied Hollandse Kust (Zuid). Deze bureaustudie bestaat uit een historisch vooronderzoek en een risicoanalyse.

Historisch vooronderzoek
Het windgebied Hollandse Kust (Zuid) en het omliggende gebied waren het toneel van vele oorlog gerelateerde gebeurtenissen gedurende zowel de Eerste, als de Tweede Wereldoorlog. Ten gevolge van de volgende feiten moet het volledige windgebied als NGE-risicogebied worden aangemerkt:

- Windgebied Hollandse Kust (Zuid) ligt net ten noorden van de belangrijkste vluchtroutes van geallieerde bommenwerpers. Er zijn een groot aantal vliegtuigen neergestort in de Noordzee. Tevens zijn grote hoeveelheden bommen afgeworpen boven de Noordzee.
- In beide wereldoorlogen werden grote hoeveelheden zeemijnen ingezet in de Noordzee. In windgebied Hollandse Kust (Zuid) waren vijf bekende mijnenvelden (WO I en II) aanwezig. De aanwezigheid van zeemijnen in de overige delen van het windgebied kan, ten gevolge van het in het geheim leggen van offensieve mijnenvelden, niet worden uitgesloten. Van alle mijnen die tijdens de Tweede Wereldoorlog werden gelegd is slechts 10% tot 25% geruimd. Er zijn geen gegevens van het ruimen van mijnen na de Eerste Wereldoorlog. Waarschijnlijk was het percentage geruimde mijnen na de Eerste Wereldoorlog nog geringer [19].
- De geallieerde luchtlegers vielen regelmatig (Duitse) schepen en konvooien aan. Bij deze aanvallen werden vliegtuigbommen, torpedo’s, raketten en boordwapens ingezet. De geallieerde vliegtuigen werden aangevallen door Duitse jachtvliegtuigen en met FLAK van FLAK-schepen en FLAK-batterijen langs de Nederlandse kust.
- Sinds april 2005 zijn binnen het windgebied Hollandse Kust (Zuid) door vissers acht NGE bij de kustwacht aangemeld. Van deze NGE zijn er zeven geruimd door de Marine. Eén NGE (vliegtuigbom) kon niet worden teruggevonden.
- De zeebodem is erg dynamisch ten gevolge van getijdestromingen en de beweging van zandduinen. Hierdoor kunnen NGE zijn verplaatst, waardoor ze niet meer op hun oorspronkelijke positie liggen.
- In de periode na de oorlog is de zeebodem intensief gebruikt. Ten gevolge van intensieve visserij zijn NGE verplaatst. Tot 2005 werden de meeste NGE na het aantreffen weer terug in zee geworpen.

Dit gebeurde vaak in de buurt van bekende scheepswrakken. Deze locaties werden veelal vermeden om schade aan de netten te voorkomen en vormden zodanig vaak een verzamelplaats voor NGE.

Op basis van het verzamelde bronnenmateriaal kunnen de volgende soorten NGE in het windgebied Hollandse Kust (Zuid) zijn terechtgekomen en achtergebleven:
- Zeemijnen;
- Vliegtuigbommen;
- Dieptebommen;
- Mijn vernietigingsladingen;
- Torpedo's;
- Granaten.

Risicoanalyse
De NGE die mogelijk zijn achtergebleven in het windgebied Hollandse Kust (Zuid) zijn gevoelig voor toucheren, bewegen, veranderingen in waterdruk en versnellingen groter dan 1 m/s^2. Binnen het windgebied Hollandse Kust (Zuid) worden diverse grondroerende activiteiten uitgevoerd. Deze activiteiten kunnen een detonatie van een aanwezig NGE veroorzaken. Vanwege het vaak grote kaliber van de te verwachten NGE, heeft een detonatie een vernietigende werking op vaartuigen, materieel, funderingen, personeel en de omgeving. Een detonatie vormt daarom een niet toelaatbaar risico.

De mogelijke aanwezigheid van NGE in het windgebied vormt echter geen belemmering voor de realisatie van het windgebied. Met goed NGE-risicomanagement kan het risiconiveau tot een aanvaardbaar niveau worden teruggebracht.

De Arbeidsomstandighedenwetgeving schrijft voor dat de risico's zo veel mogelijk gereduceerd moeten worden. Het aanvaardbare risiconiveau kan echter pas worden vastgesteld tijdens de ontwerpfase van het windgebied.

Aanbevelingen
Ten einde de NGE-gerelateerde risico's te beheersen, zijn aanbevelingen gegeven voor de voorbereidende fase, de uitvoeringsfase en de exploitatiefase van het windgebied.

<u>Voorbereidende fase</u>
- Aanbevolen wordt een uitgebreid geofysisch (bathymetrisch) onderzoek uit te voeren ter voorbereiding op een specifiek op NGE gerichte detectie. Dit geofysisch onderzoek dient ten minste te bestaan uit hoge resolutie multibeam en side scan sonar metingen. De multibeam metingen dienen te resulteren in een hoge kwaliteit data met een hoge resolutie. Deze data worden gebruikt voor het morfologisch onderzoek en de beoordeling van de verplaatsing van zandduinen. Met side scan sonar worden objecten met een grootte van meer dan 1 m geïdentificeerd, teneinde de aanwezigheid van objecten, vervuilde gebieden en wrakken vast te stellen.
- Aanbevolen wordt dit rapport ter beschikking te stellen aan het bedrijf dat het geofysisch onderzoek gaat uitvoeren.
- Aanbevolen wordt het personeel dat het geofysisch onderzoek gaat uitvoeren een bewustwordingstraining[2] te laten volgen.

[2] Training, toolbox of kick-off gericht op bewustwording van de risico's die het werken in een op explosieven verdacht gebied met zich meebrengt.

- Ten behoeve van het geotechnisch onderzoek dienen mitigerende maatregelen te worden genomen om te voorkomen dat een NGE wordt getoucheerd of bewogen. Deze maatregelen kunnen bestaan uit het begeleiden van het geotechnisch onderzoek door een gecertificeerd opsporingsbedrijf (WSCS-OCE, deelgebied A). De locaties van grondroerende werkzaamheden dienen in dit geval voorafgaand aan het geotechnisch onderzoek te worden vrijgegeven op de aanwezigheid van NGE. Het is aan de ontwikkelaar om een besluit te nemen over de te treffen mitigerende maatregelen.
- Tijdens de weerkundige, geotechnische en oceanografische onderzoeken kunnen zich NGE-gerelateerde risico's voordoen. Om deze risico's te beheersen wordt een bewustwordingstraining voor het betrokken personeel aanbevolen.
- Met betrekking tot oceanografische metingen vinden mogelijk grondroerende werkzaamheden plaats. Geadviseerd wordt om de locaties van de grondroerende activiteiten voorafgaand aan de werkzaamheden door een gecertificeerd opsporingsbedrijf te laten onderzoeken en vrijgegeven op de aanwezigheid van NGE.
- Het is van groot belang om de mobiliteit van de zandduinen in het windgebied vast te stellen. Vervolgens dient het effect van de beweging van de zandduinen op de diepteligging (verzanding) van de te verwachten NGE te worden vastgesteld.
- Er is een kans dat de aanwezige wrakken worden verwijderd om realisatie van het windgebied mogelijk te maken. Van de meeste wrakken, restanten van wrakken en verontreinigde gebieden ontbreekt specifieke informatie. Mogelijk betreft een deel van de bekende wraklocaties (restanten) van gecrashte vliegtuigen. Geadviseerd wordt de bekende wraklocaties nader te onderzoeken. Dit in verband met de mogelijke aanwezigheid van NGE en stoffelijke resten in en om deze locaties. In geval van (restanten van) vliegtuigwrakken en stoffelijke resten dient de Bergings- en Identificatiedienst te worden ingeschakeld.

Uitvoeringsfase

- Aanbevolen wordt de NGE-risicoanalyse te herijken op basis van het ontwerp van het windgebied. Mogelijk kunnen aanpassingen in het ontwerp worden doorgevoerd om een deel van de risico's te mitigeren. Voor de overige risico's dient een gedetailleerde risicoanalyse te worden uitgevoerd. Op basis hiervan dient een NGE onderzoeksstrategie te worden ontwikkeld. Rekening moet worden gehouden met het opsporen en ruimen van NGE in een nader te bepalen deel van het windgebied. De omvang van het te onderzoeken gebied wordt vastgesteld in de gedetailleerde risicoanalyse en is gebaseerd op het ontwerp.
- Voorafgaand aan de opsporing dient een maatwerk detectieplan te worden opgesteld. Dit plan dient mede te worden gebaseerd op het uitgevoerde geofysisch onderzoek.
- Het detectieplan dient in te gaan op de volgende onderwerpen:
    - Hoogteverschillen van de zeebodem in het windgebied;
    - De maximale penetratiediepte van de te verwachten NGE;
    - De types en kalibers van de te verwachten NGE (bijvoorbeeld de Duitse GC mijn die een beperkte hoeveelheid ferro-houdend materiaal bevat);
    - De locaties van wrakken en restanten van wrakken;
    - Detectie verstorende objecten in het windgebied, zoals kabels en leidingen.
    - Etc.
- Aanbevolen wordt de opsporing en ruiming van NGE zo kort mogelijk voorafgaand aan de constructiewerkzaamheden te plannen. De houdbaarheid van de detectiedata is ten gevolge van de getijdestromingen, de beweging van zandduinen en het gebruik van de zeebodem beperkt. De verschillende projectfasen dienen derhalve aaneensluitend te worden gepland en uitgevoerd.

Exploitatiefase

- Vanwege getijdestromingen, de mobiliteit van zandduinen en het gebruik van de zeebodem bestaat de mogelijkheid dat NGE worden verplaatst tot in het windgebied nadat het windgebied is gerealiseerd. Bij het uitvoeren van onderhoudswerkzaamheden moet met dit risico rekening worden gehouden.
- Aanbevolen wordt een onderhouds- en monitoringsplan te schrijven. In dit plan moeten veilige werkprotocollen voor de toekomstige onderhoudswerkzaamheden worden vastgelegd. Tevens wordt geadviseerd een bewustwordingstraining te verzorgen voor personeel dat betrokken is bij het uitvoeren van onderhoudswerkzaamheden.

General information

1 INTRODUCTION

The Ministry of Economic Affairs has requested 'The Netherlands Enterprise Agency to prepare and collect all site data required for the development of offshore wind farms in Hollandse Kust (Zuid) offshore wind farm zone. In this context The Netherlands Enterprise Agency has commissioned this unexploded ordnance (UXO) desk study. In this chapter a general introduction on offshore wind energy is given. Subsequently the area of research for this UXO-Desk Study and the purpose and main objectives are set.

1.1 GENERAL INTRODUCTION TO THE OFFSHORE WIND ENERGY IN THE NETHERLANDS

This paragraph provides a general introduction to the offshore wind energy in the Netherlands.

1.1.1 Offshore wind farms in the Netherlands

The first two wind farms that were built in the Dutch part of the North Sea are the offshore wind farm Egmond aan Zee and the Princess Amalia wind farm. Wind farms Luchterduinen and Gemini are under construction and will be fully operational late 2015 respectively 2017. These wind farms have a total capacity of some 1,000 MW.

1.1.2 The Energy Agreement for Sustainable Growth

In the Energy Agreement for Sustainable Growth (Energieakkoord voor duurzame groei), more than forty organisations have laid the foundation for a robust, future-proof energy and climate policy for the Netherlands, enjoying broad support.

An important part of this agreement is increasing the production of offshore wind power to 4,450 MW, operational in 2023. In addition to this, a total of 3,450 MW will be contracted for by means of phased tender procedures commencing in 2015.

1.1.3 Wind farm zones

The Government has decided that three offshore wind farm zones, within the appointed designated areas for offshore wind, will be used for the production of the 3,500 MW of new offshore wind power as agreed upon in the Energy Agreement. These offshore wind farm zones are Borssele (1,400 MW), Hollandse Kust (Zuid) (1,400 MW) and Hollandse Kust (Noord) (700 MW). Figure 1 shows a schematic representation of these wind farm zones and the planned timetable for related tenders to be issued.

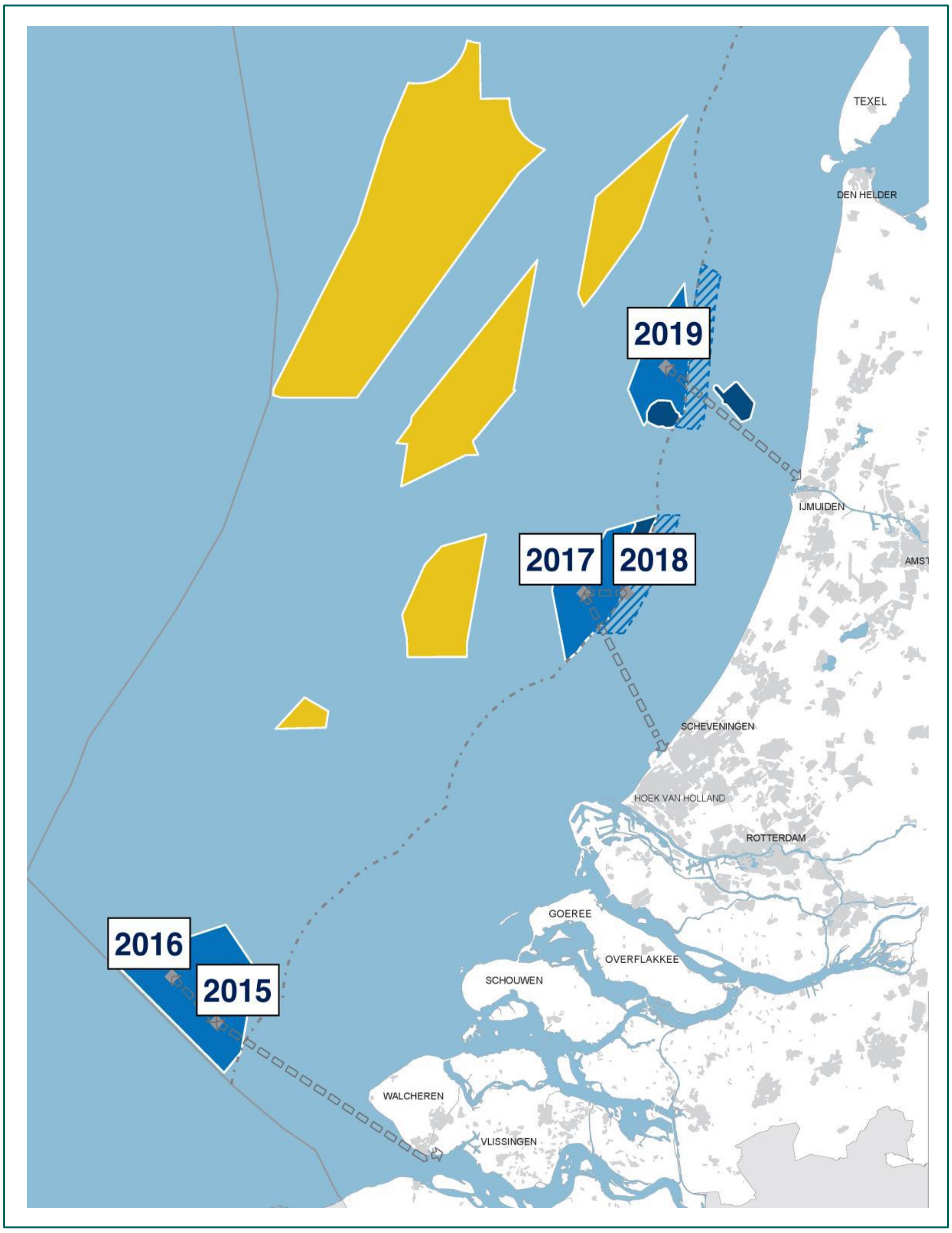

Figure 1: The road map towards 4.500 MW offshore wind power.

1.1.4 Wind farm sites

To ensure the required cost reduction for offshore wind, the government has introduced a price cap on projects for each wind farm zone (the price cap decreases each year). In 2017 and 2018, tenders to develop the Hollandse Kust (Zuid) wind farm zone will be issued under the subsidy programme, Stimulation of Sustainable Energy Production (SDE+, or Stimulering Duurzame Energieproductie). These tender rounds comprise four wind farm sites of approximately 350 MW each. Developers will be selected according to the schedule shown in Table 1.

Tendering		Wind farm zone	Price cap
Year	Capacity		[eurocent/kWh]
2015	700 MW	Borssele Wind Farm Zone, Wind Farm Site I and II	12.400
2016	700 MW	Borssele Wind Farm Zone, Wind Farm Site III and IV	11.975
2017	700 MW	Hollandse Kust (Zuid) Wind Farm Zone	10.750
2018	700 MW	Hollandse Kust (Zuid) Wind Farm Zone	10.320
2019	700 MW	Hollandse Kust (Noord) Wind Farm Zone	10.000

Table 1: Schedule for tendering wind farms.

1.1.5 Selection of developers

Developers who can build and operate wind farms on the sites will be selected by tender procedures in which respectively the grant and the permit for constructing and operating a wind farm can be awarded. To facilitate developers in competitive bids for the tenders, site data on the wind, water and soil conditions will be made available.

1.1.6 Site data

The Netherlands Enterprise Agency makes site data available. This site data includes:

- Geological, morphodynamical and geomorphological data;
- Archaeological and UXO analysis;
- Metocean data;
- Geophysical and geotechnical data (based on surveys).

The investigations for this data will also be used for the EIA. Investigations relevant for the design basis will be certified according to DNV-OS-J101 or equal.

1.2 INVESTIGATION AREA DESK STUDY

The Hollandse Kust (Zuid) wind farm zone is located 12 Nautical Miles off the west coast of the Netherlands. It is the intention of the government to expand the wind farm zone two Nautical Miles on the east side. Wind farm Luchterduinen (see paragraph 1.1.1) lies within the wind farm zone.

In Figure 2 the investigation area of this desk study is shown.

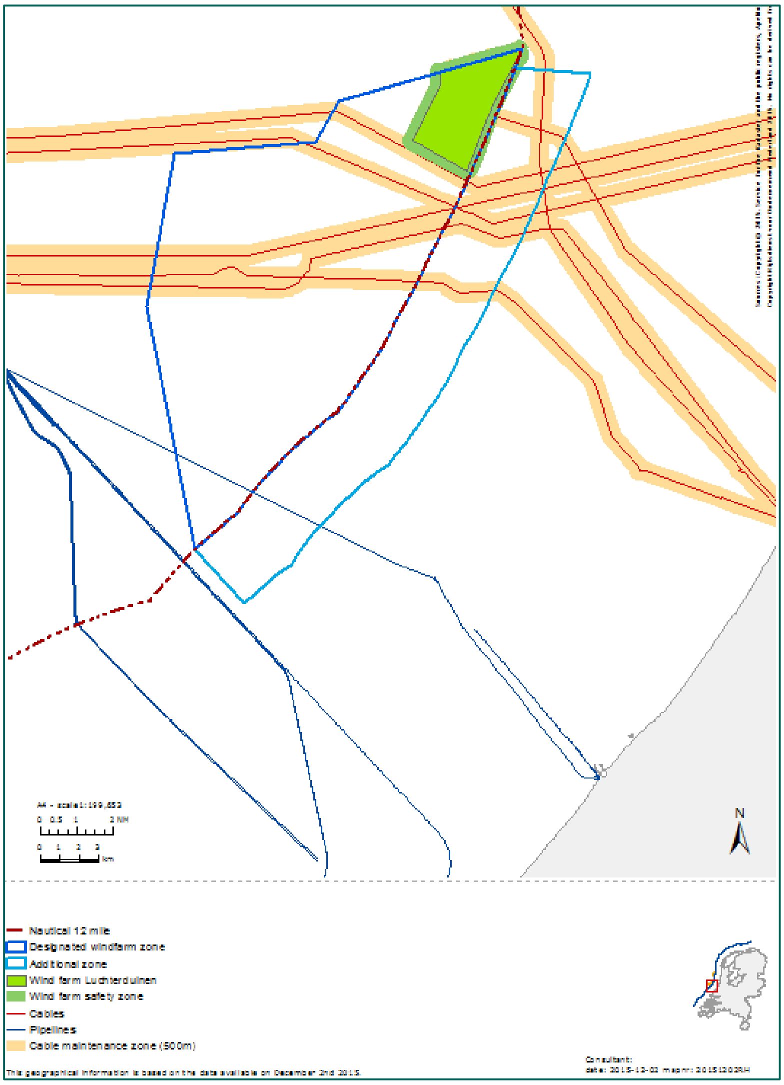

Figure 2: The Hollandse Kust (Zuid) wind farm zone investigation area.

The wind farm zone of approximately 356 km^2 will be sub-divided into four wind farm sites. In total, 1,400 MW offshore wind is planned in the zone, roughly 350 MW per site. The investigation area for this study also includes an additionally area of several kilometres around specified Hollandse Kust (Zuid) wind farm zone.

1.3 PURPOSE AND MAIN OBJECTIVES

The purpose of the UXO desk study is to get insight in the areas in the Hollandse Kust (Zuid) wind farm zone with an increased risk of encountering unexploded ordnances (UXO's).

The main objectives of this study are:

1. Identification of possible constraints for offshore wind farm related activities in the Hollandse Kust (Zuid) wind farm zone as a result of the presence of UXO's.
2. Identification of areas within the Hollandse Kust (Zuid) wind farm zone that should preferably not be used for the installation of offshore wind farms and/or cables.

3. Identifying the requirements from UXO perspective that should be taken into account for:
   a. Determining the different concession zones in the wind farm zone.
   b. Carrying out safe geophysical & geotechnical investigations.
   c. Installation of wind turbine foundations.
   d. Installation of cables.

1.4 STRUCTURE OF THE REPORT AND TOPICS ADDRESSED IN EACH CHAPTER

This report describes phase I (historical research) and phase II (UXO risk assessment) of the UXO risk management process. These phases are rendered within the red rectangle. The UXO risk management process is shown in Figure 3 (see Figure 27 on page 72 for a larger image). The execution of the following phases of the UXO risk management process is the responsibility of the future developer.

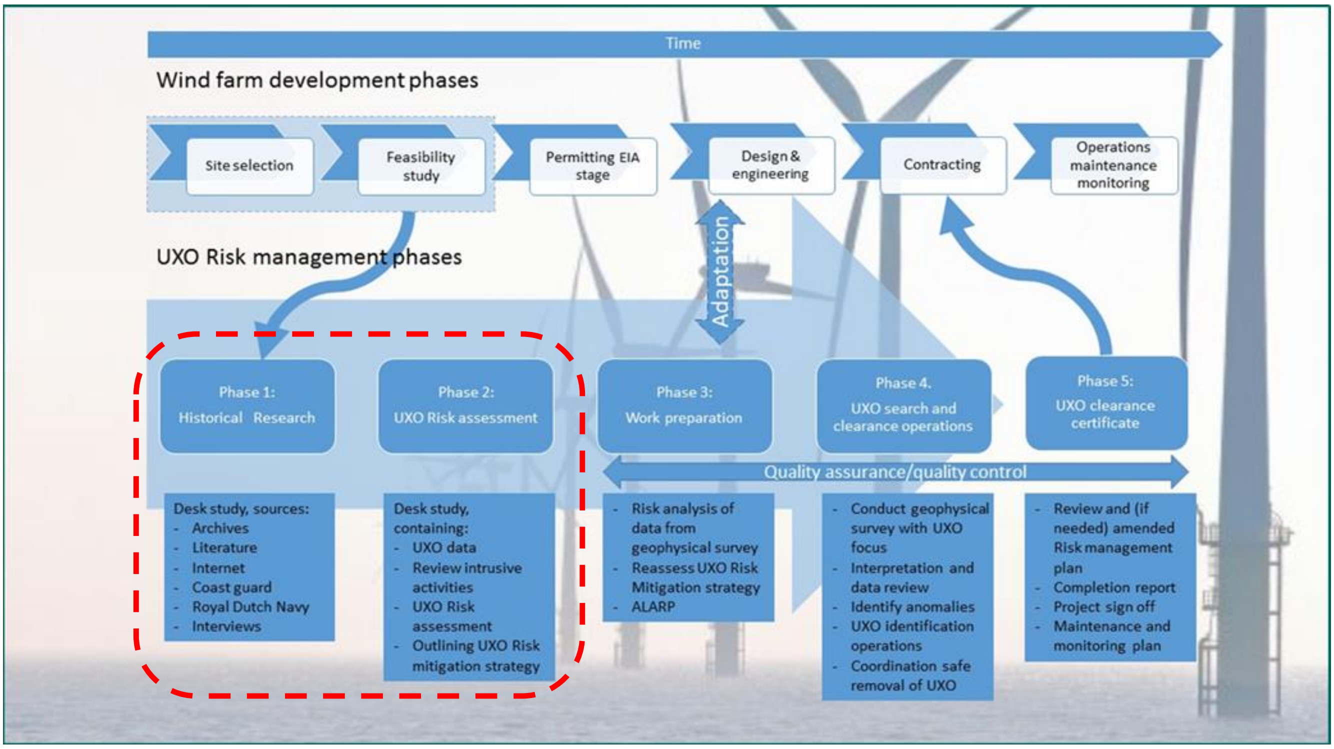

Figure 3: UXO risk management phases.

The structure and content of this report is as follows:

- Chapter 2:
  At first a historical research is conducted to determine if UXO are to be expected in the Hollandse Kust (Zuid) wind farm zone as a result of war related activities, and to define the type of UXO to be expected.

- Chapter 3:
  In this chapter the types of UXO likely to be encountered are described. This information is crucial for defining the hazards and effects of the expected UXO due to the intrusive activities needed to realise the wind farm.
- Chapter 4:
  In this chapter the effects of underwater detonations and chemical warfare agents are given. These effects on vessels, equipment, constructions, crew members and surroundings will determine the level of risk during the preparation phase (site investigations), execution phase (construction works) and operational phase (maintenance) of the wind farm development.
- Chapter 5:
  The level and nature of UXO risks will amongst other things, depend upon the intrusive activities in the area and the nature of the proposed works. Therefore all possible intrusive survey, construction and maintenance activities during the preparation, execution and operational phases of the Hollandse Kust (Zuid) wind farm zone are summarized.
- Chapter 6:
  This chapter provides the characteristics of the wind farm zone relevant for defining the UXO mitigation strategy and the selection of appropriate survey techniques.
- Chapter 7:
  The possible presence of UXO in the wind farm area, is no constraint for offshore wind farm related activities. With proper UXO Risk Management the risks can be reduced to a level that is as low as is reasonably practicable (ALARP). Chapter 7 provides the outline of the UXO risk mitigation strategy.
- Annex 1:
  This annex provides an overview of reference documents.
- Annex 2:
  This annex contains an overview of war related events

Historical research

2 HISTORICAL RESEARCH

In this chapter the results of the desk study will be presented. Although the Netherlands remained neutral during the First World War, this war also bears consequences for the Hollandse Kust (Zuid) wind farm zone. Therefore both wars are described in this chapter. The information is drawn from literature, open source information, military information, information derived from the client and a plethora of archives (for references see Annex 1). The war related activities are analysed in chronological order, starting with World War I and World War II, followed by analyses of UXO-dumping and UXO clearance activities in the post-war period.

The historic research is conducted according to the guidelines of the WSCS-OCE, the "Werkveld Specifiek Certificatie Schema – Opsporen Conventionele Explosieven (WSCS-OCE)". The WSCS-OCE regulates the entire field of EOD-operations and includes the basic requirements of historical research. The basic requirements consist of compulsory historic resources, guidelines for defining UXO risk areas and requirements for traceability of historical research.

The WSCS-OCE guidelines concerning historical desk studies mostly apply to land-based UXO-research, and are only partially applicable to offshore historical research. Some compulsory historical sources, like municipal archives, military maps and aerial photography, do not offer relevant information for this particular project. As a result, these non-applicable sources have not been consulted. Sources specifically applicable to naval warfare have, on the other hand, been consulted. These sources include offshore UXO clearance reports, hydrographic maps and naval minefield charts. The guidelines for defining risk areas are not applicable on offshore desk research either, since the guidelines are based on definable targets. Since the locations of most of the relevant World War I and World War II combat action cannot be traced back, these guidelines are not valid in this study. The risk areas are rather situationally delineated based upon historic evidence, comprehensive historic analyses and the sparsely available location indications. The requirements for traceability of historic sources have been met in the most systematic and thorough possible way.

Aim of the historical research is to determine if UXO are to be expected in the Hollandse Kust (Zuid) wind farm zone as a result of war related activities. The objective is to identify (if possible) areas within the Hollandse Kust (Zuid) wind farm zone that preferably should not be used for the installation of offshore wind farms and/or cables. The secondary objective is to define the type of UXO to be expected. This information is crucial for defining the hazards (see chapter 3) and effects of the expected UXO (see chapter 4).

2.1 WORLD WAR I

World War I, also known as the First World War or the Great War, was a global war centred in Europe that began on 28 July 1914 and lasted until 11 November 1918. The Allied Powers, including the United Kingdom, France, Russia and the United States of America, fought the Central Powers, led by Germany, the Austrian-Hungarian Empire and the Ottoman Area. During the war, the Netherlands maintained a policy of neutrality. The warfare between the Central and the Allied Powers on the North Sea nevertheless had its influence on the surroundings of the Hollandse Kust (Zuid) wind farm zone, especially due to the laying of naval mines in the North Sea and naval combat. There is little specific information on war related activities in (the direct vicinity of) the Hollandse Kust (Zuid) wind farm zone. The only activity that can be traced back to the vicinity of the investigation area is a sea battle on September 22nd 1914.

In this sea battle three British cruisers - the Aboukir, Cressy and Hogue – were sunk by a single German U-boat, U-9 (see paragraph 2.1.3). Both the minelaying and naval combat are analysed in this paragraph.

2.1.1 Naval mines

Naval Warfare in World War I was mainly characterised by the efforts of the Allied Powers, with their larger fleets and surrounding position, to blockade the Central Powers by sea, and the efforts of the Central Powers to break that blockade or to establish an effective blockade of the United Kingdom and France with submarines and raiders. The North Sea was a major theatre of the war. The British Grand Fleet took position against the German High Seas Fleet. Britain's larger fleet could maintain a blockade of Germany, cutting it off from overseas trade and resources. The German fleet remained mostly in the harbours behind a screen of mines, occasionally attempting to lure the British fleet into battle. It was the blockade of German commerce through the North Sea, which ultimately starved the German people and industries and contributed to Germany seeking the Armistice of 1918.

During World War I, mines were used extensively to defend coasts, coastal shipping, ports and naval bases around the globe. The Germans laid mines in shipping lanes to sink merchant and naval vessels serving Britain. The Allies targeted the German U-boats in the Strait of Dover and the Hebrides. In an attempt to seal the northern exits of the North Sea, the Allies developed the North Sea Mine Barrage. From June to October 1918 almost 70,000 mines were laid by the United States Navy, blocking the North Sea's northern exits.

The total number of mines laid in the North Sea, the British East Coast, Straits of Dover, and Heligoland Bight is not known. Estimations vary from approximately 200,000 to 650,000. Figure 4 shows a naval mine map from 1918.

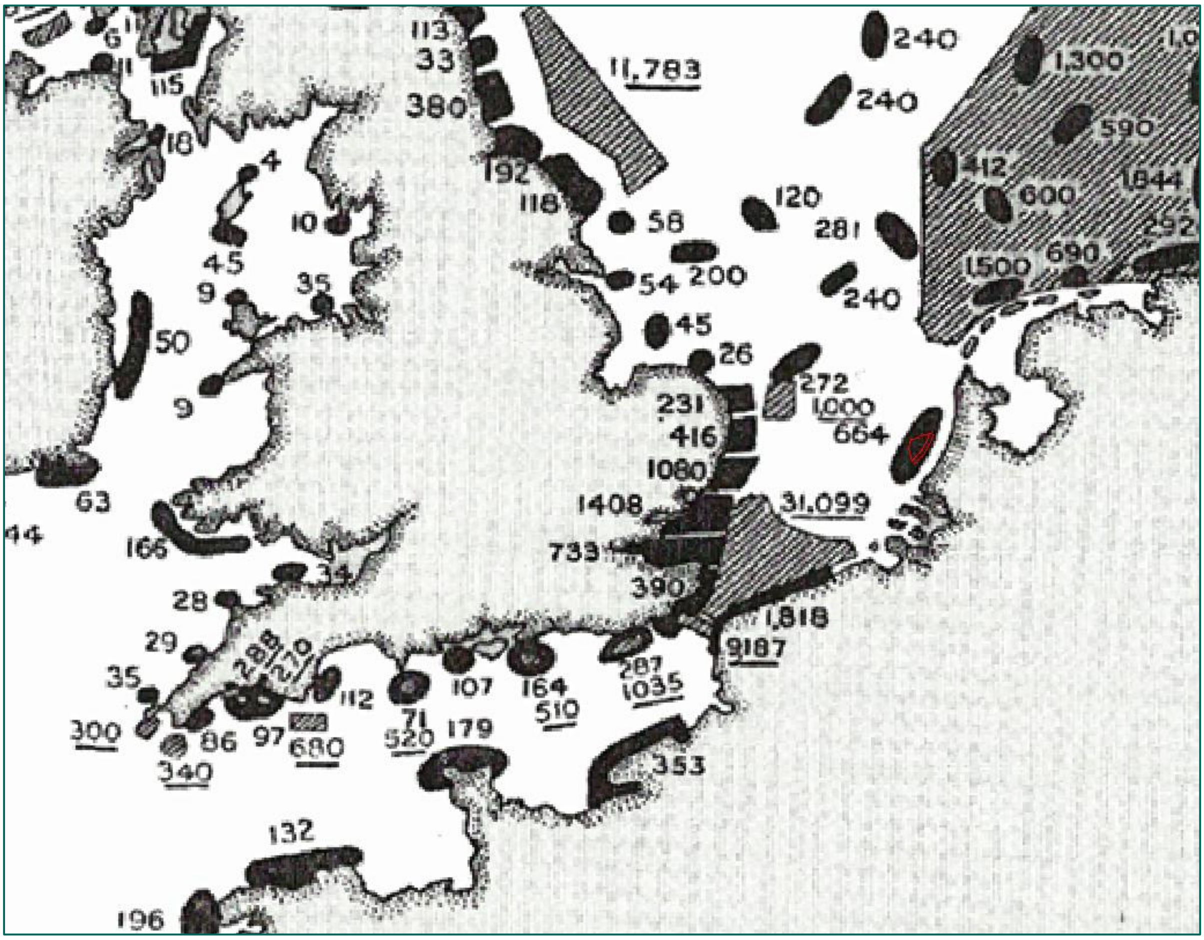

Figure 4: Map of mines laid during World War I [15].
Black shapes denote the German laid mines. Grey shaped denotes the Allied laid mines. Underlined numbers are the number of mines laid by the Allies, the other are German number of mines. The Hollandse Kust (Zuid) wind farm zone is displayed within the red line.

In (the vicinity of) the Hollandse Kust (Zuid) wind farm zone two German minefields were present. Specific information about the number and type of mines laid is not available. In Figure 5 the locations of the known minefields are shown. The locations of mentioned mine fields are also shown in Annex 2.

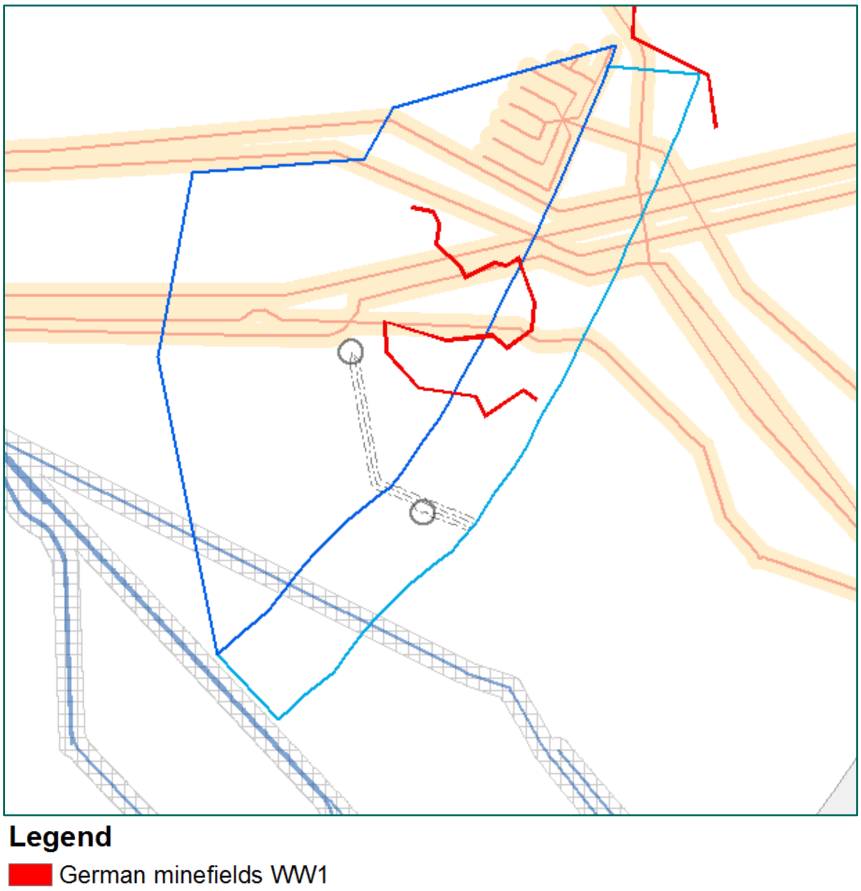

Figure 5: German mine fields World War I [35].

As a result, some mines may migrate due to tidal and other weather and seabed mobility factors. Records kept by the Dutch authorities during WWI show that almost 6,500 mines drifted into neutral coastal areas of the Southern Netherlands during the four years of war.

Unfortunately, wartime records concerning mine laying and mine clearance are not always particularly accurate. While it is clear that mine sweeping operations were undertaken post 1918, the precise extent and success rate is not known. Similar clearance operations were conducted during and post-WWII, during which an estimated 10% to 25% of all laid mines were rendered safe. Clearly, a significant number of mines were not accounted for, which may pose an offshore threat to this day.

Conclusion

In WOI two German mine fields were present in the Hollandse Kust (Zuid) wind farm zone. Specific information about the number and type of mines laid is not available. Despite mine sweeping operations undertaken post 1918, the presence of WOI naval mines cannot be ruled out.

2.1.2 Naval warfare

On patrol on September 22th 1914 were three cruisers of the Royal Navy's 7th Cruiser Squadron: Aboukir, Hogue, and Cressy. A fourth cruiser, Euryalus, had returned to port for refuelling on the 20th. The squadron's accompanying destroyers had been forced to depart by heavy weather on the 17th.

U-9 had been ordered to attack British transports at Ostend, but had been forced to dive and shelter from the storm. On surfacing, she spotted the British ships and moved to attack. The location was approximately eighteen sea miles northwest of the Hook of Holland [9].

At 06:20, the submarine fired one torpedo[3] at the nearest ship from a range of 500 m, which struck Aboukir on the starboard side under one of her magazines. As a consequence, the UXO in the magazines detonated, causing a large amount of damage to the ship [9]. The engine room flooded, causing the ship to come to a halt. No submarines had been sighted, so the commander assumed that the ship had hit a mine, and ordered the other two cruisers to close in to help. After 25 minutes, Aboukir capsized, sinking five minutes later. Only one lifeboat could be launched, because of damage from the explosion and the failure of steam-powered winches needed to launch them.

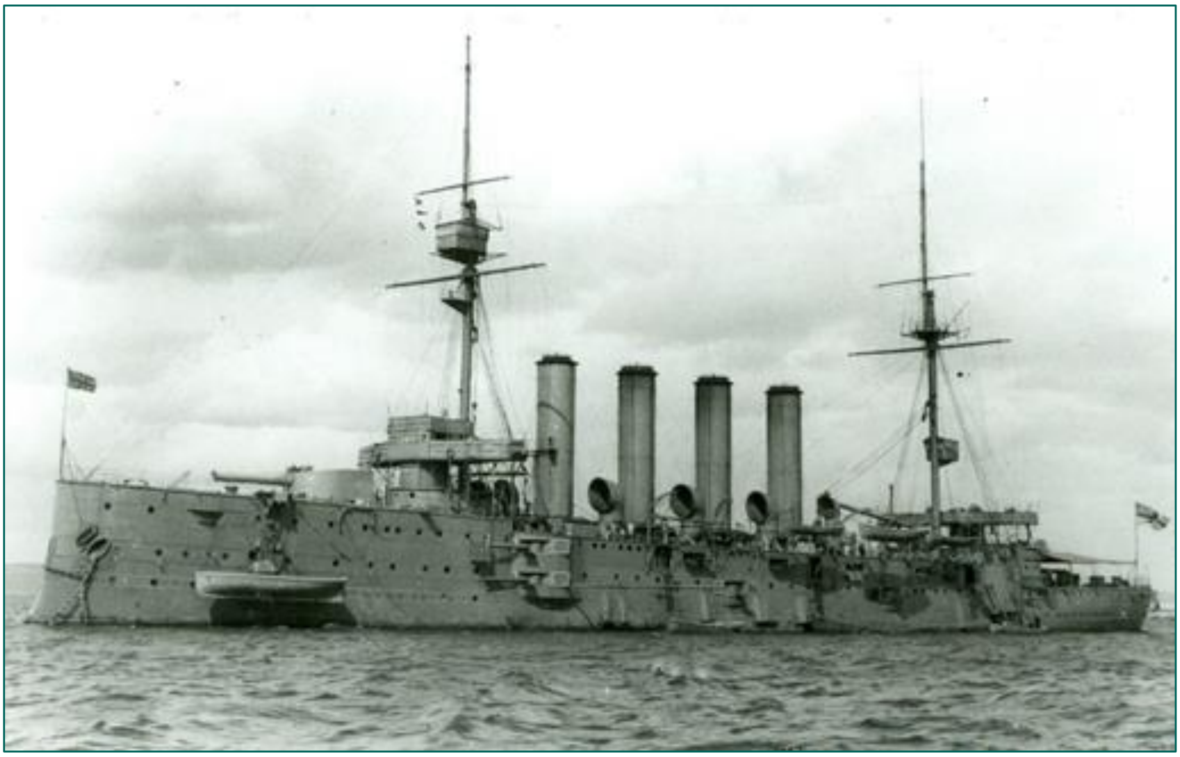

Figure 6: HMS Aboukir [27].

U-9 rose to periscope depth from her dive after firing the initial torpedo to observe two British cruisers engaged in the rescue of men from the sinking ship. U-9 fired two more torpedoes at his next target, Hogue, from a range of 270 m. As the torpedoes left the submarine, her bow rose out of the water and she was spotted by Hogue, which opened fire before the submarine dived.

3 A torpedo is a self-propelling explosive charge that stabilizes itself in the water. The course is the same as the flight direction. It can reach a speed of 70 km/hour and is equipped with a contact fuse for detonation on impact. Torpedoes struck the ships where they were most vulnerable, just beneath the waterline.

The two torpedoes struck Hogue. Within five minutes, the captain gave the order to abandon ship. After 10 minutes the ship capsized and subsequently sank.

Five minutes later U-9 fired two torpedoes from her stern torpedo tubes at a range of 910 m. One missed, so the submarine turned to direct her one remaining bow torpedo toward Cressy, and fired at a range of 500 m. Cressy had already seen the submarine, had opened fire and attempted to ram, but failed. The ship had then returned to picking up survivors.

One torpedo from the first attack struck the starboard side. The torpedo from the second attack struck the port beam. The ship capsized to starboard and floated upside down. Before sinking it is believed the cruiser fired its 9.2 inch (234 mm) gun at two Dutch fishing trawlers nearby. Others sources report that not one of the three cruisers had been able to use any of its big guns [9].

The three ships sunk outside of the Hollandse Kust (Zuid) wind farm zone. One torpedo missed its target. It is not known in which direction this torpedo was fired. Possibly the 9.2 inch guns were used. The torpedo and Artillery shells of the 9.2 inch gun could have ended up in the wind farm zone.

<u>Conclusion</u>
The naval combat took place in the direct vicinity of the area of investigation. The exact location of the war related activities is not traceable. However, it cannot be ruled out that UXO derived from World War I naval warfare have ended up in the wind farm zone. It concerns UXO of torpedoes and Artillery shells up to 9.2 inch calibre.

2.2 WORLD WAR II

The Second World War, also known as World War II, was a coalescence of several initially separate military conflicts. The war was fought between the Allied forces and the Axis powers on a global scale in the period from 1939 until 1945. Several war related activities took place near the Hollandse Kust (Zuid) wind park zone. These include aerial attacks by both the German and the Allied air forces, air crashes, extensive minelaying by the belligerent nations and naval warfare resulting in sunken ships. The locations cited in the historic sources are often imprecise, mentioning ‘off the coast of IJmuiden’ or ‘near Scheveningen’. For this reason, a broad selection of war related in World War II activities is analysed in this paragraph.

2.2.1 Flight path of the Allied bomb raids

Air warfare was a major component of World War II. Germany and Japan depended on air forces that were closely integrated with land and naval forces; they downplayed the advantage of fleets of strategic bombers, and were late in appreciating the need to defend against Allied strategic bombing. By contrast, Britain and the United States took an approach that greatly emphasized strategic bombing, and to a lesser degree, tactical control of the battlefield by air, and adequate air defences. They both built a strategic force of large, long-range bombers that could carry the air war to the enemy's homeland.

An around-the-clock campaign attacked Germany, with British bombers at night and U.S. aircraft during the day. From 1942 onward, the intensity of the British bombing campaign against Germany became less restrictive, increasingly targeting industrial sites and eventually, civilian areas. By 1943, the United States had significantly reinforced these efforts. The controversial fire bombings of Hamburg (1943), Dresden (1945), and other German cities followed.

The German 'Ruhrgebied', al large industrial zone, was a main target in many Allied bombings. The Hollandse Kust (Zuid) wind farm zone is located just north of the main flight path of the Allied bomb raids. The Allied aircrafts were attack by German Night Fighters, FLAK (abbreviation of Flugabwehrkanone) ships and intensive FLAK on the Dutch coast line. As a consequence a large number of airplanes were shot and crashed in the North Sea (see paragraph 2.2.4). Also many bombs were dropped above the North Sea, for example by Bombers damaged by FLAK or German Night hunters or aircrafts returning to England who still had bombs aboard. As a consequence a large amount of aerial bombs are encountered annually (see paragraph 2.4). Bombs are encountered in large parts of the North Sea, including the (surroundings of the) Hollandse Kust (Zuid) wind farm zone.

2.2.2 Aerial attacks by the German Luftwaffe

On the 12th of May 1940 a single German bomber attacked the cargo ship Sembilan. The ship, on her way to England, was attacked approximately 15 miles southwest of IJmuiden [33, page 46] [43, page 22]. The type and calibre of the used bombs is unknown.

Conclusion

The attack on the Sembilan took place in the direct vicinity of the area of investigation. The exact location is not traceable. However, it cannot be ruled out that UXO derived from this attack ended up in the wind farm zone. It concerns UXO of bombs with unknown calibre.

2.2.3 Aerial attacks on ships by Royal Air Force (RAF)

The Royal Air Force consisted of different Commands or aerial fleets. Each Command had its own duties. Most important were Coastal Command, Bomber Command and Fighter Command. Coastal Command was responsible for battles over sea. The planes of this aerial fleet protected friendly convoys, patrolled the coasts and seas in search for enemy submarines and war vessels and attacked enemy convoys and ships.

During the early years of the war, bombers of Bomber Command also carried out attacks on ships near the Dutch coast. In general Bomber Command primarily carried out attacks in Germany or in German occupied territory. This included attacks on military targets (airports, ammunition storages, barracks etc.) and non-military targets (harbours, railways, factories etc.). Due to clouds, it could occur that bombers were not able to locate their targets. On the return to England, the bomb load was often dropped in the North Sea, because it was safer to land without this load.

Fighter Command was responsible for the defence of the English airspace against enemy bombers. Over the course of the war, Fighter Command became more involved in offensive actions. Moreover the fighters escorted bombers and planes of Bomber and Coastal Command to protect them against enemy fighters. They also carried out offensive reconnaissance and patrol flights. During those missions the pilots had great liberty and could decide what to do as they encountered possible targets, such as ships or convoys.

Most attacks on ships and convoys were conducted by planes of Coastal and Bomber Command and occasionally by Fighter Command.

A ship is a relative small and moving target, hence difficult to hit with bombs. For allied pilots the only certitude to strike a ship, was by flying quite low and dropping the bombs just above the ship. This means that planes had to fly a few meters above the sea and had to pull up in front of the target.

The bombs hit the ship shortly after and were therefore equipped with a time delayed fuse, so the pilots would have enough time to get to a safe distance before detonation [40] [41] [42]. This tactic made airplanes vulnerable for the ships anti-aircraft guns. Notwithstanding the pilot's courage, sinking ships was quite difficult. Furthermore, the planes could only carry bombs of smaller calibres, like 100 lbs, 250 lbs and 500 lbs.

More effective were attacks with torpedoes. Torpedoes were dropped from planes flying less than 30 meters above the sea, about 600 meters distance from the target [40] [41] [42].

From 1940 onwards Coastal and Bomber Command attacked (German) ships and convoys in the various theatres of war, using bombs, rockets and torpedoes. Also in the vicinity of the Hollandse Kust wind farm zone several attacks took place. The exact location of the attacks is often not known.

To position the locations of the attacks the Operations Record Books of Coastal Command were consulted[4]. For pilots however, the North Sea does not provide many reference points. Mostly, pilots referred to the 'Dutch coast'. In a few occasions a position is given, e.g. 5207 North 0405 East, but this is not very accurate either.

The books *Oorlogsstorm over zee en havens, IJmuiden 1939-1946* [53] en *En nooit was het stil, kroniek van een luchtoorlog* [8] mention several attacks. The German Kriegsmarine[5] (the navy of Nazi Germany from 1935 to 1945) confiscated Dutch trawlers. These ships were modified and used for military purposes. Some ships were outfitted with a radio transmitting device and a wireless operator on board. For this reason many trawlers were attacked by Allied airplanes. The relevant occurrences are presented in table 2.

Date	Description
July 5, 1940	Blenheim Bombers (Bomber Command) attacked a convoy south of Den Helder. An escorting ship was hit. Due to the attack, the convoy splitted up [28].
January 17, 1941	Between 13.25 and 13.47 hours, four Beauforts and three Blenheim Bombers (Coastal Command) attacked a convoy of four carriers and three Anti-aircraft ships. The attack took place approximately 7 miles out of the coastline at IJmuiden. There were direct hits on two carriers and two near misses. Around 13.26 hours one of the Beauforts attacked a convoy about 15 miles southwest of IJmuiden. The convoy consisted of one destroyer, four larger carriers and 26 smaller ships. Probably one of the smaller ships was hit. German reports indicated that seven airplanes attacked a convoy between Noordwijk and Zandvoort. Two tugs and a ship were damaged [28].
March 22, 1941	Six Blenheim bombers (Bomber Command) spotted a convoy of 15 ships near IJmuiden. One bomber carried out an attack. The bombs straddled one of the ships [28].
March 25, 1941	Five Blenheims attacked several ships near the Dutch coast. One Blenheim attacked a ship 7 kilometres North West of Egmond aan zee. One near miss was reported. Five Blenheim bombers (Bomber Command) attacked ships near the Waddeneilanden and the Dutch coast. One Blenheim attacked a grey motor ship (length: approximately 70 meters) 7 km northwest of Egmond. There were several near misses [8, part 1, page 123] [43, page 55].

4 These records are kept in The National Archives (Londen).
5 The navy of Nazi Germany from 1935 to 1945.

Date	Description
March 26, 1941	The Belgian Trawler Mar del Plata was attacked. The ship was located south west of IJmuiden. It was attacked by Allied airplanes and struck by a torpedo [43, page 67].
March 26, 1941	A Beaufort on patrol torpedoed a 6,000 tons ship in a convoy of 13 ships about 30 km southwest of IJmuiden. One torpedo was fired but no results were observed [28].
May 11, 1941	The Dutch trawler Vios was attacked by Allied bombers. The ship was struck and subsequently sank [43, page 115].
June 9, 1941	Eighteen bombers were detailed to attack ships. One Wellington bomber observed an unescorted convoy of 14 ships heading north about 30 km west of Den Haag. One bomb was dropped and came down ahead of the ships [8, part I, page 206].
June 20, 1941	Blenheims of Bomber Command attacked ships near Den Helder and Den Haag. Outside the coast of Den Haag a 360 ton trawler was attacked by two planes. Later that day a Dutch trawler, named Sursum Corda was bombed and sunk by airplanes [43, page 53].
July 7, 1941	Eleven Blenheim bombers (Bomber Command) were detailed to The Hague area. The bombers attacked a convoy of eight carriers and four anti-aircraft ships. Claims: three 4,000 tons ships destroyed, one 2 to 3,000 tons ship destroyed and one 2,000 tons ship destroyed [8, part I, page 223].
July 19, 1941	Eleven Blenheim bombers (Bomber Command) attacked a convoy 12 km northwest of The Hague. Three 6,000 tons carriers and one 4,000 tons carrier are destroyed. The 6,000 tons carriers were hit by two or more bombs and were left in thick black smoke. All four bombs of one Blenheim came down on the rear of the 4,000 tons carrier. One anti-aircraft ship was also attacked and hit [8, part I, page 230].
July 23, 1941	The Margaretha Cornelia was sunk by Blenheims of the Bomber Command. The attack took place approximately 8 to 9 miles out of the coastline at Camperduin. Two airplanes were lost [43, page 55]
October 21, 1941	Blenheim bombers (Bomber Command) were detailed to attack a convoy about 8 km west of IJmuiden. Blenheims attacked one 2,000 tons and one 4,000 tons ship and a 2,000 tons tanker. Results were not observed. Two other bombers attacked a 4,000 tons and 1,000 tons ship and were shot down by anti-aircraft guns shortly after the attack [28].
November 11, 1941	The Dutch trawler Vios IV was lost. The ship was bombed several miles off the coast of IJmuiden. The position of the attack was 52 gr. 33 min. north and 4 gr. 19 min. east. The ship was attacked with bombs and cannons [43, page 55].
November 27, 1941	The trawler Delft was attacked by Allied bombers. The ship was hit and sank outside Noordwijk [43, page 113].
May 4, 1942	Coastal Command attacked a German convoy with six Hudsons. The attack took place west of IJmuiden (German location QA AN 8531). The convoy was attacked with bombs and cannons. No hits were observed. A reasonable amount of FLAK was reported, from the ships and the coast. One of the Hudsons was lost and crashed in the sea west of the convoy. German sources report that the Sizilien was hit and sank soon after the attack. The Norwegian ship Troma ran into a minefield while avoiding the bombs. She struck a mine. Although the front hold flooded, she managed to resume the journey to Rotterdam. The steering mechanism of the Tarnholm was damaged by fragments of bombs detonating nearby. The Jantje Fritzen was also severely damaged [43, pages 75, 78].
May 4, 1942	Six Hudsons were detailed to a convoy near IJmuiden. The attack was carried out with bombs (no hits) and cannons [8, part I, page 351].

Date	Description
October 1,2 1942	During the night a Hudson (Coastal Command) attacked a convoy near IJmuiden. An explosion was observed [8, part I, page 410].
February 18, 1943	During the evening six Hudsons with bombs, four Beaufighters and six Hampdens with torpedoes attacked two convoys. Four Hudsons scored two direct hits and one near miss on ships near IJmuiden.
June 22, 1943	Three Squadrons of Spitfires (Fighter Command) made rendezvous with Beaufighters (Coastal Command) and attacked a convoy near Scheveningen. The convoy was heading south and existed of ten carriers and fourteen escort ships. Twelve Beaufighters dropped torpedoes from a distance of about 1,000 to 1,500 yards. Results were not observed. At least five escorting ships were sunk after being attacked with rockets by Beaufighters. Two Beaufighters were shot by anti-aircraft guns and, unable to drop their torpedoes, crashed in the North Sea. All torpedoes missed their targets. This was the first attack ever of Beaufighter with 60 lbs rockets [8, part II, page 26] [28, AIR 27/1515] [5, no's. T2489 and T2490].
June 27, 1943	Four Spitfire Squadrons (Fighter Command) escorted Beaufighters (Coastal Command) for an anti-shipping attack near The Hague. The Beaufighters, equipped with rockets, attacked a convoy of six carriers and eight escorting vessels. The attack was carried out around 15.04 hours [8, part II, page 29] [28, AIR 27/978] [5, no. T2613G].
February 12,13, 1944	During the night a Beaufighter (Coastal Command) on patrol attacked a 4/5,000 tons ship 7 miles north of IJmuiden. A torpedo was dropped and probably struck the carrier. [28, AIR 27/1341] [5, no. T1405].
March 26, 1944	The Dutch ship Adriana was seized by Germany. The ship was renamed Holland Hafenschurz IJmuiden by the Kriegsmarine. On the 26th of March 1944 the ship was bombed and lost [43, page 131].
April 19,20, 1944	During the night a Wellington Bomber (Coastal Command) on anti-shipping patrol attacked a convoy 15 miles southwest of IJmuiden. The convoy existed of eight ships. Five 500 lbs bombs were dropped. One was a direct hit on a 2,000 tons carrier [8, part II, page 199].
May 20, 21, 1941	In the night German records reported an attack on a convoy west of Katwijk [8, part II, page 217].
October 5,6, 1944	In the night three Beaufighters attacked a convoy of 10 to 15 ships near The Hague with 25 lbs rockets [8, part II, page 389].

Table 2: Aerial attacks on ships relevant for the Hollandse Kust (Zuid) wind farm zone

Figure 7: Attack on convoy on 27th June 1943 [8, part 2, page 30].

Figure 8: Aerial photograph of the attack on a convoy off The Hague on the 27th of June 1943 [28].

Conclusion
Multiple aerial attacks on ships and convoys took place in the direct vicinity of the area of investigation. The exact location of the attacks is not traceable. However, it cannot be ruled out that UXO derived from aerial attacks have ended up in the wind farm zone. It concerns UXO of torpedoes, bombs and Artillery shells (20 mm calibre).

2.2.4 Airplane crashes

During World War II a large number of anti-shipping and reconnaissance missions were carried out by Allied air forces. The Allied planes were frequently engaged by FLAK-ships, coastal FLAK-batteries and German airplanes. As a consequence a large number of airplanes crashed in the North Sea. Several airplanes crashed in the vicinity of the Hollandse Kust (Zuid) wind farm zone.

The 'Studiegroep Luchtoorlog 1939-1945' provides online data on aircraft losses that are somehow related to the Netherlands [6]. The online database remains a work in progress. It still is not complete, and a lot of data has not yet been entered into the database. At this moment (December 2015) the database holds some 7,000 aircraft registrations, including some 1,200 damaged aircraft (mostly German) considered to be repairable and almost 22,000 registrations on aircrew. In total 758 aircrafts have reportedly crashed in the North Sea. Several aircrafts are crashed near Scheveningen, Katwijk, Zandvoort and IJmuiden. Exact coordinates of the crashed planes are not available. The crash database only provides estimated distances, e.g. 30 kilometres out the Dutch coast west of Katwijk. Therefore crash locations are not very precise. Figure 9 gives an indication of crashed airplanes in (the vicinity of) the Hollandse Kust (Zuid) wind farm zone, based upon the descriptions of crash locations provided in the database. The accuracy of the displayed positions is estimated to be approximately 1-10 kilometres.

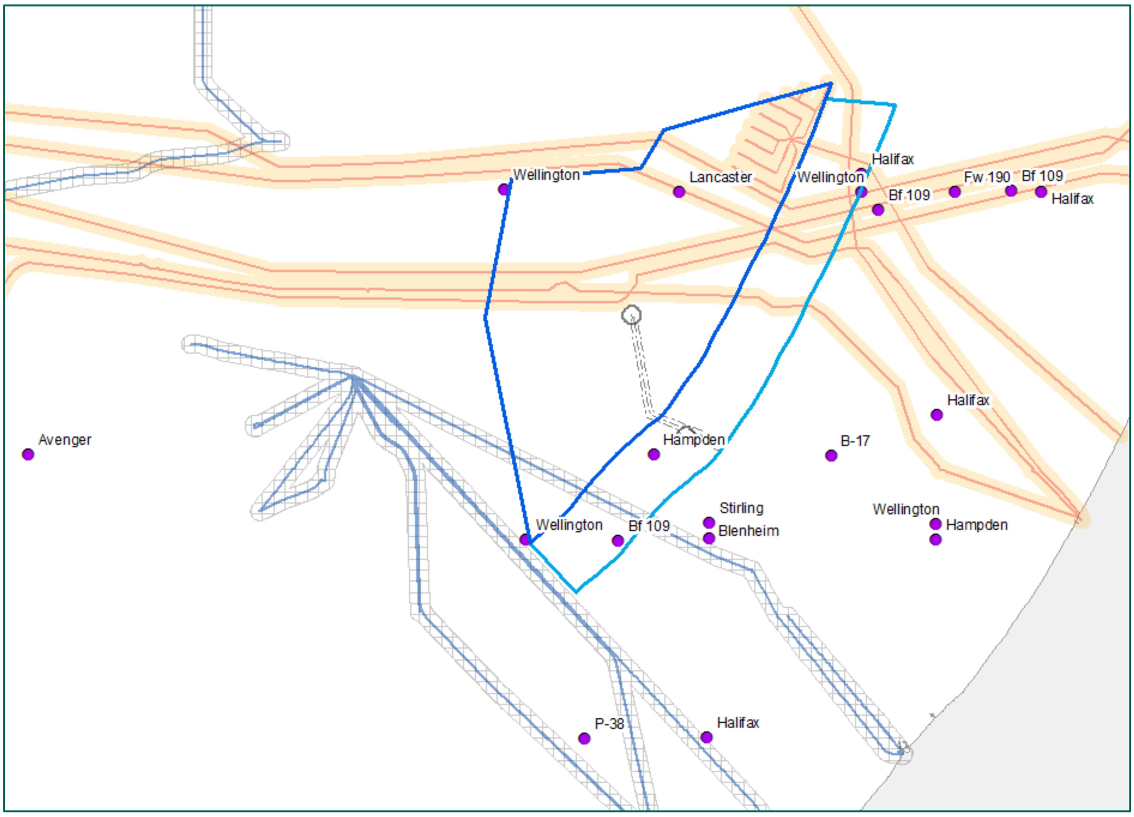

Figure 9: Airplane crashes (German and Allied). (Source: SGLO crash database).

Based on the number of crashed aircrafts the possibility of encountering (parts of) aircrafts has to be taken into account. An example is given in Figure 10. It shows a Dornier-17 bomber in the English Channel.

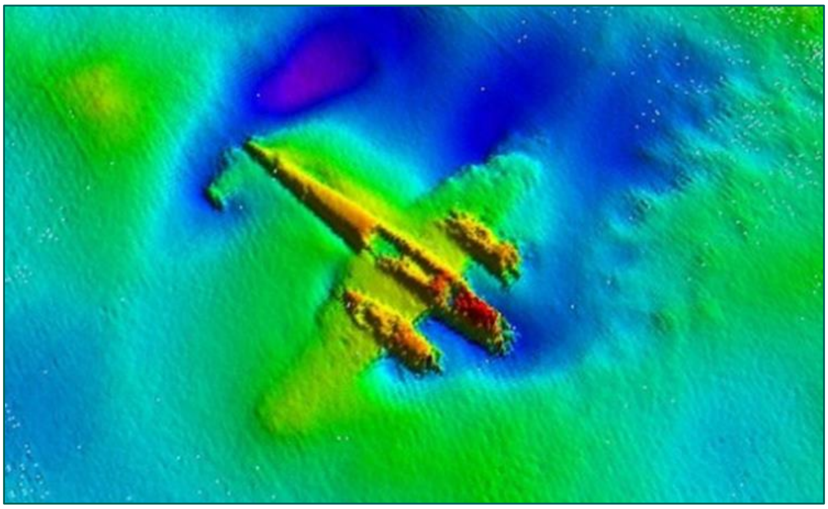

Figure 10: A scan of the sea bed in the English Channel shows the Dornier-17 German bomber, buried under sand since World War Two [16].

<u>Conclusion</u>
A large number of aircrafts crashed in the North Sea. Several planes crashed in the vicinity of the wind farm zone. Based on the number of crashed aircrafts the possibility of encountering (parts of) aircrafts has to be taken into account.

2.2.5 Naval warfare

At the beginning of the war much of the early action by German forces involved minelaying on convoy routes and ports around Britain. For defensive purposes Britain laid extensive minefields along the British coast. Initially, contact mines were employed, usually tethered at the end of a cable just below the surface of the water. By the beginning of World War II, most nations had developed mines that could be dropped from aircraft sunk to the bottom (LMB) and floated on the surface, making it possible to lay them in enemy harbours.

A large quantity of mines were used in the North Sea and the Dover Barrage. Figure 11 shows the British and German declared mine areas at the beginning of World War II.

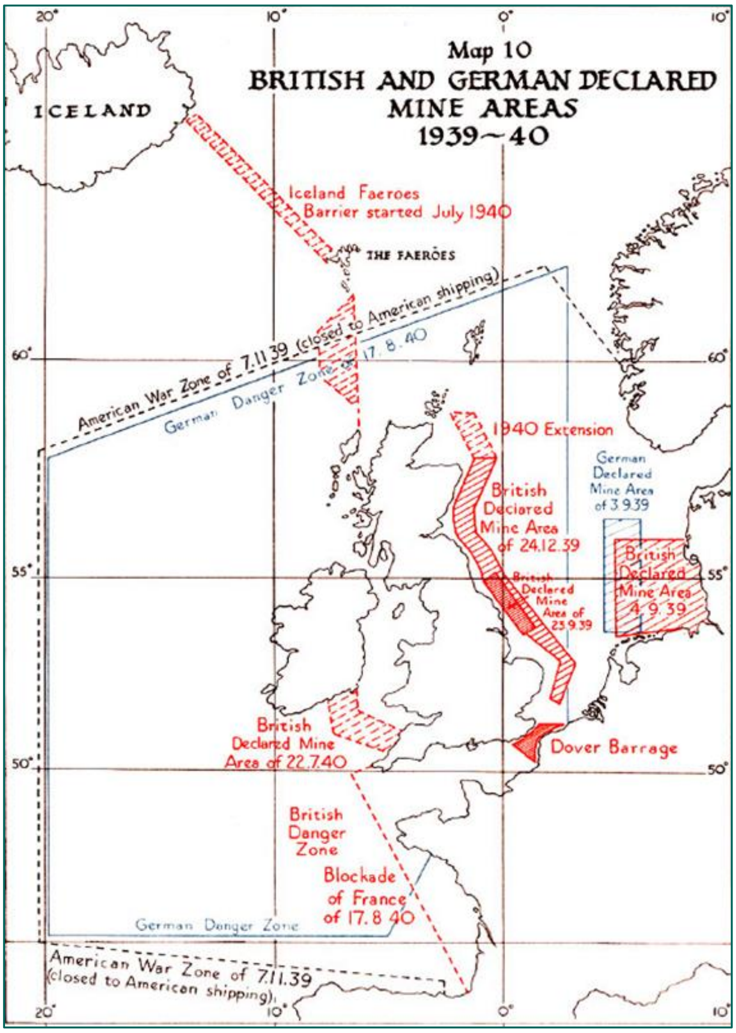

Figure 11: British and German declared mine areas 1939-1940 [39].

In May 1940 the German air force jettisoned magnetic mines in front of the harbour of IJmuiden. British minesweepers tried to clear the shipping lanes, but soon afterwards new mines were laid [14, page 23].

In May 1940, the British minelayer HMS Princess Victoria has laid a large minefield in front of the Dutch coast. A total of 236 mines were laid. The minefield was located approximately 5 miles of the coast of Castricum [43, page 22]. During the course of war many ships and vessels were lost due to naval mines (e.g. Cornelia Maria s, struck a mine near IJmuiden on the 1st of April 1941 and sank [43, page 126].

The trawler Limburgia was also seized by the Kriegsmarine. The ship was turned into a warship (outpost ship). On the 18th of April 1943 the ship was sunk by three motor torpedo boats northwest Scheveningen [43, page 114].

The Dutch trawler Witte Zee was seized by the German Kriegsmarine. The ship was turned into a warship (outpost ship). The ship was sunk by two British motor torpedo boats on the 15th of July 1944, west of IJmuiden [43, page116].

Three known minefields were (partly) situated in the Hollandse Kust (Zuid) wind farm zone [35]. These minefields are shown in Figure 12.

For offensive purposes, especially during World War II, many non-declared minefields were laid, e.g. aerial dropped German mines in the Thames estuary. Offensive minelaying proved to be much more successful then defensive minelaying. Therefore a large number of mines were laid by aircraft, surface ships and submarines.

Figure 15 (paragraph 2.4) shows that a number of naval mines were encountered in the vicinity of the known minefields. One naval mine was encountered within the wind farm zone.

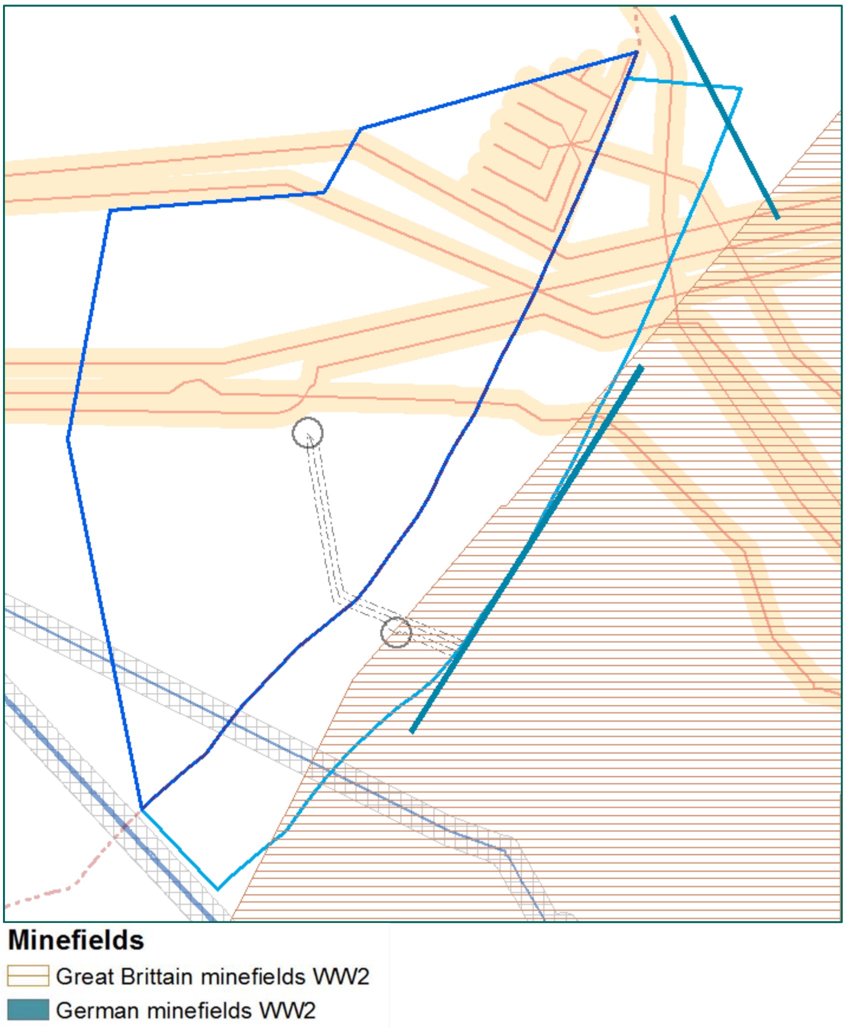

Figure 12: British and German mine fields [35]

The Second World War was, in terms of naval warfare, again mostly a submarine war on the German side. However, this time the emphasis was not in the North Sea but rather on the Atlantic. Also different from the previous war, the North Sea was no longer exclusively Allied territory. In this first years of the Second World War it was rather the stage for an intensive coastal war, featuring mainly small vessels like submarines, minesweepers, and Fast Attack Craft.

These vessels used torpedoes, depth charges and Artillery shells during combat on the North Sea. As a result rather large quantities of torpedoes, depth charges and Artillery shells are encountered in the North Sea.

Conclusion

In the Hollandse Kust (Zuid) wind farm zone three minefields were present. Since 2005 several naval mines were encountered in (the vicinity of) the wind farm zone. Due to the intensive minelaying in the North Sea, UXO from naval mines might be encountered. As a consequence of naval warfare it cannot be ruled out that UXO have ended up in the wind farm zone. It concerns UXO of torpedoes, depth charges and Artillery shells (up to and including 15 inch).

2.2.6 Ship wrecks

UXO risks can be generated by a variety of offshore sources. For example various vessel sunk during the course of WWII contained UXO, such as bombs and torpedoes. Merchant and naval vessels also transported munitions. While such wreck areas tend to be well charted, they can break up over the years, and their cargos may spill from them, contaminating the seafloor [31].

During the wars a large number of ships sunk in the North Sea. The 'Wreck map' [7] and the 'Wreck register' [22] provide an overview of known ship wrecks. The following known ships sunk in the vicinity of the Hollandse Kust (Zuid) wind farm zone because of war related activities:

- Houtrust
  This is likely the wreck of a German outpost ship. The wreck is named Houtrust because it lies in the vicinity of the "Houtrust" buoy [7].
- Sperrbrecher 147
  This ship was built in 1936 and named "Raket". After being damaged in a collision in the sluice-gate of Terneuzen is was repaired and renamed "Koert". The "Koert" was seized by the German forces. On the 21st of December 1940 the ship was deployed as Sperrbrecher NS VII (4e Sperrbrecher Flotille). On the 27th of May 1942 the ship struck a mine and sank [30] [33, page 247].
- Aspen
  The Swedish cargo ship Aspen SS was built in 1918 as the Norwegian cargo steamer Konsul Olsen SS. It was renamed several times. In 1936 it was renamed Aspen. The ship was sunk by aircraft on July 16th, 1941, outside IJmuiden [30].
- Cressy HMS, Hogue HMS and Aboukir HMS
  On September 22nd of 1914, U-9 (Ltn. Otto Weddigen) became world famous when she sank three 12.000 ton British cruisers in less than one hour: Aboukir HMS, Cressy HMS and Hogue HMS, with the loss of almost 1459 men [30].
- Delft
  In August of 1940 the Germans seized the Dutch fishing trawler Delft. At first the ship was used as a hospital ship. In 1941 the ship was handed over to the Kriegsmarine. The ship was turned into a warship (outpost ship). On the 27th of October the ship was bombed by Allied airplanes outside Noordwijk aan Zee and sank [32].

The wrecks mentioned above lie in the vicinity of the wind farm zone. The `Wrakkenregister´ provides an overview of all known (ship) wrecks, wreck remains and foul areas. Figure 13 shows all known wrecks, wreck remains and foul areas, a number of which lie within the wind farm zone. Houtrust, Sperrbrecher 147 and Aspen are located outside the displayed area.

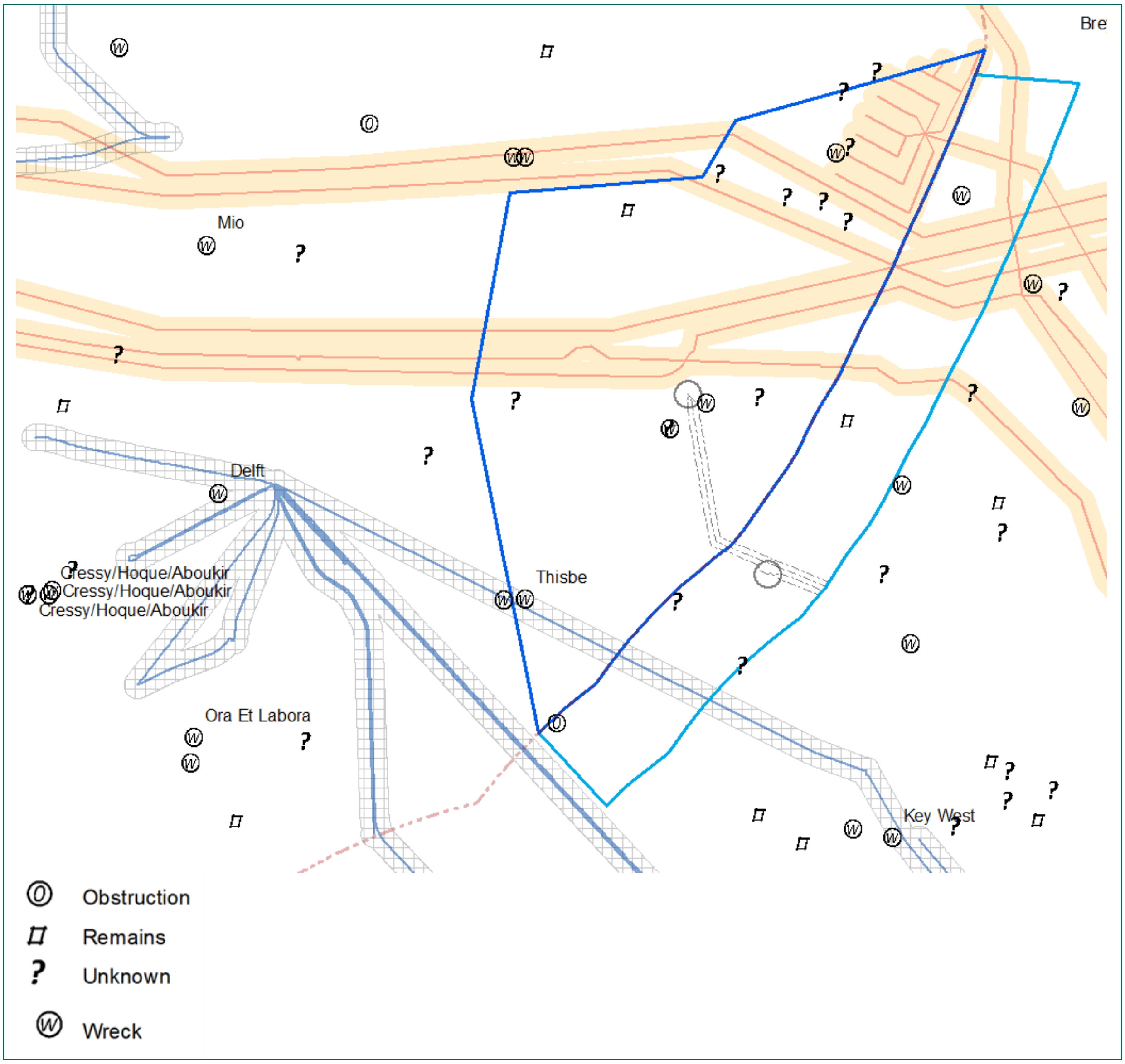

Figure 13: Location known wrecks, wreck remains and foul areas [7, 32].

The locations of mentioned wrecks, wreck remains and foul areas are also shown in Annex 2.

Conclusion

In the vicinity of the wind farm zone several ships sunk because of war related activities. Several wrecks and wreck remains are present in the wind farm zone. The origin of these wrecks is unknown. As a result of the many aerial attacks on ships and airplane crashes it cannot be ruled out that the wrecks are war related and UXO are present on the wreck locations.

2.3 AMMUNITION DUMP SITE

At the end of World War II the surface of the Netherlands was littered with large amounts of AXO (abandoned explosive ordnance). In the years 1946-1948 some 200.000 tons of ammunitions were gathered. Ammunition that could not be transported was demolished by detonation on site. All AXO that could not be re-used were prepared for dumping at sea. The dumping of AXO at sea was considered to be an acceptable solution in order to limit the dangers of contact with AXO.

The dumping was executed under the auspices of English Forces by the Royal Netherlands Navy with help of German prisoners of war. In 1946 the responsibility for the dumping activities was handed over to the Dutch authorities. Several ministries were involved, including the ministry of General Affairs and the ministry of War [29] [46].

The dumping took place on two locations in the North Sea - at the height of Hoek van Holland and IJmuiden - and in the Oosterschelde [34, 45]. The dumping sites are located approximately 30 to 40 kilometres out of the coastline. Between September 1945 and June 1946 10,000 tons of AXO were dumped under responsibility of the British [46] at the dump site Hoek van Holland. Under responsibility of the Dutch authority 6,000 tons of AXO were dumped at IJmuiden and 5,400 tons at Hoek van Holland [46]. These amounts do not include AXO dumped by the Navy [46]. In total approximately 30,000 tons of AXO were dumped in the IJmuiden dump site [29]. The total amount of AXO in the Hoek van Holland dump site is unknown [29]. Since the 1st of January 2013 no shipping is allowed over the dump sites.

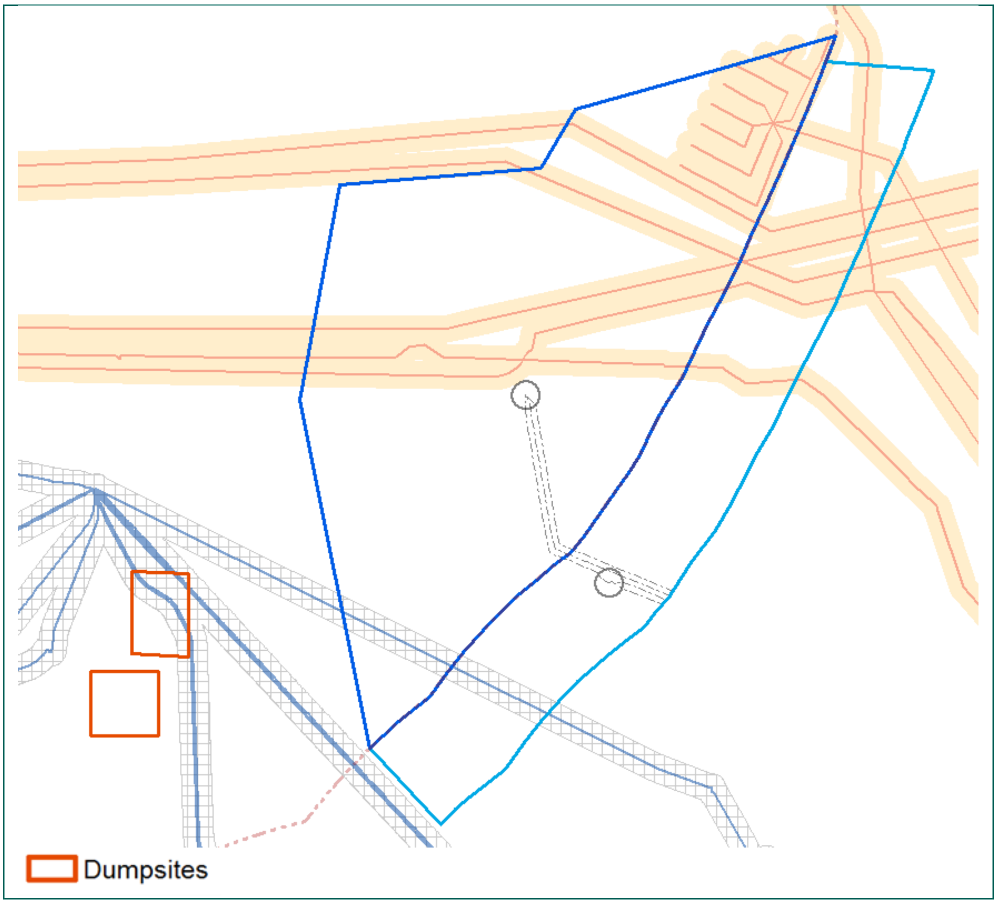

Figure 14: AXO dump sites [34, 45]

Conclusion

The known dumpsites are located well outside the Hollandse Kust (Zuid) wind farm zone. The nearest distance between the AXO dump site and the wind farm site boundary is approximately 5.2 km. However, it is expected that some trawlers may have unintentionally moved AXO. It cannot be ruled out that AXO derived from the dump sites ended up in the area of investigation.

2.4 POST-WAR UXO CLEARANCE IN THE NORTH SEA

Since the Second World War the Dutch fishing fleet almost weekly encounters UXO in fishing nets. To compensate fisherman for the loss of income in case they encountered UXO, a deficiency payments regulation was introduced. Due to the height of the payments, fisherman deliberately fished for UXO when fishing was poor. As a consequence large amounts of UXO were brought ashore each year. These UXO were subsequently rendered safe by the Dutch EOD (Explosive Ordnance Disposal).This situation eventually led to the abolishment of the compensation. In the period that followed, no UXO were reported. However, this does not mean no UXO were encountered, as all encountered UXO were simply put overboard. This often led to dangerous situations.

On April the 6th 2005 three crewmembers of the vessel OD-1 'Maarten Jacob' (a fishing boat) were killed after an airplane bomb detonated on the deck of the vessel.
This event led to a change in the handling of UXO by fisherman. The Dutch Coast Guard developed the "Bijstands- en bijdrageregeling" [4]. The aim of this regulation was to reduce the risks attached to the encountering of UXO as much as possible. The regulation provides guidelines for fisherman and professional support from the Coast Guard and EOD. To prevent fisherman from dumping the UXO a financial compensation was implemented.

After the tragic event with the OD-1 a detailed registration is kept regarding encountered UXO in the North Sea. In total 1.569 UXO were reported to the coast guard, Royal Netherlands Navy and other authorities. The Royal Netherlands Navy Mine Counter Measures Service destroyed 1,173 of the reported UXO, 394 could not be found.

Within the wind farm zone 8 UXO were reported since April 2005. In the vicinity of the wind farm zone 24 UXO were reported. Table 2 shows the reported types and numbers of UXO. The locations of the reported UXO are rendered in Figure 15 and Annex 2. One of the reported bombs in the wind farm zone could not be found by the Royal Netherlands Navy Mine Counter Measures Service. This bomb may still be present in the area. All other UXO encountered in the wind farm zone were destroyed and are no longer present.

UXO type	Number in windfarm zone	Number in vicinity of wind farm zone
Naval mine	1	7
Bomb	5	9
Torpedo	-	3
Unknown	1	-
Grenade	1	3
Depth charge	-	2
Total	**8**	**24**

Table 3: Types and numbers of UXO reported within and near the Hollandse Kust (Zuid) wind farm zone [17]].

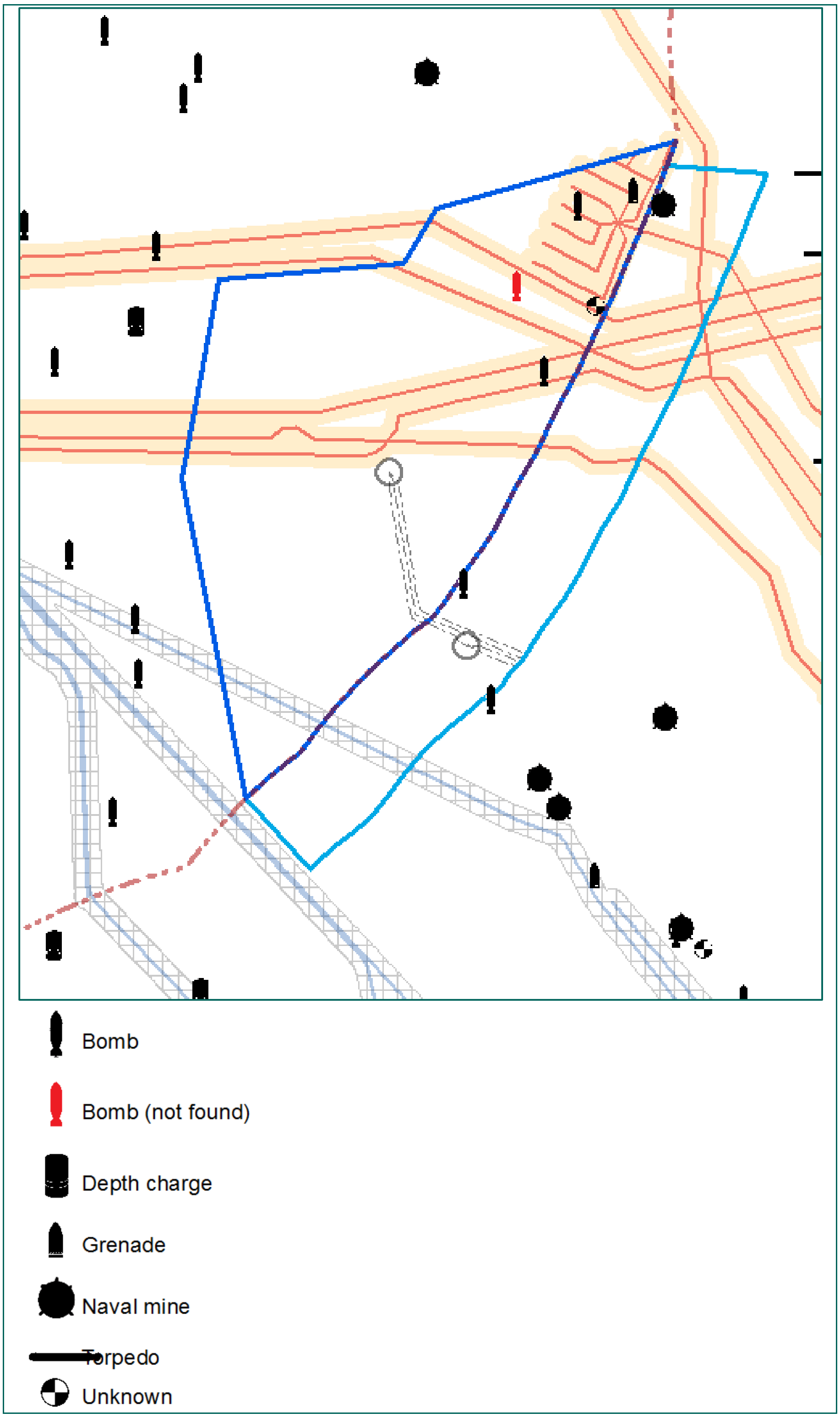

Figure 15: Locations of encountered UXO [17]

The registration kept since April 2005 shows that UXO are present in the entire Dutch part of the North Sea. Concentrations of UXO are present in the following areas:
- The approach path of allied bombers.
- UXO dump sites.

In particular on the 'Bruine bank' many UXO are reported. The Hollandse Kust (Zuid) wind farm zone is located in the vicinity of this location and just north of the main flight path of Allied bomber raids (see paragraph 2.2.1.

<u>Conclusion</u>
Information obtained from the Dutch Coast Guard and the Royal Netherlands Navy supports the conclusion that UXO may be encountered in the Hollandse Kust (Zuid) wind farm zone. Considering the fact that UXO has been encountered within the borders of the Hollandse Kust (Zuid) wind farm zone, it cannot be ruled out that more UXO are present in the zone.

2.5 DEFINING THE UXO RISK AREA

There are several war related activities relevant for defining the UXO risk area:
- The Hollandse Kust (Zuid) wind farm zone is located just north of the main flight path of Allied bombers. Consequently a large number of aircrafts are crashed in the North Sea and many bombs were dropped in the North Sea.
- In World War I and II a large number of naval mines were deployed in the North Sea. Minefields were laid by submarines, ships and aircrafts. In World War I and II a total of five known minefields were (partially) located within the Hollandse Kust (Zuid) wind farm zone.
  The presence of mines, due to secret offensive mine laying operations can not be ruled out. Of the mines that were laid in WWII, only around 10 - 25% were cleared after the war. There are no records for minesweeping following WWI, so recovery is likely to have been even lower [19]. Unexploded mine clearance charges, used for detonating naval mines during minesweeping operations, might also be present in the wind farm zones.
- The Allied air force attacked (German) ships and convoys on a regular basis. During these attacks bombs, torpedoes, depth charges, rockets and cannons were used. The airplanes were attacked by German fighters and FLAK from FLAK-ships and coastal FLAK-batteries.
- Naval combat between the belligerent navy surface and sub-surface ships. Naval combat saw the deployment of depth charges, torpedoes and naval guns.
- The position of the wind farm zone in relation to the main allied bomber route. The position in relation to the bomber route lead to an increased amount of crashes bombers and emergency bomb drops by planes in distress.
- Since April 2005 eight UXO [17] were encountered by fisherman within the Hollandse Kust (Zuid) wind farm zone.
- The seabed is dynamic by nature, due to tidal streams and the movement of sand waves (also see paragraph 6.3). For this reason UXO can migrate from their original position. Also the burial depth of UXO can be influenced by erosion and sedimentation.
- In the post-war period the seabed was intensively used. Due to intensive fishing (trawling) UXO could have been moved. Until 2005 most of the UXO that were encountered in fishing nets were simply put overboard, often in the direct vicinity of known shipwrecks. These locations were normally avoided because of the risk of damaging the fishing nets, thus offering a gathering place of remnants of war.

Due to the stated factors a large part of the seabed of the North Sea must be considered a UXO-risk area. Exact areas are indefinable, since the precise locations of the majority of the military action cannot be traced back. Because several aerial attacks on German ships, the fact that several minefields were present and mines were encountered, the naval combat involving warships and submarines and the possible presence of wrecks of ships and airplanes the entire Hollandse Kust (Zuid) wind farm zone must be considered a UXO risk area. The UXO that may be expected are UXO of torpedoes, rockets (60 lbs Semi-Armour Piercing or SAP), aerial bombs, depth charges, Artillery shells (20 mm up to and including 15 inch), naval mines, mine clearance charges and unknown UXO aboard ship and plane wrecks possibly present in the area. The varieties and state of the expected UXO are discussed in more details in the following paragraphs.

2.6 TYPE OF EXPECTED UXO

Based upon the described source material the following UXO are likely to be encountered:

- Naval mines (see Figure 16)
  British and German naval mines from World War I and II may be present. Since 2005 one naval mine was encountered within the Hollandse Kust (Zuid) wind farm zone. Because of the large number and variety of mines that were deployed, the presence of several types of mines cannot be ruled out.

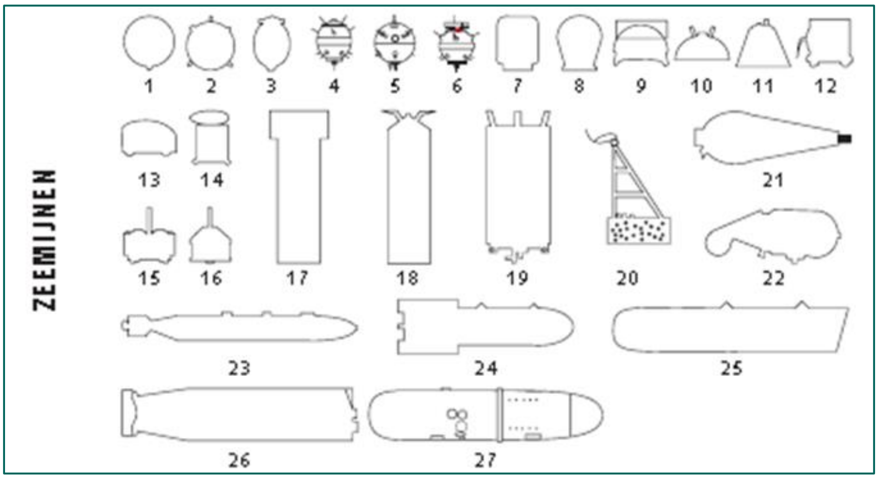

Figure 16: Cropping from the explosives chart regarding Naval mines [4].

- Aerial bombs (see Figure 17)
  The likelihood of encountering aerial bombs is high. Both German and British bombs may be encountered. Since 2005 most of the encountered UXO in the North Sea are Allied bombs. Within the Hollandse Kust (Zuid) wind farm zone five bombs were encountered by fisherman.

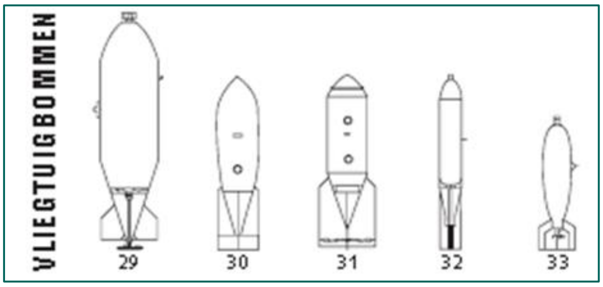

Figure 17: Cropping from the explosives chart regarding bombs [4]

- Depth charges (see Figure 18)
  A depth charge is an anti-submarine warfare weapon intended to destroy or cripple a target submarine by subjecting it to a powerful hydraulic shock. According to the overview of encountered UXO, depth charges are encountered on a regular base. Since 2005 two depth charges have been encountered in the vicinity of the Hollandse Kust (Zuid) wind farm zone.

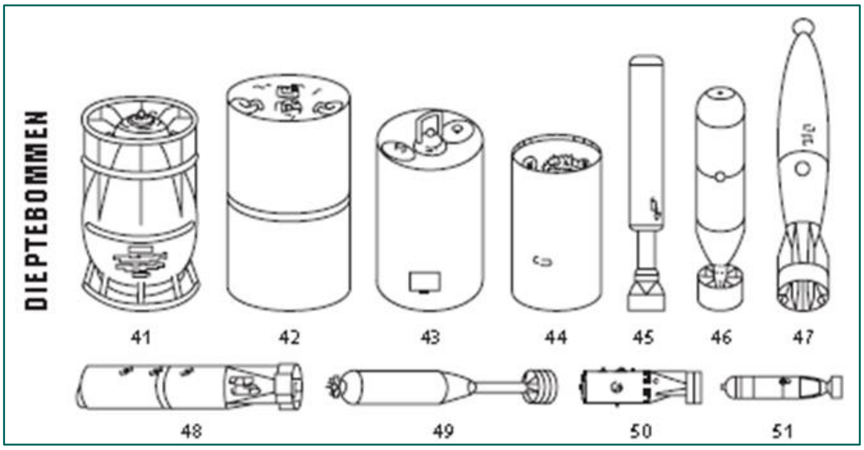

Figure 18: Cropping from the explosives chart regarding depth charges [4].

- Naval mine destruction charges (see Figure 19)
  These charges were used to destroy mines. The shockwave created by these charges causes nearby naval mines to detonate.

Figure 19: Cropping from the explosives chart regarding mine destruction charges [4]

- Torpedoes (see Figure 20)
  Torpedoes were widely used in the First and Second World War, both against shipping and against submarines. Germany disrupted the supply lines to Britain largely by use of submarine torpedoes. Britain and its allies also used torpedoes throughout the world wars. Torpedoes were used intensively by Beauforts on anti-shipping missions. U-boats themselves were also often targeted. Failed torpedoes, or those who missed their target, will sink to the seabed with their warhead intact when they run out of propulsion. Since 2005 three torpedoes were encountered in the vicinity of the Hollandse Kust (Zuid) wind farm zone.

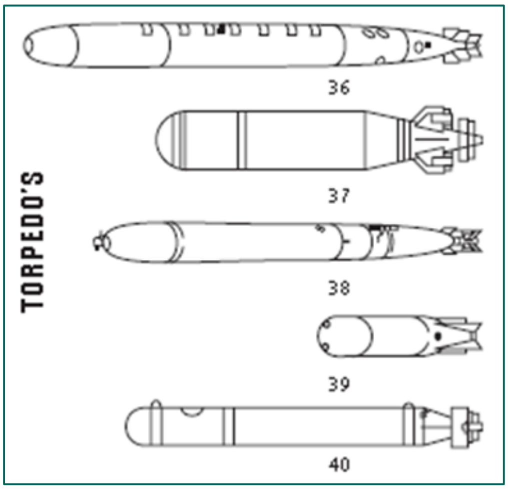

Figure 20: Cropping from the explosives chart regarding torpedoes [4].

- Artillery shells (see Figure 21)
  Artillery shells were used for anti-aircraft purposes and naval warfare. Due to incidents of naval combat, aerial attacks and/or dumping operations Artillery shells may be encountered. Since 2005 one shell was encountered within the Hollandse Kust (Zuid) wind farm zone.

Figure 21: Cropping from the explosives chart regarding artillery shells [4].

2.7 STATE OF EXPECTED UXO

The expected UXO are likely to be armed. This means that the safety devices preventing the UXO to detonate premature, e.g. during handling, are removed. Therefore the explosive train, is in line. The explosive train is a sequence of events that culminates in the detonation of explosives. The reaction starts with the blasting cap. The highly sensitive explosives in the blasting cap explodes, causing the main charge to detonate.

In case of aerial bombs dropped by aircrafts in trouble the bombs could be dropped safe by dropping the devices with safety features still in place.

Some of the expected UXO, e.g. naval mines, may be encountered in very poor condition as the thin metal casing has been severely eroded. The high explosive main charge however, will not have significantly deteriorated and the explosive capability will remain more or less undiminished. Stability of the device is likely to deteriorate with age.

The exact state of encountered UXO can only be determined after positive identification by an EOD-expert.

2.8 OTHER REMNANTS OF WAR POSSIBLY TO BE ENCOUNTERED

It cannot be ruled out entirely that (parts) of crashed airplanes are present, since a large number of planes crashed in the North Sea in the vicinity of the wind farm zone. The available information regarding the crash sites is often not very accurate.

Several crewmembers of the crashed aircrafts were never found. This means there's a possibility of encountering human remains.

There also is a possibility of encountering (parts of) ship wrecks. There are several wrecks and wreck remains present. Some of these wrecks and wreck remains may be sunk in WOI or II. All three categories can contain explosive components.

UXO Risk assessment

3 HAZARDS OF UXO LIKELY TO BE ENCOUNTERED

In this chapter the types of UXO likely to be encountered are described. The given information, together with the impact of UXO and other remnants of war (see chapter 4), the planned intrusive activities (see chapter 5) and the specific characteristics of the site (see chapter 6) forms the input for outlining the UXO mitigation strategy (see chapter 7).

3.1 AERIAL BOMBS

An aerial bomb is a type of explosive weapon intended to travel through the air with predictable trajectories, designed to be dropped from an aircraft. As with other types of explosive weapons, aerial bombs are designed to kill and injure people and destroy enemy materiel through the projection of blast and fragmentation outwards from the point of detonation. Therefore most bombs were accommodated with an explosive charge, although incendiary bombs were also put to use.

The deployed fuzes are highly important for the likelihood of a bomb to detonate as a consequence of seabed activities. Fuzes have two purposes, one is to cause the bomb to explode, and the other to prevent the bomb from detonation before it has left the aircraft and at close range of the aircraft.

The fuzes are armed during and after the bombs are dropped. Upon impact, the fuze has a striking pin or electrical circuit that detonates the bomb. If the fuze has a striking pin, that pin is driven into a small firing cap that sets off the explosive train, and thus the main charge. An electrical fuze uses an electrical detonator to set off the detonation charge.

Fuzes can have various timer devices to make the blast more effective. Some function at a given time after arming, e.g. chemical long delay fuzes such as tail fuze no. 37 Mk.I (see Figure 22). More common are short delay or instantaneous fuzes to delay the detonation for a few fractions of a second.

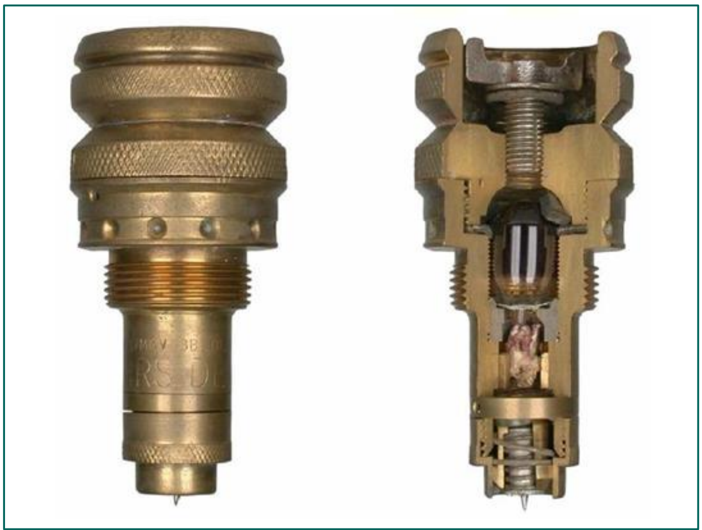

Figure 22: Tail fuze no. 37 MkI.

Once a fuze is armed, any hard jolt can set it off causing the bomb to detonate. Fuzes, and chemical long delay fuzes in particular, are sensitive to movement and accelerations with an amplitude > 1 m/s^2 in the surrounding soil. This kind of accelerations can occur as a consequence of vibrations causes by any kind of piling operations.

3.2 DEPTH CHARGES

A depth charge is an anti-submarine warfare weapon intended to destroy or cripple a target submarine by subjecting it to a powerful hydraulic shock. Most depth charges are fitted with conventional high explosives and a fuze set to cause detonation at a preselected underwater depth. Depth charges can be dropped by ships and patrol aircraft.

Depth charges were detonated by a spring-loaded firing pin released by a water pressure driven bellows system. The mechanism could be set to various depths based on the attacking vessel's estimate of the depth of the submarine. A late war variant included a magnetic detonator which automatically detonated the depth charge when it reached the proximity of a submarine. The change of encountering this type of fuzing is estimated to be low.

3.3 TORPEDOES

A torpedo is a self-propelled weapon with an explosive warhead, launched above or below the water surface, propelled underwater towards a target, and designed to detonate either on contact with its target or in proximity to it. Proximity fuzes were developed later in World War II. The chance of encountering this type of fuze is estimated to be low.

A proximity fuze is a fuze that detonates an explosive device automatically when the distance to the target becomes smaller than a predetermined value, which can also take place when the fuze and the target pass by each other.

3.4 NAVAL MINES

Naval mines can be classified into three major groups: contact, remote and influence mines. Naval mines can be subdivided by appearance or the way they are positioned in the water column, such as:

- Moored mines;
- Ground mines;
- Drifting mines;
- Oscillating mines;
- Crawling mines;
- Limpet mines.

Moored mines and ground mines are the most commonly used. Practise mines exist as variants of all types of war type naval mines with only absence of the warhead and extra equipment such as floats for marking the position and initiation of the exercise mine. The presence of explosives components with a small explosive payload in practise mines cannot be ruled out.

3.4.1 Contact mines

The earliest mines were usually of this type. They are still in use today, as they are extremely low cost compared to any other anti-shipping weapon and are effective, both as a terror weapon and to sink enemy ships. Contact mines need to be touched by the target before they detonate, limiting the damage to the direct effects of the explosion and usually affecting only the single vessel that triggers them.

Based on the different firing systems one can summarize the following types of contact mines:

- Mechanical: upon contact a firing pin will set off the detonator initiating the explosive train;
- Electrical: contact mines with an electrical firing system are often equipped with Hertz Horns (or chemical horns), switch horns or galvanic horns.
    - Hertz Horn: these fuzes work reliably even after the mine has been in the sea for several years. The mine's upper and/or lower half is studded with hollow lead protuberances, each containing a glass vial filled with chromium acid. When a ship's hull crushes the metal horn, it cracks the vial inside it, allowing the acid to run down a tube and into a lead–acid battery which until then contains no acid electrolyte. This energizes the battery, which detonates the explosive.
    - Switch Horn: this horn acts as the switch in the electrical circuit. Closing this circuit will set off the electrical detonator initiating the explosive chain. An internal battery is needed for the supply of the electrical power.
    - Antenna or Galvanic Horn: this type of horns works on the principle of creating battery power based on the salt water environment. A copper antenna or horn fitted to the mine casing acts as positive electrode. When another metallic object (i.e.: ships hull) makes contact with the antenna or horn

During the initial period of World War I, the British Navy used contact mines in the English Channel and later in large areas of the North Sea to hinder patrols by German submarines. Later, the American antenna mine was widely used because submarines could be at any depth between the surface and the seabed.

This type of mine had a copper wire attached to a buoy that floated above the explosive charge which was weighted to the seabed with a steel cable. If a submarine's steel hull touched the copper wire, the slight voltage change caused by contact between two dissimilar metals was amplified and ignited the explosives.

3.4.2 Remotely controlled mines

Frequently used in combination with coastal artillery and hydrophones, controlled mines (or command detonation mines) can be in placed in peacetime, which is a huge advantage in blocking important shipping routes. The mines can usually be turned into "normal" mines with a switch (which prevents the enemy from simply capturing the controlling station and deactivating the mines), detonated on a signal or be allowed to detonate as a 'normal' mine.

3.4.3 Influence mines

These mines are triggered by the influence of a ship or submarine, rather than direct contact. Such mines incorporate electronic sensors designed to detect the presence of a vessel and detonate when it comes within the blast range of the warhead. There were also a small amount of other specialised devices but these were few in number and are unlikely to be encountered.

Even as far back as the Second World War it was possible to incorporate a "ship counter" facility into mine fuzes e.g. set the mine to ignore the first two ships to pass over it (which could be mine-sweepers deliberately trying to trigger mines) but detonate when the third ship passes overhead, which could be a high-value target such as an aircraft carrier or oil tanker.

3.5 ARTILLERY SHELLS

Artillery shells were deployed by aircraft (20 mm), submarines and warships. It's also possible that Artillery shells are encountered, initially used on land and dumped at sea as a matter of clearance. Artillery ammunition can be deployed with different kinds of artillery fuzes.

An artillery fuze specific with artillery munitions, typically projectiles fired by guns (field, anti-aircraft, coast and naval), howitzers and mortars. A fuze is a device that initiates the main charge of an explosive ordnance, most commonly causing it to detonate or release its contents, when its activation conditions are met. This action typically occurs on a present time after firing (time fuze), on physical contact with a target (contact fuze) or a detected proximity to the ground, a structure or other target (proximity fuze).

3.6 ANTI-HANDLING DEVICES

Some fuzes, e.g. those used in air-dropped bombs and naval mines may contain anti-handling or anti withdrawal devices specifically designed to kill bomb disposal personnel. Generally, the more sophisticated the mine design, the more likely it is to have some form of anti-handling device fitted in order to hinder clearance. The technology to incorporate booby-trap mechanisms in fuzes has existed since at least 1940 e.g. the German ZUS40 anti-removal bomb fuze or the earlier mentioned Pistol No. 37.

3.7 SELF-DESTRUCTION DEVICES

The Hague Conventions of 1907 [20] states that is forbidden (article 1):

- to lay unanchored automatic contact mines, except when they are so constructed as to become harmless one hour at most after the person who laid them ceases to control them.
- to lay anchored automatic contact mines which do not become harmless as soon as they have broken loose from their moorings.
- to use torpedoes which do not become harmless when they have missed their mark.

As a consequence of The Hague convention naval mines were presumed to be equipped with a deactivating or self-destruction device. These devices often did not work properly. In case a self-destructing device malfunctioned the UXO holding the device is to be considered highly sensitive to handling (movement). Because washed up mines were falsely considered safe they claimed many casualties during and after the wars. Despite of the prohibitions of The Hague conventions, naval mines and torpedoes must be considered dangerous at all times.

4 EFFECTS OF DETONATIONS

In this chapter the effects of underwater detonations are given. These effects on vessels, equipment, constructions, crew members and surroundings will determine the level of risk during the preparation phase (site investigations), execution phase (construction works) and operational phase (maintenance) of the wind farm development.

4.1 EFFECTS OF UNDER WATER DETONATIONS

The damage that may be caused by an underwater detonation depends on the "shock factor value", a combination of the initial strength of the explosion and of the distance between the target and the detonation. When taken in reference to ship hull plating, the term "Hull Shock Factor" (HSF) is used, while keel damage is termed "Keel Shock Factor" (KSF). If the explosion is directly underneath the keel, then HSF is equal to KSF, but explosions that are not directly underneath the ship will have a lower value of KSF [11]. The effect of a detonation mainly depends on the amount of explosive content (Net Explosive Weight) of the UXO and the type of explosive content (e.g. TNT, Torpex, etc.). The type of explosive is of less importance.

4.1.1 Direct damage

Direct damage can occur to vessels and platforms that come into contact with e.g. a contact mine. Direct damage is a hole blown in the ship or platform. Among the crew, fragmentation wounds are the most common form of damage. Flooding typically occurs in one or two main watertight compartments which can sink smaller ships or disable larger ones. Contact mine damage often occurs at or close to the waterline near the bow, but depending on circumstances a ship could be hit anywhere on its outer hull surface.

It is unlikely that direct damage occurs due to seabed activities. Present UXO are most likely to be present in or on the seabed.

4.1.2 Bubble jet effect

The bubble jet effect occurs when a mine or bomb detonates in the water under (e.g. on the seabed), or a short distance away from a ship. The explosion creates a bubble in the water, and due to the difference in pressure, the bubble will expand from the bottom. The bubble is buoyant and rises towards the surface. If the bubble reaches the surface as it collapses it can create a pillar of water that can go over a hundred meters into the air (a "columnar plume"). If conditions are right and the bubble collapses onto the ship's hull the damage to the ship can be extremely serious; the collapsing bubble forms a high energy jet that can break a meter wide hole straight through the ship, flooding one or more compartments, and is capable of breaking smaller ships apart. The crew in the areas hit by the pillar are usually killed instantly. Other damage is usually limited.

4.1.3 Shock effect

If a UXO detonates at a distance from the ship, the change in water pressure causes the ship to resonate. The whole ship is dangerously shaken and everything on board is tossed around. Engines rip from their beds, cables from their holders, etc. A badly shaken ship usually sinks quickly, with hundreds, or even thousands of small leaks all over the ship and no way to power the pumps. The crew fare no better, as the violent shaking tosses them around [11], [13]. This shaking is powerful enough to cause disabling injury to knees and other joints in the body, particularly if the affected person stands on surfaces connected directly to the hull (such as steel decks).

In Table 3 the distances on with a certain amount of shock damage is expected are shown for the common types of Allied bombs. The distances are calculated by TNO. Leakage is to be expected in case of a Hull Shock Factor (HSF) > 0,3 kg 0.5/m. Damage to equipment is to be expected in case of a HSF > 0,02 kg 0.5/m [13].

NEW [kg]	Leakage of working vessels [m]	Damage to equipment [m]
51 (e.g. bomb 250 lbs	29	430
105 (e.g. bomb 500 lbs)	41	617
270 (e.g. bomb 1,000 lbs)	66	989

Table 4: Distances for shock damage due to detonation [13].

Table 4 shows that in case a UXO detonates, it is highly likely severe damage to the equipment and injury of personnel will occur. Furthermore damage to foundations (mono piles) cannot be ruled out, depending on the distance between the detonation and the foundation.

4.1.4 Shredding effect or spalling

A shock wave with a peak pressure of 37.2 bar and higher reflecting against the water surface, will generate a cracking effect on this water surface. The water particles in the surface layer will be thrown out into the air with great force. This phenomenon, where a shock wave travels from a dense medium (water) into a less dense medium (air) and thus creating a distortion of the surface layer between water and air, is called the “shredding effect” or “spalling”.

The mechanism of wounding a human body can be explained by this shredding effect. A shockwave travelling through a human body will cause severe damage to tissue around air compartments like ears, lungs and intestines.

Gas containing organs can be harmed by the shock wave transferring from the water environment to the air environment. Specifically the transfer of the shock wave energy between water and air causes ruptures in the lungs and other gas containing organs. These ruptures can be fatal in the worst cases.

4.1.5 Lethality of fragments

Fragments from explosives charges in water quickly lose energy. A scientific study on the effects of fragments travelling under water after detonation, is used by the Dutch EOD for calculating the safe distances [12].

In the Hollandse Kust (Zuid) wind farm zone UXO with explosive weights (TNT equivalent explosive weight) up to 1,000 kg can be present. To detain all fragments a water depth > 16 m is needed. Because of the actual water depths at the site (> 16.9 m) it is unlikely that lethal fragments are ejected above the surface of the water (see Figure 23).

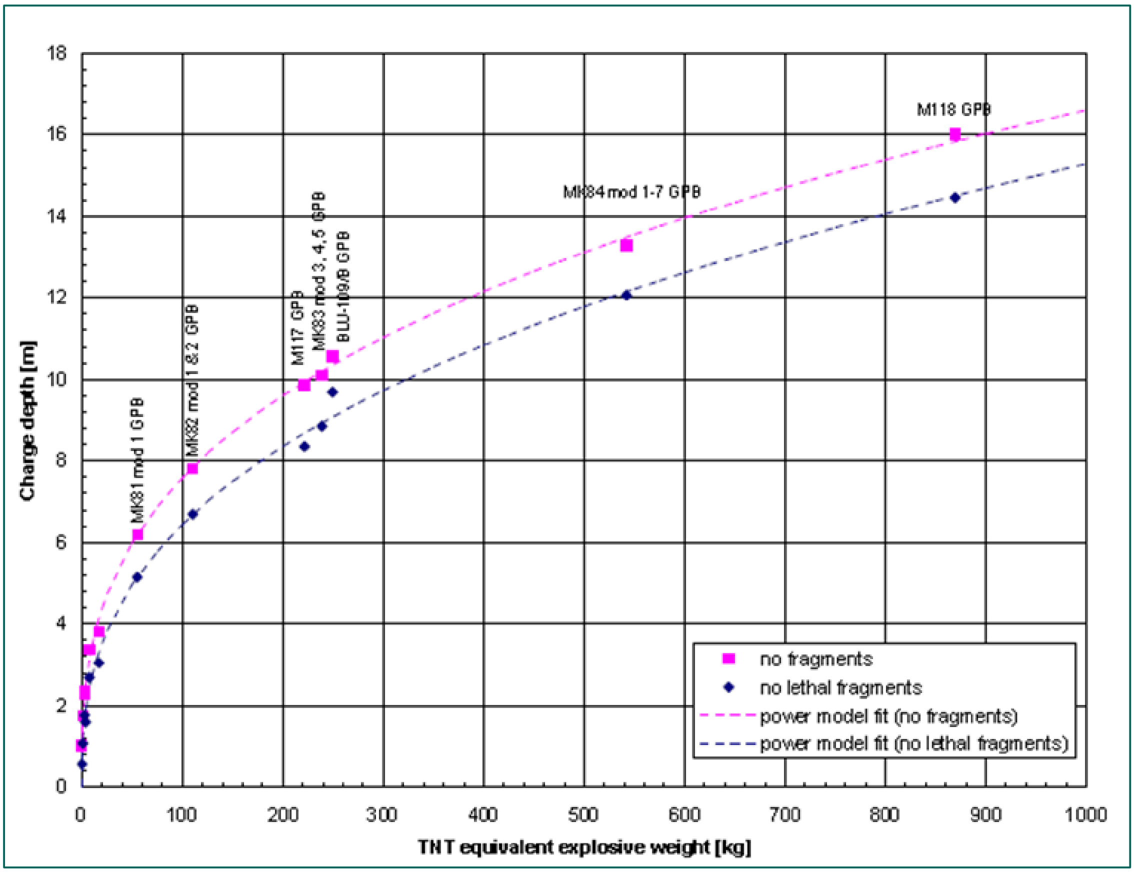

Figure 23: Minimal water depth to detain fragmentation of explosives with a Net Explosive Weight of 0-1,000 kg TNT equivalent [12].

4.2 SAFE DISTANCES

The Dutch EOD regulation provides formulas for calculating the safe distances in case of a controlled demolition of UXO in water. In case of a controlled demolition of UXO in water in the stated area [12]:

a) R = 270 3√W diving is not allowed;
b) R = 24√W civilian shipping is not allowed;
c) R = 36√W tankers are not allowed;
d) R = 12√W warships are not allowed.

R : Radius in meters
W : Net Explosive Weight (NEW) in kg. TNT-equivalents

In Table 4 the safe distances for UXO with a net explosive weight of 100, 200, 300 and 1,000 kg TNT are given. The safe distances are calculated with the formulas stated above. The explosive weights are representative for the types and calibres of UXO likely to be present in the wind farm area (e.g. naval mines, aerial bombs, depth charges and torpedoes).

W [NEW]	Diving [m]	Civilian shipping [m]	Tankers [m]	Warships [m]
100 kg	1,253	240	360	120
200 kg	1,579	339	509	170
300 kg	1,807	416	624	208
1,000 kg	2,700	759	1,138	380

Table 5: Safe distances for controlled demolition [12].

5 INTRUSIVE ACTIVITIES

The level and nature of UXO risks will depend upon the wartime and post-war activity in the area, any previous construction works, intrusive activities in the area and the nature of the proposed works.

In this chapter all possible intrusive survey, construction and maintenance activities during the preparation, execution and operational phases of the Hollandse Kust (Zuid) wind Farm are summarized. Since, in the current stage of the project, an execution plan is not yet available, the needed information is derived from open sources. Therefore the activities described in this chapter only provide a range of possible activities that could occur. Not all activities could be required or additional activities could be planned.

For each intrusive activity the relevant effects for the UXO risk assessment are given. In general the assumption is made that magnetic sensors on present influence mines became ineffective. Therefore the presence of large steel constructions is not considered relevant for the UXO risk assessment.

5.1 PREPARATION PHASE

Preliminary site investigations are planned to be conducted, comprising of:

- Geophysical investigations:
    - multibeam echo sounder;
    - side scan sonar;
    - magnetometer;
    - metal detector;
    - sub-bottom profiler.
- Geotechnical investigations:
    - cone penetration tests, covering the whole area;
    - a limited number of boreholes for sampling purposes;
    - grab samples.
- Metocean measurements:
    - FLIDAR (offshore meteorological station) installation;
    - Wave buoy installation;
    - Installation of Met mast.

<u>Potential UXO risks</u>

Potential UXO risks are:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels conducting the site investigations.
- Direct contact between a UXO and the cone or drill during the geotechnical investigations.

5.1.1 Metocean measurements

In order to optimize the energy output from a wind farm, detailed statistical information on wind direction, speed and altitude is desirable. In order to collect this information, a metocean campaign is conducted prior to the development of the wind farm itself.

RVO is planning for a metocean campaign by means of a floating device on which a LIDAR (Light Detection and Ranging) is installed. Also a sea bottom unit is planned for this metocean campaign. Possibly a Met mast will be installed by the future developer after winning the tender.

A Met mast is a slender structure containing measurement equipment. For the UXO risk assessment only the intrusive activities of the metocean campaign are relevant.

Potential UXO risks

Potential UXO risks are:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels installing the foundation.
- Direct contact between a UXO and dredging equipment and/or gravel or rock during the removal of obstructions, the preparation of the seabed and/or gravel/rock dumping.
- Direct contact between a UXO and the foundation during the placement of the foundation.
- Accelerations with an amplitude > 1 m/s^2 in the surrounding soil during the placement or removal of the foundation (depending on the type of foundation, there are techniques that are vibration-free).
- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels conducting the investigations.
- Direct contact between a UXO and divers during cable connection operations.
- Direct contact between a UXO and divers/ROV's during inspections and as-built checks.

5.2 EXECUTION PHASE

A wind farm contains a variety of structures. The following elements are identified and briefly described:

- Wind turbines.
- Converter- and transformer stations.
- Scour protection.
- Cable routes (internal and external).

5.2.1 Wind turbines

A wind turbine consist of a nacelle with rotor blades, a support structure and a foundation. For the UXO risk assessment only intrusive activities (all activities that influence the soil) are relevant. There are several suitable foundation options. The decision for a foundation type will be based on a range of factors, including water depth; tidal, wind and wave conditions; logistical practicalities; commercial factors; ease of construction and installation; and the type and size of turbine chosen. Figure 24 shows three possible foundation types. Suction anchors may also be a suitable solution.

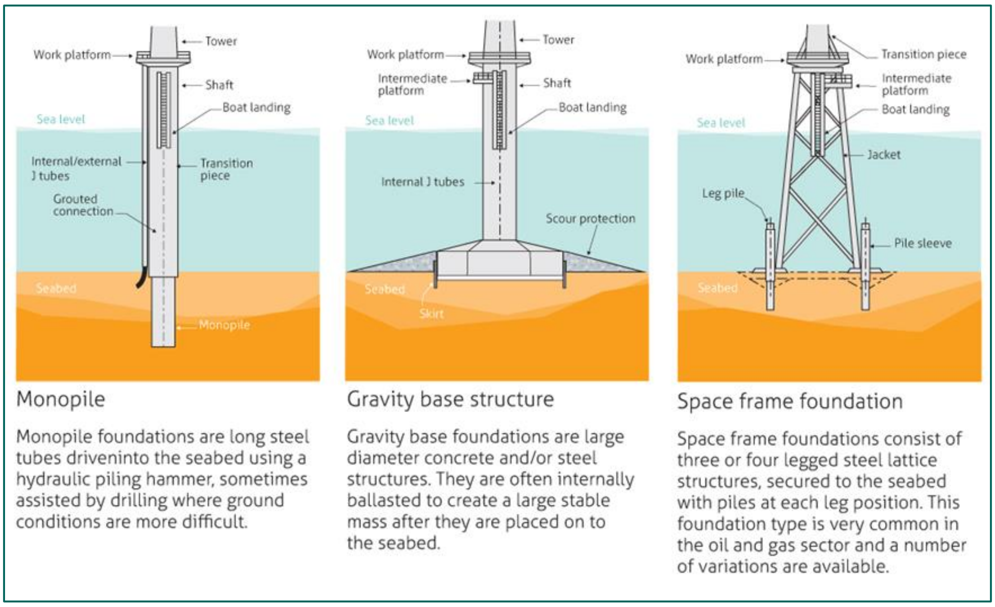

Figure 24: Example of suitable foundation types [21].

Potential UXO risks

Potential UXO risks are:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels installing the foundation.
- Direct contact between a UXO and dredging equipment and/or gravel or rock during the removal of obstructions, the preparation of the seabed and/or gravel/rock dumping.
- Direct contact between a UXO and the foundation during the placement of the foundation.
- Accelerations with an amplitude > 1 m/s^2 in the surrounding soil during the placement or removal of the foundation (depending on the type of foundation, there are techniques that are vibration-free).
- Accelerations with an amplitude > 1 m/s^2 during operation of the turbines.
- Direct contact between a UXO and divers during cable connection operations.
- Direct contact between a UXO and divers/ROV’s during inspections and as-built checks.

5.2.2 Converter- and transformer stations

In order to deliver a constant flow of electricity to shore, all generated electricity is collected on substations and transformed to the predetermined voltage and frequency. The transformer station size can be compared with medium-sized oil and gas facilities, which is why its structure is mostly found equivalent. For the UXO risk assessment only the realization of the foundation of the transformer station is relevant.

Potential UXO risks

Potential UXO risks are:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels installing the foundation.
- Direct contact between a UXO and dredging equipment and/or gravel or rock during the removal of obstructions, the preparation of the seabed and/or gravel/rock dumping.
- Direct contact between a UXO and the foundation during the placement of the foundation.
- Direct contact between a UXO and divers during cable connection operations.
- Direct contact between a UXO and divers/ROV’s during inspections and as-built checks.

- Accelerations with an amplitude > 1 m/s^2 in the surrounding soil during the placement or removal of the foundation (depending on the type of foundation, there are techniques that are vibration-free).

5.2.3 Scour protection

Sandy soils, such as present in the Hollandse Kust (Zuid) wind farm zone, can be more or less susceptible to a type of erosion called scour. Due to tidal currents, a significant section of the soil around the piles can be removed, due to the effect of the foundation on the local flow pattern and velocities. Therefore, depending on the local conditions and the chosen type of foundation, scour protection may be needed. A common way of scour protection is rock dumping around the piles. Typically, the scour protection will be realized using layers of natural, crushed rock, increasing in size when going up from the seabed. The lowest layer of rock, which is small enough to restrain the soil, may be replaced by a geotextile. Prior to applying the scour protection seabed preparation may be needed.

<u>Potential UXO risks</u>

Potential UXO risks are:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels installing the scour protection.
- Direct contact between a UXO and dredging equipment and/or gravel or rock during the removal of obstructions, the preparation of the seabed and dumping of gravel/rock.
- Direct contact between a UXO and divers/ROV's during inspections and as-built checks.

As a consequence of scour buried UXO in the vicinity of the piles can change position or even get moved by tides. This risk can occur in the operational phase of the wind farm (see paragraph 5.3).

5.2.4 Cable routes

In order to transport the generated power from the turbine to the transformer station, cables are installed (in-field cables). The electricity is transported from the transformer station to shore through the export cables. To avoid damage by scratching anchors or fish nets, cables are buried below the sea bed. In most cases, cables are buried beneath the seabed to a set target depth in conjunction with a stone protection.

Cables are buried in a narrow trench cut by water jet or plough. The usual and most efficient burial method is by use of a subsea cable plough which is towed on the seabed behind the cable ship or subsea crawler. The cable passes through the plough and is buried into the seabed. The plough lifts a wedge of sediment so that the cable can be inserted below, thus minimizing seabed disturbance to a very narrow corridor.

Before the main laying and ploughing operations take place, a seabed Route Clearance operation and a Pre-Lay Grapnel Run (PLGR) operation is carried out. This is to remove items of debris such as abandoned fishing nets, wires, abandoned cables, hawsers etc. Removal of any debris ensures a clear route for the plough to negotiate so that burial can be maximized.

Following plough burial, a post lay burial and inspection is normally carried out in areas where the plough could not bury, such as at cable and pipeline crossings, locations where the plough may have been recovered for repairs etc. This burial is carried out by a Remotely Operated Vehicle (ROV), which buries the cable on the same target depth as the main lay plough but by use of water jetting. At pipeline crossings, due to pipelines often being situated proud of the seabed, further protection to the cable and pipeline is normally made by means of a post-lay rock placement operation.

Potential UXO risks

Potential UXO risks are:

- Encountering UXO during the Pre Lay Grapnel Run and Route Clearance.
- Direct contact between a UXO and the cable plough during the installation of the cables.
- Movement of a UXO as a consequence of water jetting during the installation of the cables.
- Direct contact between a UXO and rocks during rock placement operations.
- Direct contact between a UXO and divers/ROV's during inspections and as-built checks.

5.3 OPERATIONAL PHASE

The North Sea is a highly dynamic morphological system. The action of the tides and the waves constantly move objects on the sea bed and over a period of time an area which was previously cleared may no longer be so. In 2011 a good example of the dynamic nature of the North Sea was shown when a WW2 1,000 lbs high explosive bomb was discovered lying against the side of the monopile base of a UK offshore wind farm under construction [19]. This bomb had drifted towards the monopile from elsewhere. Another noticeable example is a torpedo being discovered in 2002, having drifted against a North Sea oil pipeline [19].

During the operational phase of the wind farm maintenance activities will be needed onwards. Intrusive activities may be conducted, e.g. cable laying and anchoring of working vessels. Because of the likelihood of a UXO drifting in an offshore wind farm (previously cleared), these intrusive activities may cause safety and exploitation risks.

Potential UXO risks

Potential UXO risks are:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of vessels conduction maintenance operations.
- Direct contact between a UXO and dredging equipment and/or gravel or rock during the maintenance of scour protection.
- Direct contact between a UXO and divers/ROV's during inspections.
- High energetic fields which can possibly influence electrical detonators.

6 SPECIFIC CHARACTERISTICS OF THE WIND FARM ZONE

The Hollandse Kust (Zuid) wind farm zone is located 12 Nautical Miles (22.2 km) off the west coast of the Netherlands. The wind farm zone of approximately 356 km^2 will be sub-divided into four wind farm sites. It is the intention of the government to expand the Hollandse Kust (Zuid) wind farm zone two Nautical Miles on the east side. Wind farm Luchterduinen lies within the Wind Farm Zone. The wind farm zone is surrounded by:

- A sand extraction area (east side);
- An anchoring area (north);
- Shipping lanes (west);
- Gas exploration (west);
- A gas pipe line (south).

This chapter provides the relevant characteristics of the wind farm zone for defining the UXO mitigation strategy (chapter 7) and the selection of appropriate survey techniques.

6.1 WATER DEPTH AND SAND WAVES

The conducted geological desk study [36] provides a map of recent bathymetry. This map was compiled based on a set of 17 bathymetric surveys, providing full coverage of the study area.

The water depth in the area varies from 16.9 to 27.4 meter (LAT), with an average of 21.5 meter (LAT). This means that a decompression tank is needed in case divers are deployed for UXO clearance.

The seabed consists of sand waves with an eastsoutheast-westsouthwest orientation and an average height of three meters. The distance between the crests amounts to 500 meter. The dunes are superimposed by current ripples.

The mobility of the seabed is not yet known. Assessing the mobility of the seabed is of importance for assessing the maximum burial depth of UXO beneath the seabed. The possibility must be taken into account that UXO are present at depths beneath the seabed outside the detection range of survey equipment.

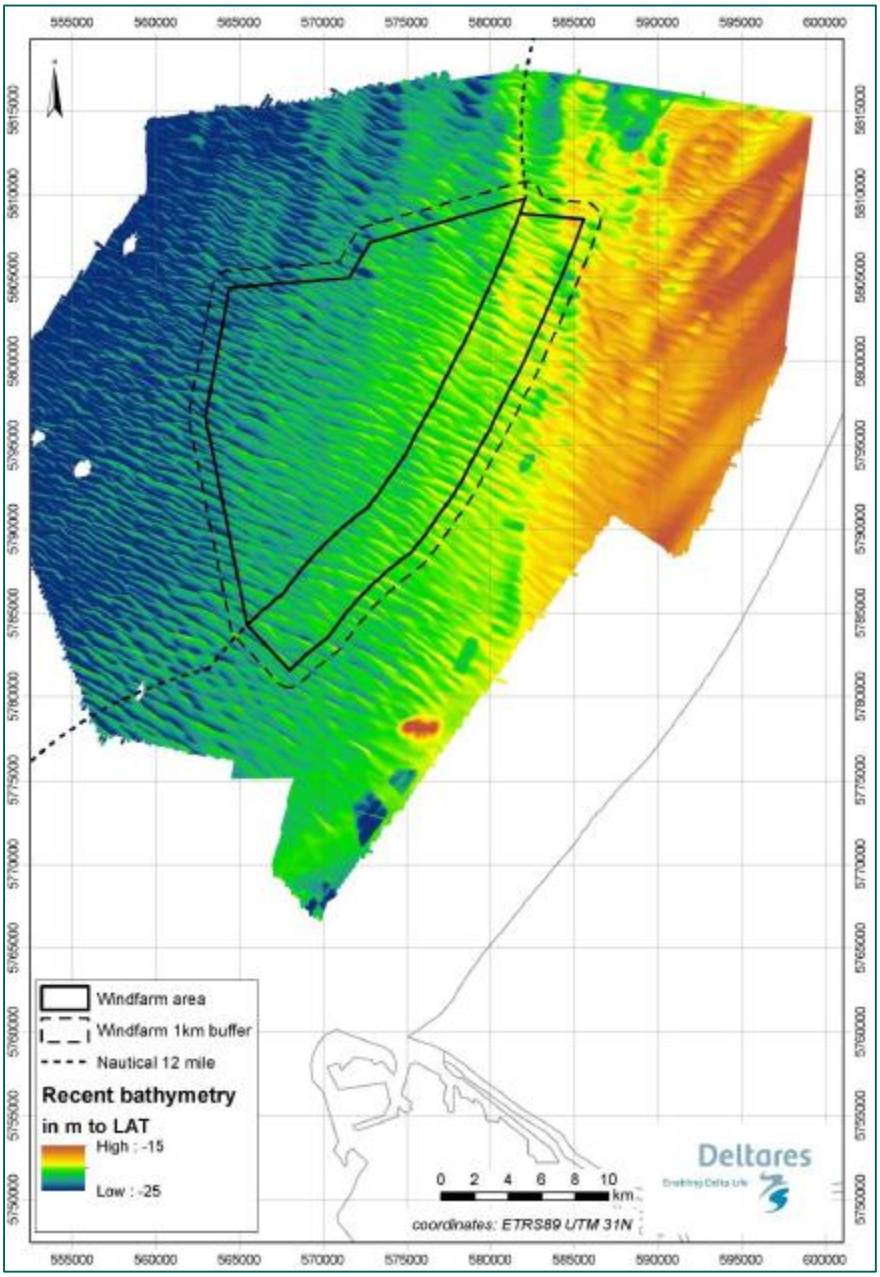

Figure 25: Bathymetry Hollandse Kust (Zuid) wind farm zone [36].

6.2 GEOLOGY

The subsurface of the Hollandse Kust (Zuid) wind farm zone consists mainly of sands for the first 20-25 m. Locally some thin clay layers (normally 2 to 20 cm thick, occasionally reaching 3 m thickness) are present. The geological study [36] concludes that it is not likely that very deep incised channels filled with soft sediments are present in the area. The deeper part (25-180 m depth) is expected to consist of fine sands and silt-rich clays.

In the northern part of the research area land ice is expected to have been present during the Saalien ice age. Here in the subsurface over consolidated layers can be present due to preloading and other (peri) glacial processes. Therefore, stiffer layers and possibly glacial till and (large) stones can be present in the northern area. The geology in the 10 to 12 nautical mile zone (East) and outside the 12 nautical miles (West) appears to be similar.

In order to fully assess the geological setting of the study area for the use as a wind farm zone, an additional seismic survey and a geophysical survey are proposed to be performed.

6.3 BURIAL OF UXO ON IMPACT

A discussion concerning the initial burial depth of UXO generally applies to air delivered bombs and high trajectory artillery projectiles. These UXO have the greatest potential to penetrate the seabed upon their initial deployment. Burial on impact typically depends on the type of sediment and its associated "shear strength". The likelihood that penetration of the seabed will occur is significantly reduced in water depths of over 20 m. The water column significantly reduces the UXO's velocity and thus its energy, before it reaches the seabed. Therefore, in such conditions UXO often has insufficient energy to penetrate more than 2 m (in most soil types).

6.4 POST-WAR UXO BURIAL AND MIGRATION

Over time, UXO can migrate across the seabed. Migration of UXO depends on the nature of the sediments, the varieties of UXO that may be encountered, the initial position of UXO on/in the seabed, tides and currents, storms and human interaction.

UXO can also become buried upon initial deployment. Post-deployment burial can occur due to the effects of scour. Particularly larger items of UXO (e.g. sea mines and bombs) on the seabed are subject to scour. Critical factor in the process of "mine burial" and burial of UXO at the surface of the seabed is wind causing waves and turbulence of the water volume [23]. There is significant empirical evidence to indicate to what degree scour will bury certain types of munitions. For example, sea mines subject to scour are only likely to bury themselves up to 50% of their diameter [23][37]. Large bombs (e.g. those in excess of 250 kg mass) are expected to behave similarly [37].

Buried (or partially buried) UXO are less likely to migrate. They may move if they are otherwise subjected to an extraordinary event (e.g. a 1:100 year storm or human interaction). UXO buried within a mobile bed form, such as sand waves or mega ripples, have the potential to move at a similar rate and distance of that associated with the bed form itself. Different natures of UXO (sizes, shapes and masses especially), are likely to have different rates at which they might be buried, moved and/or uncovered or and/or re-buried, which might generate a different prospective rate of migration. Any UXO not partially or wholly buried are likely to migrate into depressions and dips in the seabed topography.

Because of the water depth, tides and localised currents are unlikely to have an impact on the migration of UXO within the wind farm site.

Movement of UXO items within the wind farm site is more likely to occur through the actions associated with storm events. In that case UXO may migrate in the direction of the residual current during the storm. A "significant" storm (for example a 1:100 year storm event), after a geophysical survey for UXO might cause items to move. In this case confirmatory geophysical survey may be warranted in order to make sure that items had not moved or to scope the magnitude and direction of any such movement.

Fishing activities have the capacity to move items of UXO. Particularly in areas where beam and pair trawling is prevalent. Currently the wind farm zone is fished several times a year [38]. It is expected that some trawlers may have unintentionally moved UXO. These UXO items may have been transported with the movements of the vessel's nets for considerable distances before they are returned to the seabed. In such circumstances, fishing nets have been known to move UXO up to 30 miles (48km) from their original location [37].

6.5 TIDAL STREAMS

The average tidal streams during average weather conditions (wind south-west force 3 to 4) reaches speeds up to 1.0 kts (1.5 kts at spring tides) [18].

The given speeds of tidal streams are the average calculated speeds. The actual speed depends upon a large number of variables. Therefore the actual speed may be higher than the calculated speed.

Depending on the wave height, water depth, visibility, experience of the divers, type of activities, etc. diving within tidal waves must be taken into account.

6.6 EXISTING INFRASTRUCTURE

The wind farm zone is crossed by several in-use cables and a pipelines. Further, several defunct cables and pipelines cross the wind farm zone. Figure 2 (page 10) shows the Hollandse Kust (Zuid) wind farm zone and infrastructure crossing the zone. Burial depth, if any, is unknown at this stage and would need to be thoroughly documented.

Name	Trace	Type	Status
Circe 1 North	Zandvoort (NL) to Lowesoft (GB)	Fibre Optic	In use
Concerto 1 Segment 1 North	Zandvoort (NL) to Sizewell (GB)	Unknown	In use
Concerto 1 Segment 1 North	Zandvoort (NL) to Zeebrugge (B)	Fibre Optic	In use
Flute Ltd	Zandvoort (NL) to Zeebrugge (B)	Fibre Optic	In use
GTS	Zandvoort (NL) to Aldeburgh (GB)	Fibre Optic	In use
TAT14 Segment I	Katwijk (NL) to Saint Valery en Caux (F)	Fibre Optic	In use
TAT14 Segment J	Katwijk (NL) to Norden (D)	Fibre Optic	In use
UK - NL 6	Katwijk (NL) to Covehite (GB)	Coax	Abandoned
UK - NL 7	Katwijk (NL) to Covehite (GB)	Coax	Abandoned
Ulysses 2	IJmuiden (NL) to Lowesoft (GB)	Fibre Optic	In use

Table 6: Cables and pipelines in the Hollandse Kust (Zuid) wind farm zone [44].

In case detection is conducted the disruptive effect of the cables / pipelines on the detection data must be taken into account. The disruptive influence can occur up to 20 meters distance of the cables / pipelines.

6.7 WRECKS, WRECK REMAINS AND FOUL AREAS

The draft report 'Desk study archaeological assessment Hollandse Kust (Zuid) WFZ' [44] provides a list of other known obstacles derived from 'The National Contact Number (NCN)' databases. 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).

The tables 6, 7 and 8 list the known objects and contacts within and outside of the twelve mile nautical zone.

NCN	SR92	DHY	Easting	Northing	R95	Description
253	167	2087	578989	5793459	5	Wreck Swept by wire drag 41.5x8m
1920	-	2073	573048	5786823	0	Wreck Unknown Unknown
1923	-	2079	570643	5789106	5	Wreck Swept by side scan sonar
1934	-	2093	578156	5794786	5	Wreck Found by multi-beam 3x2m
1959		2121	581257	5804376	5	Wreck Found by echo sounder 34x11m
2755		3302	577040	5795934	1000	Foul, archived - BDS 1242/05
4660	3261		566205	5783526	5	Elongated object (4.1x0.6), discovered in 2009
4664	3265		566116	5784683	5	Object (4,7x3,5x0,7) with scouring, discovered in 2009
7572	6186	-	570270	5783757	5	Possible cable or chain, 2010
14632		3758	566137	5784742	5	Obstruction Found by multi-beam 2x2m
15198	11936	-	578092	5793448	5	Wreck remains HY 2087, 1995. ROV images available

Table 7: Overview of known objects and contacts in the research area within the 12NM zone [44].

NCN	SR92	DHY	Easting	Northing	R95	Description
1922	-	2078	564932	5789305	5	Wreck Unknown
1933	-	2092	570361	5795591	5	Wreck, archived - BDS 1699/2007
1941	-	2100	564665	5796595	5	Wreck Found by echo sounder
1942	-	2101	571658	5796547	5	Wreck Found by echo sounder Unknown 24x24m
1943	-	2102	573754	5796722	5	Wreck Unknown
1956	-	2118	574777	5804155	5	Wreck Found by echo sounder
1957	-	2119	576065	5804020	5	Wreck Found by echo sounder
1958	-	2120	577061	5803263	5	Wreck Found by echo sounder
1963	-	2128	572212	5805044	5	Wreck, archived - BDS 1699/2007
1964	-	2129	577090	5806199	5	Wreck Found by echo sounder
1965	-	2130	576505	5805858	5	Wreck Found by echo sounder 20x7m
1978	-	2146	578107	5808842	5	Wreck Found by echo sounder

NCN	SR92	DHY	Easting	Northing	R95	Description
2497	-	2903	568847	5803855	5	Foul Found by echo sounder Unknown 20x0m
2520	-	2943	564167	5789208	5	Wreck Found by multi-beam 2x2m
2737	-	3265	576849	5808168	5	Obstruction Swept by side scan sonar
4655	3256	-	565725	5788081	5	Elongated object, discovered in 2009
4656	3257	-	564748	5788653	5	Small (1.8 x 1.4x0.1) object, discovered in 2009
4657	3258	-	564156	5789245	5	Small (1.9 x 1.2x0.2) object, discovered in 2009
4658	3259	-	564078	5789057	5	Small (3.4 x 1.0x0.3) object, discovered in 2009
7974	6605	-	569498	5803345	5	Cluster of small objects (1.7x1.1x0.3), 2009
7975	6606	-	569493	5803334	5	Cluster of small objects (1.7x1.1x0.3), 2009
7979	6610	-	567111	5793814	5	Possible cable or chain, 2010
7980	6611	-	567518	5803057	5	Elongated object (5.8x0x0), discovered in 2010
7981	6612	-	565734	5789186	5	Contact or seabed disturbance (1.9x1.2x0.5m)
7985	6616	-	565380	5793913	5	Possible cable or chain, 2010
7986	6617	-	566148	5800001	5	Ridge (8.7x1.5x0.1m) 2010
7987	6618	-	564183	5789210	5	Seabed disturbance (17.2x9.3m)
7989	6620	-	566418	5801866	5	Elongated object (2.8x0.8x0.1), discovered in 2010
7990	6621	-	567064	5791212	5	Elongated object (2.7x0.6x0.0), discovered in 2010
7991	6622	-	567790	5798376	5	Small (2.2 x 0.6x0.2) object, discovered in 2010
7994	6625	-	567908	5798358	5	Elongated object (2.7x0.6x0.0), discovered in 2010
8001	6632	-	565751	5803886	5	Possible cable or chain, 2010
8004	6635	-	564462	5794879	5	Small (1.3 x 1.0x0.2) object, discovered in 2010
8005	6636	-	564808	5799794	5	Small (2.1 x 1.0x0.3) object, discovered in 2010
8007	6638	-	568586	5799408	5	Contact or seabed disturbance (3.4x1.4x1.1m)
8011	6642	-	567134	5792960	5	Manmade object (4.1x1.8x0.4) 2010
8017	6648	-	567774	5800510	5	Small (1.4 x 1.1x0.2) object, discovered in 2010
8026	6657	-	567293	5801089	5	Object (2.2 x 2.1x0.2), discovered in 2010
8028	6659	-	566349	5796268	5	Possible cable or chain, 2010
8048	6679	-	564793	5794782	5	Possible cable or chain, 2010
8053	6684	-	565390	5801373	5	Small object (1.5 x 1.0x0.1), discovered in 2010
8076	6707	-	565132	5801701	5	Small object (1.7 x 1.0x0.1), discovered in 2010
8077	6708	-	565170	5802833	5	Cluster of small objects (1.6x1.0x0.0), 2010
9563	1105	-	576711	5807696	5	Wreck remains at 1831m of wreck HY 2130

Table 8: Overview of known objects and contacts in the research area outside the 12 NM zone [44].

During geophysical surveys for Windfarm Luchterduinen (2013) and a pipeline for Delta Hydro Carbons (2009) several objects were mapped with side scan sonar and magnetometer. These objects are listed in table 8.

Survey	Side scan sonar	Magnetometer anomalies
Delta Hydro Carbons 2009	5 unknown objects	2
Luchterduinen 2013	117 (89 unknown objects)	331 (117 cable contacts)

Table 9: Results from geophysical surveys within the research area [44].

In case detection is conducted the disruptive effect of the wrecks, wreck remains and/or foul areas on the detection data must be taken into account. The wrecks could even hinder the detection at the wreck sites.

7 OUTLINING THE UXO MITIGATION STRATEGY

Because the Hollandse Kust (Zuid) wind farm zone was located just north of the flight path of Allied bombers, the frequent aerial attacks on shipping in the area and the fact that several minefields were present and several UXO were encountered within the wind farm zone, the entire location must be considered a UXO risk area.

The possible presence of UXO in the area, however, is no constraint for offshore wind farm related activities. With proper UXO Risk Management the risks can be reduced to a level that is as low as is reasonably practicable (ALARP).

7.1 ALARP

The possible effects of a detonation of a UXO on vessels, equipment, wind farm structures and personnel (including divers) form an intolerable risk. The likelihood of a detonation of a UXO is low to medium, but the consequence/harm is high to severe. This means mitigation measures are needed to reduce the risks to a tolerable level.

The duty of health and safety law is to eliminate the risk if possible or reduce it to a level that is ALARP. This recognises that it may not be possible or reasonable to search for, or remove or make safe every device within a total construction area. However it is essential to consider whether the actions taken are sufficient, taking into account the cost, time and effort required to reduce any further, the risk of harm to people. If such costs, time and effort required are grossly disproportionate to any risk reduction achieved then they may be deemed as 'not reasonably practicable'.

The level of ALARP can only be determined during the design and engineering phase of the wind farm development. Fine-tuning of the UXO Risk management strategy based on the design is needed. If not, there is the potential for the risk to either be set too low, exposing the project to physical risk and delay, or too high, and then developers may incur significant costs for unnecessary investigation. Figure 26 shows the ALARP triangle to illustrate the risk mitigation principle.

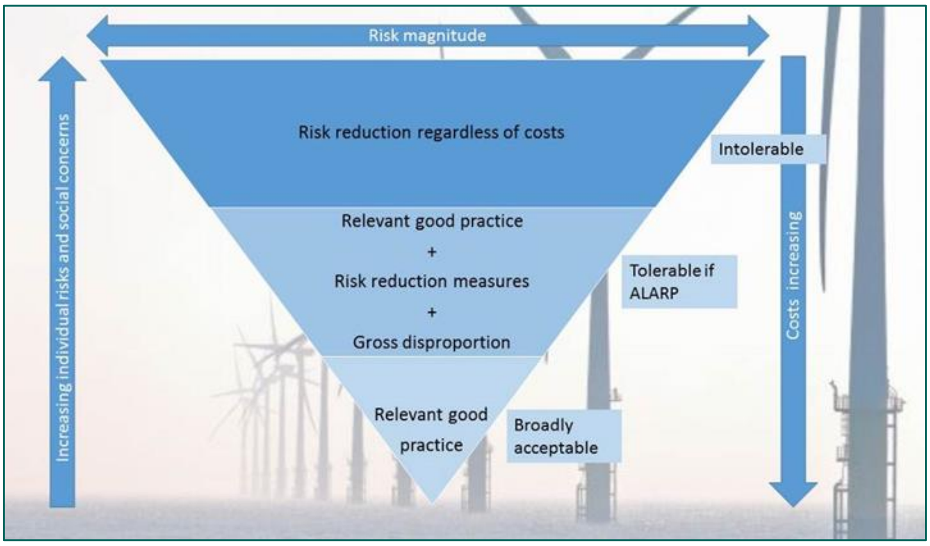

Figure 26: ALARP triangle.

The required actions will presumably consist of search and safe removal of UXO, training of personnel and deployment of safe working protocols.

7.2 PREPARATION PHASE

During the preparation phase site investigations (geophysical and geotechnical investigations and metocean measurements) will be conducted. This information is needed by future commercial developers to prepare a competitive subsidy bid for the Hollandse Kust (Zuid) wind farm zone.

Although this report gives the general outline of the UXO threat for wind farm development, the character and extent of present anomalies (magnetic objects and therefore possible UXO) remain unknown for the time being.

7.2.1 Geophysical survey

It is recommended to conduct a non-intrusive geophysical (bathymetrical) survey consisting of at least:

- Multibeam echo sounder;
- Sidescan sonar.

The multibeam echo sounder generates high quality and high resolution data of the seabed. This data is will be used for morphologic research and assessment of the movement of sand dunes. The side scan sonar must be able to identify objects > 1 m. The data generated with side scan sonar is used to identify objects, debris, debris fields and wrecks. The likelihood of UXO's being identified based on only a geophysical survey is small. Optional the additional conduction of sub bottom profiler can be considered.

The collected data needs to be reviewed by a team of experts. After review of the data a dedicated UXO survey plan can be drawn up by the wind farm site developer (see paragraph 7.3). UXO survey may be limited to the areas where intrusive activities are to be performed. In this case it is advisable to assess the risks of UXO remaining at other locations within the wind farm site for future operations and maintenance."

Due to the dynamic nature of the seabed it is highly important to minimize the time lapse between the geophysical survey and the execution of the dedicated UXO survey. Due to tidal streams, storms, the mobility of sand waves and the use of the seabed (e.g. fisheries), the validity of the collected data is limited in time.

It's recommended to provide this UXO-Desk Study to the contractor of the geophysical survey. An awareness training (or kick-off meeting) before conducting the survey is also to be recommended.

7.2.2 Geotechnical investigations

It is recommended to adapt a UXO risk mitigation strategy when performing the geotechnical survey. Preforming a (non-)intrusive survey is a possible approach to mitigate the risks. Performing CPT/boreholes on available magnetometer lines could be another.

It is recommend to position the locations of the CPT/bore holes or samples at locations that are free of anomalies. In this manner clearance operations in the preparation phase can be avoided.

Because the burial depth of UXO is unknown in this phase of wind park development, it may not be possible to guarantee a safe working environment by non-intrusive magnetometer or metal detection survey on its own.

The UXO mitigation strategy should, amongst others things, provide in raising awareness regarding working in a UXO contaminated area (e.g. awareness training, kick-off meeting, etc.).

7.2.3 Metocean measurements

During the metocean measurements potential UXO risks occur. To constrain these risks an awareness training (or kick-off meeting) before conducting the measurements is to be recommended.

As regards the Met mast installation, intrusive activities will be conducted. Before installation, the area effected by the intrusive activities has to be cleared from UXO. The clearance operations have to be conducted by a certified EOD-company (see paragraph 7.6).

7.2.4 Research into mobility of sand waves

It is highly important to assess the mobility of sand waves (banks and ridges) by comparing current bathymetry results with historic data[6]. Thereafter the effects of the mobility of sand waves on the burial depth of UXO need to be determined. Subsequently the effects of the determined burial depth on the risk assessment and survey possibilities must be assessed. A dedicated UXO survey plan (see paragraph 7.3) can only be drawn up after the maximal burial depth of UXO is determined.

7.2.5 Research into the origin of wrecks, wreck remains and foul area's

There is a possibility wrecks need to be removed in order to construct the wind farm. For most wrecks, wreck remains and foul areas, specific information is sparse. Investigating the known wrecks to gather additional information is recommended. This information is relevant for the removal of the wrecks/wreck remains and the UXO risk assessment. For wreck removal the possible presence of UXO always has to be taken into account. The geophysical survey may provide important data on the locations of wrecks and wreck remains.

7.3 EXECUTION PHASE

In this UXO-Desk Study the design and engineering is considered to be part of the execution phase. The reason for this assumption is that the design and engineering is the responsibility of the commercial participating in, or winning the subsidy tender.

7.3.1 Design and engineering

It is recommended to reassess the UXO related risks based on the first draft of the design for the wind farm. Possibly adaptations in the design can be made to mitigate a part of the risks. For the remaining (intolerable) risks a detailed UXO risk mitigation strategy needs be worked out.

The required risk mitigation actions will include search and safe removal of UXO within a, at a later stage, to assess part of the wind farm zone. The size of the survey area will be determined in the detailed UXO mitigation strategy.

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[6] A separate study commissioned by RVO will be performed to assess the morphodynamics at the site, once the multibeam data is available. In this study the max and min levels of the seabed will be determined.

Prior to the search operations the development of a detailed dedicated UXO survey is recommended. The information gathered during the geophysical survey is to be used as input for the survey plan.

Because the validity of the collected data (geophysical survey) is limited in time, it's recommended to minimize the time lapse between the survey and the execution of construction work. The validity of UXO survey data can be influenced over time by UXO migration due to natural causes, but will primarily be influenced by human interaction (trawling).

The UXO survey plan needs to address the following subjects:
- the elevation differences of the seabed;
- the maximal burial depth of UXO;
- the types and calibres of UXO (e.g. German GC naval mines, with limited ferromagnetic materials);
- locations of wrecks and wreck remains;
- elements and objects disruptive to the UXO survey data such as cables and pipelines;
- Etc.

7.3.2 Execution

It is recommended to conduct the UXO search and removal operations at short notice prior to the construction activities. The validity of the collected magnetometer survey data regarding to tidal streams, mobility of sand waves and seabed usage has to be taken into account when planning the survey and construction operations. Time lapse between project phases has to be limited as much as possible.

7.4 OPERATIONAL PHASE

Because of tidal streams, mobility of sand waves and seabed usage the possibility that UXO are moved within the wind farm zone after completion of the construction activities have to be taken in to account.

Therefore it is recommended to write a maintenance and monitoring plan. This plan needs to provide safe working protocols for future maintenance operations and a monitoring strategy. To constrain these risks the future developer is recommended to conduct an awareness training (or kick-off meeting) prior to maintenance operations.

7.5 GENERAL OUTLINE OF THE UXO RISK MITIGATION STRATEGY

UXO Risk mitigation is a staged process, consisting of 5 sequential phases. The level and extent of activities in each following phase will generally depend upon the findings of the preceding phase. For example, the extent of activities needed to be able to provide a UXO risk sign of to ALARP, can only be estimated after reassessment of the UXO mitigation strategy in regards to the design of the wind farm and a dedicated UXO survey and review of the data. This makes UXO risk management projects particularly hard to manage. Therefore a phased approach is needed. This approach is aimed at decreasing the amount of project management risks (especially time and money) in each following phase of the UXO risk management process. Figure 27 shows the wind farm development phases in comparative to the UXO Risk Management phases. This report describes phase I (historical research) and phase II (UXO risk assessment) of the UXO risk management process. These phases are rendered within the red rectangle. The execution of the following phases of the UXO risk management process is the responsibility of the future developer.

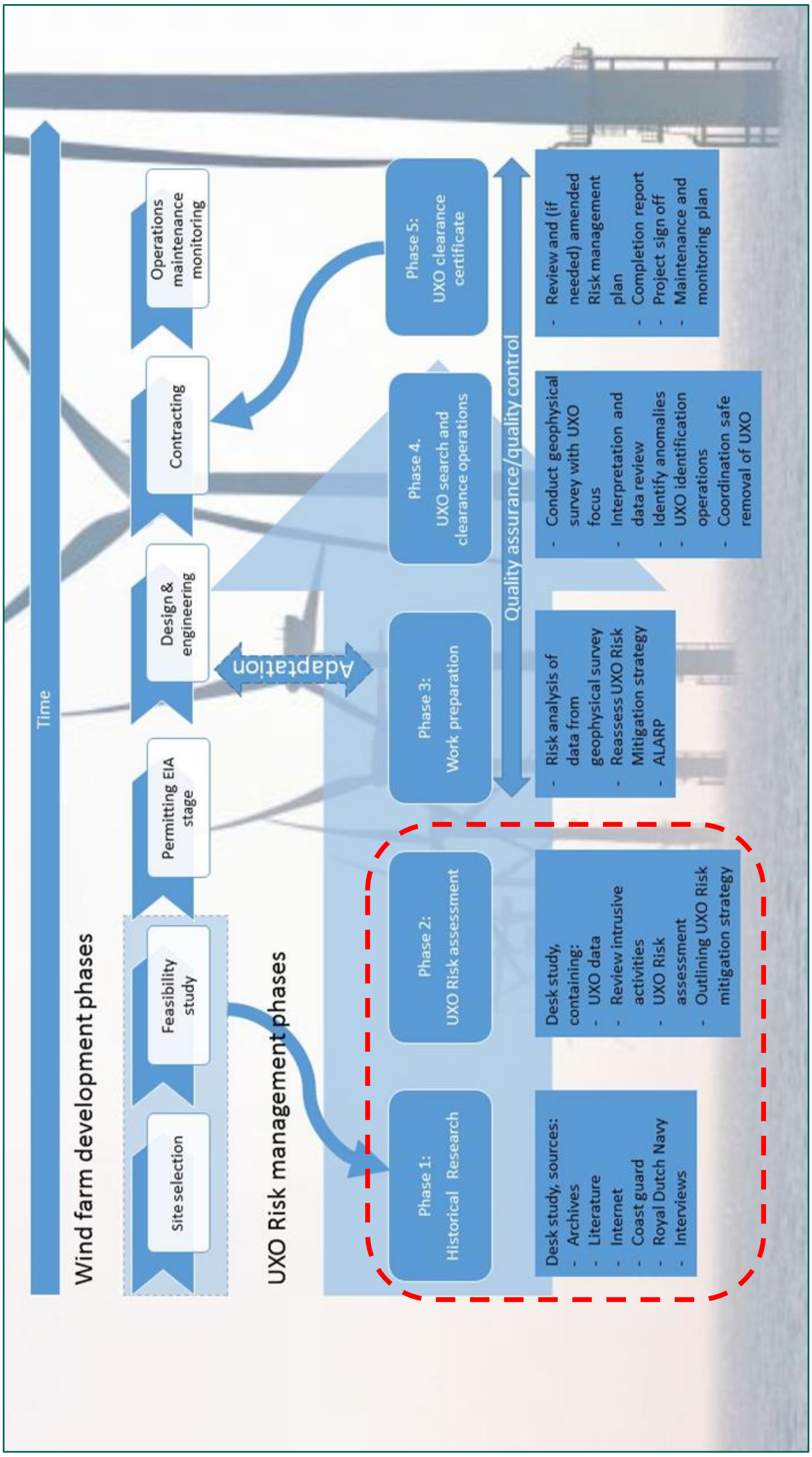

Figure 27: General outline UXO risk mitigation strategy Hollandse Kust (Zuid) wind farm zone.

7.6 COMPETENT AUTHORITIES

The 'Ministerie van Infrastructuur en Milieu, Dienst Zee en Delta' is the competent authority regarding the public security. This authority needs to approve the project plan for the search and removal of UXO, according to the applicable regulation [24]. This project plan will be drawn up by the certified UXO clearance company, which will be contracted by the future developer.

For the industrial safety the Dutch Working Conditions Act is applicable. The 'Inspectie SZW' (Labour Inspectorate) is responsible for the enforcement of the legislation.

Disposal of all UXO encountered is the exclusive preserve of the Royal Netherlands Navy. If any UXO are encountered they are reported to the Coast guard by the certified UXO clearance company. The Coast guard informs the Royal Netherlands Navy. Removal of reported UXO will generally take up to about a week, depending on the priority given and the availability of Mine Counter Measures Vessels. No costs will be charged to the wind farm developer in regards to the disposal of UXO. If due to migration, an UXO was identified in proximity to WTG substructures in the operational phase and this will be considered a risk (e.g. for maintenance vessels) the authorities will cover the costs of removal.

It is advisable to consult the competent authorities in regards to management measures that can be taken to prevent stagnation in the execution phase. A possible measure is to safely move the UXO outside the work area awaiting destruction.

7.7 REGULATION AND STANDARDS

The applicable regulation on EOD-operations in the Netherlands is the "Werkveldspecifiek Certificatie Schema – Opsporen Conventionele Explosieven (WSCS-OCE)" [24]. According to the WSCS-OCE all UXO clearance companies must be certified for 'scope A' and/or 'scope B'. A scope a certified UXO clearance company is responsible for all UXO search and clearance operations. A 'scope B' company can be responsible for supporting the operations on the level of civil engineering.

<u>Minimal standards EOD-personnel [24]</u>

The minimal standards for UXO-personnel are:

- Senior OCE-expert level UXO-clearance certificate (UXO-Supervisors);
- OCE-expert level UXO-clearance certificate (UXO-divers);
- Basic OCE level certificate (dive supervisor).

<u>Minimum standards for other personnel [24]</u>

According to the WSCS-OCE the minimum requirement is to have all personnel, directly involved in UXO-removal projects, to hold a certificate "Basic OCE". This certificate assures that all personnel is properly trained and aware of the safety regulations involved with UXO-clearance.

<u>Minimum dive standards</u>

The International Marine Contractors Association (IMCA) is the international trade association representing offshore, marine and underwater engineering companies [25]. IMCA guidelines and standards are applicable to the offshore industry. Though not mandatory, use off the IMCA guidelines and standards is advised.

All divers have to comply with the Dutch certificate B3 [26]. Certificate B4 is preferred.

Appendices

8 APPENDICES

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ANNEX 1: REFERENCE DOCUMENTS

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ANNEX 2: OVERVIEW WAR RELATED EVENTS

Annex 2 is separately attached.

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Netherlands Enterprise Agency (RVO.nl) is an agency of the Dutch Ministry of Economic Affairs. Netherlands Enterprise Agency implements policy for various ministries in to the areas of sustainability, agricultural, innovation and international business and cooperation. Netherlands Enterprise Agency is the contact point for businesses, knowledge institutions and government bodies. For information and advice, funding, networks and legislation and regulations.

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