

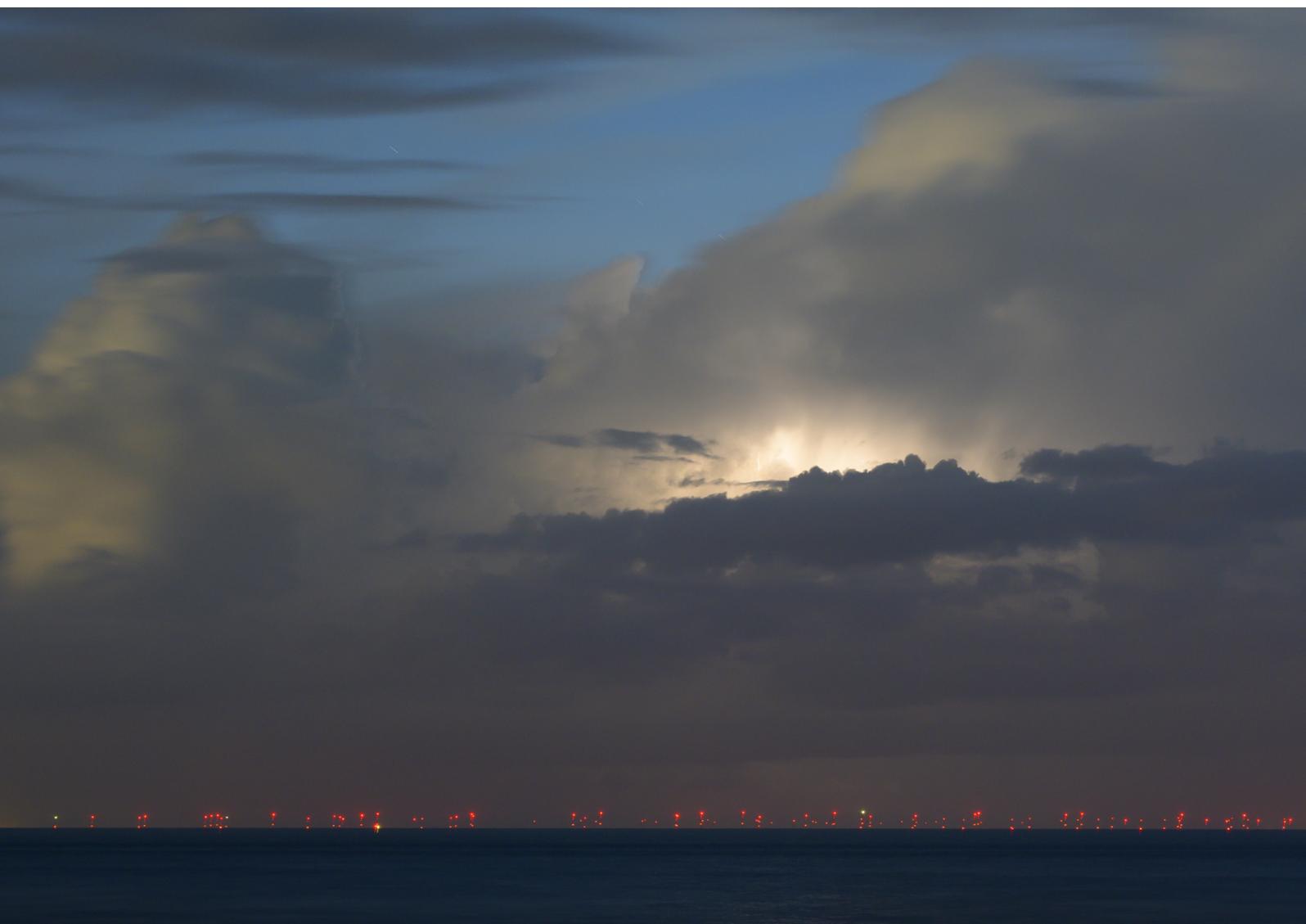


Netherlands Enterprise Agency

# UXO – Report

## Nederwiek Wind Farm Zone

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# RVO Approval for Publication

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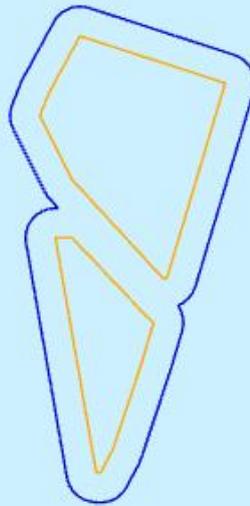
## Desk Top Study

Unexploded Ordnance (UXO)

## Nederwiek WFZ

74787/RO-220325 report version 2.0

25 January 2023



# Desk Top Study

Unexploded Ordnance

## Nederwiek WFZ

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Front page image: Fragment of oblique aerial photograph showing Bristol Beaufighter's of the North Coates Strike Wing attacking a small enemy convoy off Terschelling, Holland. The nearest trawler is being attacked with cannon gunfire, and also with rocket projectiles fired by the aircraft from which the photograph was taken. Source: Imperial War Museum.

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## SUMMARY

This unexploded ordnance (UXO) desk study is part of the site data on the Nederwiek Wind Farm Zone (WFZ). This UXO desk study consists of historical research and a UXO risk assessment.

### Historical research

The Nederwiek WFZ and its surrounding areas were the scene of several war related events during World War I and World War II. Among these are multiple airstrikes on German shipping, the presence of minefields, the sinking of multiple ships, airplane crashes and the jettisoning of bombs during both World Wars. Due to these events the entire Nederwiek WFZ is to be considered a UXO risk area. The UXO items considered most likely to be present within the investigation area are shown in the overview below. Note that the overview shows the expected likelihood of presence of generic UXO types within the site based on the evidence gathered about potential UXO sources. The different 'presence' terms are explained in the table below.

"Presence" Term	Meaning
Negligible	No evidence pointing to the presence of this type of UXO within an area, but it cannot be discounted completely.
Remote	Some evidence of this type of UXO in the wider region but it would be unusual for it to be present within the area of study.
Feasible	Evidence suggests that this type of UXO could be present within the area.
Probable	Strong evidence that this type of UXO is likely to be present within the area.
Certain	Indisputable evidence that this type of UXO is present within the area.

Table 1: Definitions of terminology used for the likelihood of presence of UXO.

UXO type	Likelihood of presence	Subtype / calibre	Remarks
Small calibre munition	Remote	Miscellaneous	Similar to the remarks about artillery shells, small arms ammunition could be fired by German and British vessels. German ships could use machineguns to repel allied aircraft. It is also known that multiple attacks with machine guns have been carried out within the Investigation Area by British aircraft.
Anti-ship bombs	Remote	Airborne versions (UK)	Both anti-E-boat and anti-submarine patrol areas intersect with the Investigation Area. Multiple patrols are reported to be carried out during the Second World War. Depth charges were often used by airplanes in an anti-submarine warfare. Because there are no direct indications of the dropping of anti-ship bombs within the Investigation Area, the likelihood of presence is deemed remote.
Artillery shells	Remote	20 mm up to and including 8.8 cm	German ships passing through the Investigation Area are known to have fired on allied aircraft on at least three occasions. The intensity of flak fire may have led to the presence of artillery shells of common flak calibres in the Investigation Area. There is at least one known surface craft battle between British and German vessels. It is to be expected that artillery shells were fired during this battle. Furthermore, it is known that Allied aircraft fired 20 mm shells on German vessels within the Investigation Area.

UXO type	Likelihood of presence	Subtype / calibre	Remarks
Torpedoes	Feasible	18 inch (45.7 cm) 21 inch (53.33 cm)	During both the First- and Second World War, some reports of the presence of submarines have been encountered. Furthermore, two torpedo attacks have been carried out within or immediately near the Investigation Area (the sinking of the HMS Ivanhoe and the 15 September 1944 attack). There are also multiple mentions of the sinking of vessels that carried torpedoes. The multitude of reports of the presence of torpedoes within the Investigation Area has led to believe that there is a feasible likelihood of presence for torpedoes.
Naval mines (WW1)	Probable	WWI: E-mine Type IV (German), contact mines Vickers Elia and type H Mk II (UK)	German maps show a suspected German minefield within the Investigation Area during the First World War. At least one German mine was encountered within the Investigation Area but outside of this minefield. Furthermore, several mine accidents are known to have happened within the Investigation Area. There is a lack of detailed information about the clearance of these mines. The presence of a minefield and multiple encounters (accidents or the spotting of mines) with mines outside this area, lead to the conclusion that the likelihood of presence of naval mines is probable.
Naval mines (WW2)	Probable	WWII: moored mines Mk XX (UK), contact mines Mk XIV and XVII (UK), EMD- and EMC contact mines (German), Explosive Floats 'Sprenboje' (German), static cutters (German)	The Investigation Area was situated between the British Coast and the German occupied Dutch Coast. During the Second World War this region was a theatre of mine warfare. Multiple German and British minefields (filled with mines and minesweep obstructors) were laid within or immediately near the Investigation Area. This resulted furthermore in several mine accidents that occurred within the Investigation Area. After the Second World War, still multiple mines were encountered near the Investigation Area. It is therefore concluded that the likelihood of presence for naval mines is probable.
Aerial Bombs	Negligible	German bombs	The consulted sources do not state the use or jettison of German bombs within the Investigation Area. However, as stated in paragraph 5.1, the <i>Luftwaffe</i> archives were systematic destroyed. Therefore, there is only sporadic information available on German Air Force activity. Hence, no conclusive evidence of German aerial bombs is at hand and the likelihood of present is deemed negligible.
	Probable	Allied bombs: Ranging from 4 lbs up to and including 4,000 lbs	According to the analysed sources, multiple allied airstrikes took place in the Investigation Area. Beside airstrikes, allied aircraft often jettisoned bombs over the North Sea. At least three direct indications of jettisons in the Investigation Area have been derived from the historical sources. Furthermore, multiple aerial bombs have been lifted immediately near the Investigation Area after the Second World War. This leads to the conclusion that the likelihood of presence of allied aerial bombs is probable.

Table 2: UXO items likely to be encountered in the Project Area.

### Risk assessment

The conducted historical research has shown that, amongst others, several calibres of aerial bombs, torpedoes and naval mines could be present within the investigation area. The possible effects of a detonation on vessels, equipment, personnel, and surroundings may form an intolerable risk. This means mitigation measures are required to reduce the risks to ALARP.

It is recommended to address the source of the hazard by performing a UXO geophysical survey prior to any intrusive works. The mitigation measures consist of UXO survey, identification of potential UXO objects, re-routing or re-location of cables and structures if possible and disposal of UXO items if required.

Legal obligations and specific procedures that need to be followed when encountering a UXO will be specified in the Project Execution Plan that has to be composed before the execution of any field research.

Source	Likelihood of presence	Pathway	Receptor	Type of encounter	Likelihood of occurrence	Hazard severity	Risk result
Small calibre munition	Remote	Touch	Personnel Equipment	Primary	Very unlikely	Negligible	LOW
Depth charges	Remote	Touch	Personnel Equipment	Primary	Very unlikely	Very High	LOW/ MODERATE
Artillery shells	Remote	Touch	Personnel Equipment	Primary	Unlikely	Negligible	LOW
Torpedoes	Feasible	Touch, Movement, Magnetism	Personnel Equipment	Primary Secondary	Possible	Very High	HIGH
Naval mines (WW1)	Probable	Touch, Movement, Magnetism	Personnel Equipment	Primary Secondary	Possible	Very High	HIGH
Naval mines (WW2)	Probable	Touch, Movement, Magnetism	Personnel Equipment	Primary Secondary	Possible	Very High	HIGH
Aerial bombs	Probable	Touch, Movement, Vibrations	Personnel Equipment	Primary Secondary	Possible	Very High	HIGH

Table 3: Risk assessment results for the Nederwiek WFZ.

## SAMENVATTING

Deze studie is onderdeel van de site data voor het gebied Nederwiek WFZ. De bureaustudie bestaat uit een historisch vooronderzoek en een risicoanalyse.

### Historisch vooronderzoek

In het gebied Nederwiek WFZ en de omgeving daarvan hebben zich in de Eerste en de Tweede Wereldoorlog diverse oorlogshandelingen voltrokken. Zo hebben er meerdere luchtaanvallen op Duitse schepen plaatsgevonden, zijn er zowel Duitse als Britse mijnevelden gelegd, zijn verschillende schepen gezonken, zijn er vliegtuigen neergestort en zijn er verschillende noodafwerpen uitgevoerd in zowel in de Eerste als in de Tweede Wereldoorlog. Ten gevolge van deze oorlogshandelingen kan binnen het gehele onderzochte gebied Niet Gesprongen Explosieven (NGE) achtergebleven zijn.

De soorten NGE die mogelijk zijn achtergebleven, zijn weergegeven in Table 5. Er dient opgemerkt te worden dat in de tabel de verwachte aanwezigheid van de verschillende soorten NGE is weergegeven. Deze waarschijnlijkheid is gebaseerd op het verzamelde historische feitenmateriaal. Uitleg over de gebruikte termen met betrekking tot de verwachte aanwezigheid van NGE is weergegeven in Table 4.

Verwachte aanwezigheid	Betekenis
Verwaarloosbaar	Er is geen indicatie aangetroffen dat dit type NGE aanwezig binnen het studiegebied, al kan dat niet volledig worden uitgesloten.
Onwaarschijnlijk	Aanwijzingen zijn aangetroffen dat dit type NGE is ingezet in de omgeving van het studiegebied. De aanwezigheid van dit type NGE binnen het studiegebied wordt onwaarschijnlijk geacht.
Waarschijnlijk	Er zijn enige indicaties dat dit type NGE aanwezig is binnen het studiegebied.
Aannemelijk	Er zijn sterke indicaties dat dit type NGE aanwezig is binnen het studiegebied.
Zeer waarschijnlijk	De bewijslast voor de aanwezigheid van dit type NGE is zeer sterk en is gebaseerd op verschillende betrouwbare bronnen.

Table 4. Definities van gebruikte terminologie om de aanwezigheid van NGE te duiden.

Soort NGE	Verwachte aanwezigheid	Subsoorten en kalibers	Opmerkingen
Klein kaliber munitie	Onwaarschijnlijk	Diversen	Vergelijkbaar met opmerkingen geplaatst onder 'geschutmunitie': KKM kon worden ingezet bij scheepsgevechten tussen Britse en Duitse vaartuigen binnen het onderzoeksgebied. Verder konden Duitse vaartuigen KKM inzetten tegen naderende/ overvliegende geallieerde vliegtuigen. Tevens zijn er enkele luchtaanvallen met machinegeweren uitgevoerd door Britse vliegtuigen. In het geraadpleegde bronnenmateriaal zijn meerdere meldingen aangetroffen van aanvallen door geallieerde vliegtuigen uitgevoerd met boordmitrailleurs binnen het onderzoeksgebied.
Dieptebommen	Onwaarschijnlijk	<i>Airborne versies</i>	Binnen het onderzoeksgebied waren patrouillegebieden aanwezig om Schnellboote en onderzeeërs uit te schakelen. Verschillende van deze patrouilles met vliegtuigen zijn tijdens de Tweede Wereldoorlog uitgevoerd. Dieptebommen werden vaak tegen onderzeeërs gebruikt. Aangezien er geen directe indicaties zijn dat er dieptebommen zijn afgeworpen binnen het onderzoeksgebied, wordt het onwaarschijnlijk geacht dat deze hierbinnen aanwezig zijn.

Geschutmunitie	Onwaarschijnlijk	20 mm t/m 8,8 cm	Duitse schepen, varende binnen het onderzoeksgebied, hebben in ten minste drie gevallen met luchtafweergeschut gevuld op geallieerde vliegtuigen. De inzet van luchtafweergeschut kan hebben geleid tot het achterblijven van NGE van geschutmunitie binnen het onderzoeksgebied. Verder is bekend dat binnen het onderzoeksgebied een scheepsgevecht heeft plaatsgevonden, en hebben er verschillende luchtaanvallen plaatsgevonden waarbij 20 mm boordkanonnen zijn ingezet. Er is enig bewijs dat geschutmunitie is ingezet in het onderzoeksgebied maar bronnen zijn niet doorslaggevend.
Torpedo's	Aannemelijk	18 inch (45,7 cm) 21 inch (53,33 cm)	Uit rapporten is gebleken dat gedurende zowel de Eerste als de Tweede Wereldoorlog enkele onderzeeërs actief waren binnen het onderzoeksgebied. Daarbij hebben ten minste twee torpedoaanvallen (het zinken van de HMS Ivarhoe en de luchtaanval op 15 september 1944) plaatsgevonden in de directe omgeving van het onderzoeksgebied. Er zijn ook verschillende meldingen aangetroffen van het zinken van schepen uitgerust met torpedo's. Het tot zinken brengen van dergelijke schepen kan leiden tot de aanwezigheid van NGE van torpedo's binnen het onderzoeksgebied. De combinatie van de aanwezigheid van met torpedo's uitgeruste vaartuigen en aanvallen op dit soort vaartuigen heeft tot de conclusie geleid dat de aanwezigheid van NGE van torpedo's binnen het onderzoeksgebied aannemelijk is.
Zeemijnen (WO1)	Waarschijnlijk	WOI: E-mine Type IV (Duits), contact mijnen Vickers Elia en type H Mk II (VK)	Duits kaartmateriaal geeft een vermoedelijk Duits mijnenveld binnen het onderzoeksgebied weer. In ieder geval één Duitse mijn is aangetroffen binnen het onderzoeksgebied, maar buiten het bekende mijnenveld. Verder hebben er verschillende mijnongelukken binnen het onderzoeksgebied plaatsgevonden. De informatie over het ruimen van de mijnenvelden is zeer summier. De aanwezigheid van een mijnenveld en het veelvuldig treffen van mijnen (het waarnemen ervan of daadwerkelijke ongelukken) binnen het onderzoeksgebied leiden tot de conclusie dat aanwezigheid van zowel Duitse als ook Britse mijnen gelegd in de Eerste Wereldoorlog aannemelijk is.
Zeemijnen (WO2)	Waarschijnlijk	WOII: Mk XX geankerde mijnen (VK), Mk XIV en XVII contactmijnen (VK), EMD- en EMC Contactmijnen (Duits), Explosive Floats 'Sprenboje' (Duits), static cutters (Duits)	Het onderzoeksgebied bevindt zich tussen de Britse kust en de door Duitsers bezette Nederlandse kust. Gedurende de Tweede Wereldoorlog zijn er meerdere Britse en Duitse mijnenvelden (met mijnen en mijnneveegobstakels) in het onderzoeksgebied aangelegd. Daarnaast hebben verschillende mijnongelukken, ook buiten de bekende mijnenvelden, plaatsgevonden. De aanwezigheid van mijnen en het plaatsvinden van mijnincidenten binnen het onderzoeksgebied heeft tot de conclusie geleid dat de aanwezigheid van NGE van Duitse mijnen, 'Sprenboje' en andere explosieve mijnveegobstakels, gelegd in de Tweede Wereldoorlog, waarschijnlijk is.

Sub- en Afwerpmunitie	Verwaarloosbaar	Duitse afwerpmunitie	In het geraadpleegde bronmateriaal zijn geen aanwijzingen aangetroffen van het gebruik (inzet of noodafworp) van Duitse bommen binnen het onderzoeksgebied. Echter, zoals gemeld in paragraaf 5.1, zijn de archieven van de <i>Luftwaffe</i> stelselmatig vernietigd. Om deze reden is het bronmateriaal betreffende de <i>Luftwaffe</i> schaars. Zodoende wordt de kans op aanwezigheid in de categorie verwaarloosbaar geplaatst.
	Waarschijnlijk	Geallieerde sub- en afwerpmunitie: 4 lb t/m 4.000 lb.	Uit het bronnenmateriaal is gebleken dat gedurende de Tweede Wereldoorlog verschillende geallieerde luchtaanvallen hebben plaatsgevonden binnen het onderzoeksgebied. Daarnaast vonden noodafworpen van geallieerde vliegtuigen vaak plaats boven de Noordzee. Ten minste drie noodafworpen hebben binnen het onderzoeksgebied plaatsgevonden. Verder zijn verschillende stuks afwerpmunitie na de Tweede Wereldoorlog aangetroffen in de directe nabijheid van het onderzoeksgebied. De hoeveelheid luchtaanvallen en het veelvoudig plaatsvinden van noodafworpen boven de Noordzee (en boven het onderzoeksgebied) heeft tot de conclusie geleid dat de aanwezigheid van NGE van sub- en afwerpmunitie binnen het onderzoeksgebied waarschijnlijk is.

Table 5: NGE die mogelijk zijn achtergebleven in Nederwiek WFZ.

### Risicoanalyse

Het HVO concludeert dat het projectgebied verdacht is op, onder andere, verscheidene kalibers afwerpmunitie, torpedo's en zeemijnen. Het effect van een mogelijke detonatie van deze NGE op schepen, materieel, werknemers en omgeving vormt volgens de risicomatrix een onaanvaardbaar risico (Table 6) Dit betekent dat mitigerende maatregelen nodig zijn om risico te beperken tot "ALARP", zo laag als redelijkerwijs mogelijk. Aanbevolen wordt om een UXO-survey uit te voeren, voor de aanvang van de werkzaamheden aan het windmolenpark. De mitigerende maatregelen bestaan uit het UXO-survey, identificatie van mogelijke NGE, het verwijderen van NGE wanneer noodzakelijk en/of het aanpassen van het kabeltracé en/of constructies.

Voor de uitvoering van mitigerende maatregelen wordt een projectplan opgesteld waarin onder andere procedures en vigerende wetgeving worden vernoemd die van toepassing zijn, wanneer een NGE wordt aangetroffen. Het projectplan dient opgesteld te worden, voordat bodemonderzoek plaatsvindt.

Soort NGE	Verwachte aanwezigheid	Invloedsfactoren	Receptoren	Wijze van invloed	Kans	Gevolgen	Risico
Klein kaliber munitie	Onwaarschijnlijk	Toucheren	Personeel Uitrusting	Primair	Zeer onwaarschijnlijk	Verwaarloosbaar	LAAG
Anti-schip bommen	Onwaarschijnlijk	Toucheren	Personeel Uitrusting	Primair	Zeer onwaarschijnlijk	Zeer groot	LAAG/MATIG
Geschut-munitie	Onwaarschijnlijk	Toucheren	Personeel Uitrusting	Primair	Onwaarschijnlijk	Verwaarloosbaar	LAAG
Torpedo's	Aannemelijk	Toucheren, Beweging, Magnetisme	Personeel Uitrusting	Primair Secundair	Mogelijk	Zeer groot	HOOG

Soort NGE	Verwachte aanwezigheid	Invloedsfactoren	Receptoren	Wijze van invloed	Kans	Gevolgen	Risico
Zeemijnen (WO1)	Waarschijnlijk	Toucheren, Bewegen, Magnetisme	Personeel Uitrusting	Primair Secundair	Mogelijk	Zeer groot	HOOG
Zeemijnen (WO2)	Waarschijnlijk	Toucheren, Bewegen, Magnetisme	Personeel Uitrusting	Primair Secundair	Mogelijk	Zeer groot	HOOG
Sub- en Afwerpmunitie	Waarschijnlijk	Toucheren, Bewegen, Trillingen	Personeel Uitrusting	Primair Secundair	Mogelijk	Zeer groot	HOOG

Table 6: Resultaten van de risicoanalyse voor Nederwiek WFZ.

## 1 GENERAL INFORMATION

This chapter describes the cause for the Desk Top Study – Unexploded Ordnance (DTS-UXO). Furthermore, the Project Area, the Investigation Area, the purpose and methodology are described. The chapter concludes with a general structure of the report.

### 1.1 INTRODUCTION

The Netherlands Enterprise Agency (RVO) preparing the procurement for all activities related to the construction of the Nederwiek Wind Farm Zone (WFZ), located in the North Sea off the coast of the province Noord-Holland, Netherlands. Part of the investigation is a DTS-UXO. A DTS-UXO is a study in which the relevant war related events are analysed in order to determine if UXO possibly remain. This study will provide input for risk assessments for all site works for both RVO contractors as well as developers of the WFZ.

### 1.2 PROJECT AREA AND INVESTIGATION AREA

The project area is the Wind Farm Zone and located in the North Sea, almost 100 kilometres off the coast of the province Noord-Holland, Netherlands. The Investigation Area is a 5,000 m radius around the Wind Farm Zone. This radius is necessary to gain full insight in activities in the Project Area during the First and the Second World War.

The given radius is based on the inaccuracies inherent to conducting offshore desk research. The positions of naval minefields, air strikes and crashes and convoy routes in historical sources are given only approximately, since navigation equipment was not nearly as accurate as modern systems. The most common method of marking locations during the World Wars was based on decimal degrees, which were accurate down to 1 naval mile (1.852 meters). Another way of positioning is found in German sources, which are based on the German Naval Grid (*Kriegsmarine Quadranten*), with a grid size of 6x6 nautical miles. Historical sources based on this grid thus position war related events in an area of 123 square kilometers.

Besides these inherent inaccuracies from historical sources, one must take into account the displacement of UXO on the seabed. Bottom trawling and recent developmental activities may have caused this displacement. The Wind Farm Zone and the Investigation Area are shown in the figure below.



Figure 1: WFZ and Investigation Area (Source of base map: Esri).

### 1.3 PURPOSE AND MAIN OBJECTIVES

The purpose of the UXO desk study is to determine the presence of the types and calibres of UXO and their specific risk profiles for possible intrusive activities within the Nederwiek WFZ.

The main objectives of this study are:

1. Identify possible constraints for offshore wind farm related activities in the Nederwiek WFZ as a result of the presence of UXOs.
2. Define specific requirements related to the presence of UXOs for any wind farm related activity that is to be carried out in the Nederwiek WFZ. And identify areas within the Nederwiek WFZ that should preferably not be used for the installation of offshore wind farms and/or cables or any other structure.
3. Identify possible requirements from UXO point of view that should be taken into account for:
  - a. Determining the different Wind Farm Sites within the WFZ.
  - b. Carrying out geophysical & geotechnical investigations.
  - c. Specific requirements (legal obligations, specific procedures) to be taken into account when finding UXOs.
  - d. Installation of wind turbine foundations.
  - e. Installation of cables.
4. Identify whether any further investigations should be carried out regarding the presence of UXOs and define the scope of these investigations, including their spatial extent and their timing within the overall site development programme – consideration of all relevant investigation methods shall be made for various stages of the project, from site investigation up to installation.

### 1.4 STRUCTURE OF THE REPORT

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 highlighted area within Figure 2: UXO risk management phases. The full UXO risk management process is also described in Figure 2 (see Annex 1 for a larger image). The execution of the following phases of the UXO risk management process is the responsibility of the future developer.

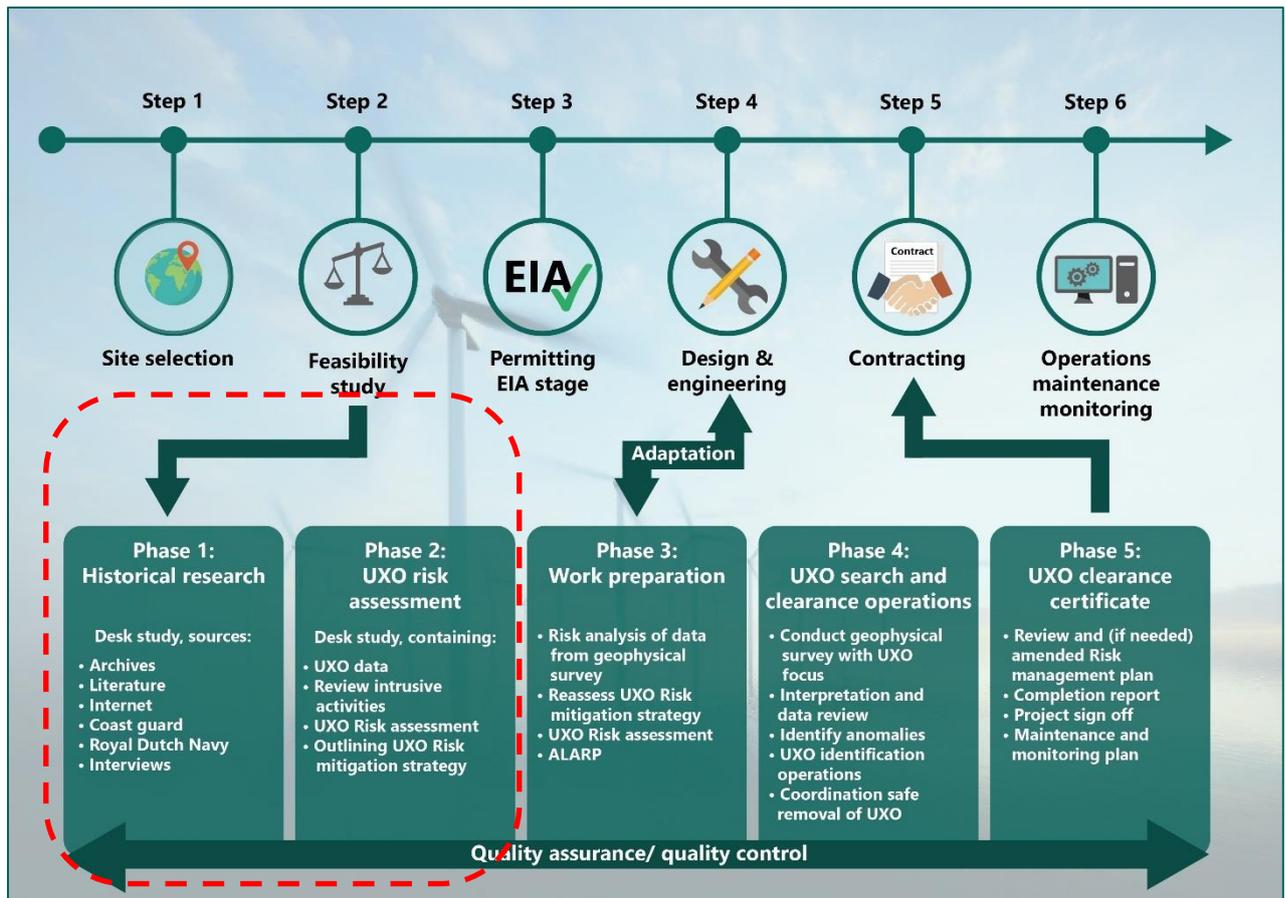


Figure 2: UXO risk management phases.

This UXO desk study exists of two main parts, according to phase I and phase II of the UXO risk management process. Each part contains specific detailed chapters. An overview of the chapters in each part is given in Table 7. A glossary of terms, additional figures and the elaboration of consulted sources are included within the annexes.

Phase of the UXO risk management	Chapters
Phase I: Historical research	<ul style="list-style-type: none"> <li>- Chapter 2: Appraisal of historical sources</li> <li>- Chapter 3: War related events</li> <li>- Chapter 4: Analysis of war related events</li> <li>- Chapter 5: Gaps in knowledge and UXO risk area</li> </ul>
Phase II: UXO risk assessment	<ul style="list-style-type: none"> <li>- Chapter 6: UXO burial assessment</li> <li>- Chapter 7: UXO migration assessment</li> </ul>

Phase of the UXO risk management	Chapters
	<ul style="list-style-type: none"> <li>- Chapter 8: Hazards of UXO likely to be encountered</li> <li>- Chapter 9: Effects of detonations</li> <li>- Chapter 10: Intrusive activities</li> <li>- Chapter 11: UXO risk assessment</li> <li>- Chapter 12: Outlining the UXO mitigation strategy</li> <li>- Chapter 13: Geophysical survey methodologies</li> <li>- Chapter 14: Threshold levels to be applied</li> </ul>

Table 7: Phases of the UXO risk management and related chapters in this report.

## 2 SOURCES

This chapter describes the consulted sources. Detailed information extracted from each source is included within the annexes. Information extracted from the sources, results in an overview of relevant war events. These events are the starting point for the review and analyses of sources in chapter 4 of this historical research.

### 2.1 METHODOLOGY OF HISTORICAL RESEARCH

The Dutch CS-000 (for the glossary of terms, see Annex 1) regulations do not state how an offshore Desktop Study UXO (DTS UXO) should be conducted. The CS-VROO (for the glossary of terms, see Annex 1) provides guidelines for conducting an onshore DTS UXO, however, no guidelines are provided for conducting an offshore DTS UXO. Therefor REASeuro conducts offshore DTS UXO's according to internal standards for offshore desk top studies. At the request of RVO, the report is similarly structured as previous UXO-DTS studies into other Wind Farm Zones. War related events that took place in the area of investigation are derived from historical sources, and subsequently analysed. Based on this analysis a UXO risk area may be demarcated.

Due to several years of experience with offshore research, REASeuro has built up a substantial database regarding war related events in the North Sea. A multitude of sources are consulted for this report. All consulted sources are listed and explained in paragraph 2.2.

The research has been conducted by a historian / UXO advisor, a GIS-specialist, a civil technician and a Senior UXO expert. Page 1 of this report mentions the involved experts. ArcGIS Pro version 3.0.3<sup>1</sup> has been used as a tool to conduct this research. Historical maps and other information have been gathered and projected in this geographical information system for analysis. GIS is also used to position and clarify the relevant war related events mentioned in the list of war related events in chapter 3.

### 2.2 SOURCES

The following table shows sources that were consulted for this UXO-DTS. Several sources are considered to be non-applicable (N/A) for this report.

Source	Consulted for this DTS
Literature	■
<b>Dutch archives</b>	
Municipal archives	N/A <sup>2</sup>
Provincial archives	N/A
Nederlands Instituut voor Militaire Historie (NIMH)	■
NIOD Instituut voor Oorlogs-, Holocaust- en Genocidestudies (NIOD)	N/A
Nationaal Archief (NA)	■
Explosieven Opruimingsdienst Defensie (EOD)	
• UXO clearance reports	N/A
• Minefield map collection (onshore)	N/A
• MMOD <sup>3</sup> -archives	N/A
<b>Collections of Aerial Photography</b>	
Wageningen University Library	N/A
KadasterTopographical Department (Zwolle)	
• Aerial photography collection	N/A
• Allied military map collections	
The National Collection of Aerial Photography (NCAP, Edinburgh)	N/A

<sup>1</sup> Mentioned as 'GIS' throughout this report.

<sup>2</sup> Not applicable sources are exclusively relevant for land-based research and have thus not been consulted.

<sup>3</sup> MMOD was the Mine and Munitions clearance service, one of the predecessors of EOD.

Luftbilddatenbank (Estenfeld)	N/A
<b>International Archives</b>	
The National Archives (London, UK)	■
Bundesarchiv-Militärarchiv (Freiburg, GE)	■
Bundesarchiv Berlin-Lichterfelde (Berlin, GE)	■
National Archives and Records Administration (College Park (MD), US)	■
Library and Archives Canada (Ottawa, CA)	N/A
<b>Sources specific to offshore research</b>	
Royal Netherlands Navy Hydrographic service	■
Noordzeeloket	■
UK Hydrographic Office	■
Marinemuseum, Den Helder, The Netherlands	■
Library of Congress	■
OSPAR-convention	■
Dutch Coast Guard/Beneficial Cooperation - The Royal Netherlands Navy and the Belgian Navy	■
<b>Other sources</b>	
Crash Database of the Studiegroep Luchtoorlog 1939-1945	■
Cultural Heritage Agency of the Netherlands	■
Crash database (SGLO)	■
Wrecksite.eu	■

Table 8: Consulted sources.

### Literature

An overview of used literature can be found in Annex 2. A variety of local, national and international books were consulted. These books have been studied for descriptions and events which might be relevant to the Investigation Area. The resulting events are shown in chronological order in tables. The references (book and page) for each event are included in the tables.

### Municipal archives and Provincial archives

Relevant information has been found.

#### Nederlands Instituut voor Militaire Historie (NIMH) in Den Haag

The NIMH is the institute for military history of the Dutch armed forces. This institution maintains several archives concerning Dutch military history. The Collection 092: Navy Monography has been checked for any relevant events in the Investigation Area. No relevant information has been found.

#### Nationaal Archief (NA) in The Hague

The Dutch National Archives have been consulted for more information on the dumping of explosives, naval minefields and minesweeping, shipwrecks and other relevant information for the Investigation Area. Annex 2 contains the relevant information from the National Archives.

#### The National Archives (TNA) in Londen

The National Archives have been consulted for information on naval minefields, air strikes, naval combat, bomb jettisons and other relevant war related events. The Admiralty, War Cabinet and Air Ministry archives have been consulted for this information. Annex 4 contains relevant results from TNA.

#### Bundesarchiv-Abteilung Militärarchiv (BAMA) in Freiburg

The German military archives were severely damaged during World War II. What remains of the archives is kept and maintained in the Bundesarchiv in Freiburg. The archives of the German navy (*Kriegsmarine*) survived the war relatively well compared to the other service branches. These have been consulted for this desk top study, as well as the German Air Force (*Luftwaffe*) archives, from which only 2% of the documents survived the onslaught of the war. Annex 4 contains the relevant information from the BAMA.

#### Bundesarchiv in Berlin-Lichterfelde (BaBL) in Berlin, Germany

In the Bundesarchiv in Berlin, location Lichterfelde, the departments *Zentrale Verwaltungsangelegenheiten*, *Archivtechnik und zentrale fachliche Dienstleistungen*, *Bereitstellung* and *Filmarchiv* are accommodated. These have been consulted by REASeuro, but no results for the Project Area are found.

#### National Archives and Records Administration (NARA) in College Park (MD)

Research has been conducted in the US National Archives and Records Administration. The NARA has been consulted for documents from the US Army Air Forces (USAAF) and for the collection of captured German records.

#### Royal Netherlands Navy Hydrographic service

This has been consulted for recent naval charts of the Investigation Area. These naval charts show wrecks and other obstructions on the seabed. Information on wrecks has also been derived from the wreck register (HP39). Annex 6 contains information from the Hydrographic Service.

#### Marinemuseum, Den Helder

The Navy Museum ('Marinemuseum') holds a collection of Royal Netherlands Navy maps and charts. The collection includes maps of post-war minesweeping operations. The relevant information is added in Annex 6.

#### Noordzeeloket

The Noordzeeloket contains information on military usage of the North Sea and has thus been consulted for information on the Investigation Area.

#### UK Hydrographic Office

The UK hydrographical office maintains a collection of historical naval charts, including charts that contain minefields and convoy routes. Naval charts showing the Investigation Area have been consulted, but no map has been found with information regarding the Investigation Area.

#### Library of Congress

On the website of the Library of Congress, which is known as the national library of the United States, a chart has been consulted regarding minefields in the First World War. This chart is shown in Annex 5.

#### Post-war UXO clearance: Beneficial Cooperation, Coast Guard and OSPAR

The Investigation Area is situated in the North Sea, 12 Nautical Miles off the Dutch coast. Therefore, the UXO-related interventions of the Beneficial Cooperation<sup>4</sup> and the database of the OSPAR Commission<sup>5</sup> were consulted. The Dutch navy is working with the Belgian navy to keep the sea, coastal waters and harbour mouths free of mines. Therefore, the UXO-related interventions in the database of the Beneficial Cooperation is consulted. The results are shown in Annex 5.

#### Cultural Heritage Agency of the Netherlands

The Cultural Heritage Agency of the Netherlands (De Rijksdienst voor Cultureel Erfgoed) has information available regarding wrecks in the North Sea. This data is called SonarReg (*Sonar Registratiesysteem*). REASeuro consulted this database and the results are presented in Annex 2.

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<sup>4</sup> The Beneficial Cooperation keeps a detailed registration on UXO encounters in the Dutch and Belgian part of the North Sea. The registration provides information on UXO encounters since 2005.

<sup>5</sup> The Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR-convention) provides a framework for reporting encounters with conventional and chemical munitions in the OSPAR maritime area.

#### [Crash Database](#)

The Dutch Air War Study Group 1939-1945 (Studiegroep Luchtoorlog 1939-1945) maintains an online database of all military airplane losses in the Netherlands during WWII. This record is checked, and the results are presented in Annex 2.

#### [Wrecksite.eu](#)

The wreck site is the world's largest online wreck database. The website has information about 205.740 wrecks around the world. When information about the reason for the sinking of a ship is known, it is mentioned on the website.

### 3 WAR RELATED EVENTS

The consulted historical sources (see annexes) indicate several war related events within the Investigation Area. The war related events derived from the historical sources are listed chronological in the table underneath. A primary analysis divides the events between events considered relevant and not relevant for the Investigation Area. Relevant events are subsequently referred to a paragraph for further analysis. All relevant events that could be located on the map, are visible on the Fact Map (see annex 7).

Event		Historical sources			Primary analysis	
Date	Details	Literature	Dutch archives	International archives	Relevant?	Paragraph
1914-present	Wrecks within Investigation Area.		HP39 Wrakkenregister		Yes, wrecks within Investigation Area.	4.4
1914-1918	British and German ships laid naval mines in the North Sea.	BEZ1 18, 24-25 CRO 62, 149-160		BAMA, RM 5/4721K	Yes, indications of minefields within the Investigation Area.	4.3.1
3 May 1915	The trawler Uxbridge was blown up by a mine at 53°43' N 02°59' E.			TNA, ADM 137/1066, 137/1067	Yes, mine near Investigation Area outside of known minefield.	4.3.1 and 4.4
6 May 1915	FV Don sunk due to a mine at 53°16'N 02°50'E.	WRE			Yes, mine and wreck near Investigation Area.	4.3.1 and 4.4
8 May 1915	The trawler Hellenic was sunk by a mine at 53°38' N 03°01' E.			TNA, ADM 137/1066	Yes, mine near Investigation Area outside of known minefield.	4.3.1 and 4.4
9-12 May 1915	Five moored mines were sighted at 52°48' N 03°21' E.			TNA, ADM 137/1067	Yes, mine near Investigation Area outside of known minefield.	4.3.1
	Mines in 53°26' N 02°25' E was partially swept.			TNA, ADM 137/1067	Yes, mine near Investigation Area outside of known minefield.	4.3.1
7 October 1915-25 December 1916	Fifteen Dutch ships ran onto moored mines and sunk within or near the Investigation Area.		NA, toegang 2.05.32.09, inv. 44		Yes, mines and wrecks within and near Investigation Area.	4.3.1 and 4.4
25 December 1915	SS Rigi hit by a mine at 53°28'N 03°30'E.	WRE			Yes, mine and wreck within Investigation Area.	4.3.1 and 4.4
5 May 1917	FV Simon was sunk by gunfire by the German submarine UC-71.	WRE			Yes, U-boat attack near Investigation Area.	4.1.1 and 4.1.4
1918	German submarine U-97 sank at 53°28,34' N 03°23,72' E	WRE			Yes, U-boat sank within Investigation Area.	4.1.4 and 4.4
1 June 1918	A red mine was sighted at 53°28' N 03°07' E.			TNA, ADM 137/1551	Yes, mine within Investigation Area outside of known minefield.	4.3.1
5 June 1918	A German Type IV Naval Mine was spotted and sunk at 52°32' N 03°28' E.			TNA, ADM 137/1551	Yes, mine within Investigation Area outside of known minefield.	4.3.1

Event		Historical sources			Primary analysis	
Date	Details	Literature	Dutch archives	International archives	Relevant?	Paragraph
11 June 1918	A mine was cut at 53°37' N 03°37' E.			TNA, ADM 137/1551	Yes, mine near Investigation Area outside of known minefield.	4.3.1
1939-1945	British and German minelaying operations in the North Sea.			TNA, ADM 1/8996, ADM 1/19745, ADM 199/154, ADM 234/560, ADM 239/304	Yes, mines laid within Investigation Area.	4.3.2
	German minefields C24 and C27 within Investigation Area.			TNA, ADM 234/560 BAMA, ZA 5/27, ZA 5/44, ZA 5/48	Yes, mines laid within Investigation Area.	4.3.2
	Bombs jettisoned in North Sea.			TNA, AIR 14/110, AIR , AIR 24/264, AIR 24/375		4.2.2
1940	British East Coast Minefields within Investigation Area.			TNA, ADM 234/561	Yes, mines laid within Investigation Area.	4.3.2
21 June 1940	MV Mercurius spotted but no attack.			TNA, AIR 28/75	No, no attack made.	-
1 September 1940	HMS Ivanhoe hit a mine at 53°30'N 03°30'E. The ship was sunk three hours later by torpedo.	WRE			Yes, mine and wreck within Investigation Area.	4.3.2 and 4.4
11/12 June 1941	A Vickers Wellington Ic crashed in the North Sea at 53°06,898'N 03°12,004'E on its way to Düsseldorf after being hit by flak.	SGLO T1052, WRE			Yes, plane crashed within Investigation Area.	4.4
12/13 June 1941	A Handley Page Hampden I crashed in the North Sea at 53°05,118'N 03°19,235'E after engine trouble.	SGLO T1054A, WRE			Yes, plane crashed within Investigation Area.	4.4
16 June 1941	A Bristol Blenheim crashed at sea at 53°23' N 03°00' E.			TNA, AIR 24/232	Yes, plane crashed within Investigation Area. It is unknown if its four 250 lb. bombs were dropped.	4.4
28/29 December 1941	A Vickers Wellington Ic was hit by flak over Wilhelmshaven and was ditched in the North Sea 100 km west of Petten.	SGLO T1369			Yes, plane crashed within Investigation Area.	4.4
1942	4.000 mines laid in shipping lanes near the Dutch coast.	BUR 120			Yes, mines laid within Investigation Area.	4.3.2
11 April 1942	Convoy attacked with bombs 80 km west of Texel.	ZWA1 344			Yes, convoy attacked near Investigation Area.	4.2.1
11 September 1942	British motor gunboat was captured in AN.8198 and taken in tow to IJmuiden.			BAMA, RM 45-II/218	Yes, gunboat captured within Investigation Area.	4.1.2
29 October 1942	A Vickers Wellington III crashed into the North Sea 80-120 km west of Katwijk.	SGLO T1892			Yes, plane crashed within Investigation Area.	4.4

Event Date	Details	Historical sources			Primary analysis	
		Literature	Dutch archives	International archives	Relevant?	Paragraph
3 February 1943	A Lockheed Hudson collided mid-air at 53°20' N 03°25' E.			TNA, AIR 25/346	No, plane landed damaged but safely on shore.	-
5 March 1943	Smoke floats and dinghy sighted.			TNA, AIR 28/595	No, no attack made.	-
21 May 1943	A mine was sighted at 53°12' N 02°56' E.			TNA, AIR 25/349	Yes, mine sighted outside of a known minefield.	4.3.2
6 July 1943	British vessels were spotted at 52° 53' N 03° 12' E.			TNA, AIR 25/351	No, no attack made.	-
29 September 1943	The mainplane was spotted at 52° 53' N 03° 10' E.			TNA, AIR 25/353	Yes, wreck within Investigation Area.	4.4
23-24 October 1943	A Schnellboot-attack took place off the coast of Cromer. One trawler sank. The S-74 Schnellboat was hit by three 40 mm shells at 53°08'N 03°25'E.	WRE			Yes, Schnellboot attacked near Investigation Area.	4.1.3
5 November 1943	Beaufighters attacked German E-boats.			TNA, AIR 25/355	Yes, attack on E-boats.	4.2.1 and 4.2.3
	A dinghy was spotted, and gunfire was used to make it sink.			TNA, AIR 35/355	Yes, dinghy fired upon, and smoke floats dropped near Investigation Area.	4.2.1
24 November 1943	An aircraft was seen on fire going into the sea at 53°12' N 03°25' E.			TNA, AIR 25/355	Yes, aircraft crashed in Investigation Area.	4.4
20 December 1943	A North American P-51b crashed 110 km east of Cromer due to engine trouble near Texel.	SGLO T3240C		TNA, AIR 25//356	Yes, airplane crashed near Investigation Area.	4.4
11 January 1944	An unidentifiable wreckage was seen at 52°51' N 02°59' E.			TNA, AIR 25/357	Yes, wreck near Investigation Area.	4.4
26/27 March 1944	A Handley Page Halifax III was ditched in the North Sea 100 km off Cromer.	SGLO T3555		TNA, AIR 25/359	Yes, aircraft crashed in Investigation Area.	4.4
8 April 1944	Bombs jettisoned within Investigation Area.			TNA. AIR 25/360	Yes, jettisoned bombs within Investigation Area.	4.2.2
30 July 1944	Wreckage spotted at 53°29' N 03°32 E.			TNA, AIR 25/363	Yes, wreck found near Investigation Area.	4.4
	A mainplane was spotted at 53°27' N 03°40' E.			TNA, AIR 25/363	Yes, mainplane spotted near Investigation Area.	4.4
13 Augustus 1944	Wreckage spotted at 52°59' N 03°22' E.			TNA, AIR 25/365	Yes, wreckage spotted near Investigation Area.	4.4
15 September 1944	Two S-boats were attacked with torpedoes from planes.			BAMA, RM 67/33	Yes, torpedo attack and wreck within Investigation Area.	4.2.1
February 1945	Air operations against German E-Boats and small submarines.			TNA, CAB 101/324	Yes, patrols within Investigation Area.	4.1.4 and 4.2.1

Event		Historical sources			Primary analysis	
Date	Details	Literature	Dutch archives	International archives	Relevant?	Paragraph
3 February 1945	A flame float was spotted at 53°28' N 03°22' E.			TNA, AIR 25/371	No, no attack made.	-
7 February 1945	Bombs jettisoned at 53°31' N 03°01' E and 53°25' N 03°00' E.			TNA, AIR 25/371	Yes, bombs jettisoned in Investigation Area.	4.2.2
21 February 1945	E-boats were attacked with bombs in 53°20' N 03°00' E.			TNA, AIR 25/371	Yes, bombing near Investigation Area.	4.2.1 and 4.2.3
1 March 1945	E-boats were attacked with 250 lb. bombs at 52°49' N 03°28' E.			TNA, AIR 25/372	Yes, bombing in Investigation Area.	4.2.1 and 4.2.3
17 March 1945	E-boats were attacked with 250 lb. bombs at 53°02' N 03°11' E.			TNA, AIR 25/372	Yes, bombing in Investigation Area.	4.2.1
18 March 1945	E-boats were attacked with bombs in 53°07' N 03°14' E.			TNA, AIR 25/372	Yes, bombing in Investigation Area.	4.2.1
18 April 1945	Drop tank at 52°27' N 03°12' E attacked with cannon fire.			TNA, AIR 25/373	Yes, cannon fire in Investigation Area.	4.2.1
25 June 1947	A SS Sonata sunk by a mine at 53°34'N 03°31'E.	WRE			Yes, mine and wreck near Investigation Area outside of known minefields.	4.3.2
Post WWII	Post-war UXO encounters.		Dutch Coast Guard	OSPAR Commission	Yes, UXO encountered within Investigation Area.	4.3.3
17 January 1967	IJmuiden 51 (Nora) encountered a floating contact mine at 53°10' N 03°35' E.		NA, toegang 2.12.56, inv. 955		Yes, mine near Investigation Area outside of known minefield.	4.3.3
3 February 1967	TX 2 (Willem) encountered a 500 lb. bomb at 52°53' N 03°05' E.		NA, toegang 2.12.56, inv. 955		Yes, mine near Investigation Area outside of known minefield.	4.3.3

Table 9: Chronological overview of war related events.

## 4 ANALYSIS OF WAR RELATED EVENTS

As listed in chapter 3, many war related events did occur in the Investigation Area. The relevant events are analysed in this chapter to determine if UXO could remain. The events are grouped into five categories: war at sea, the air war, naval mines, wrecks, and post-war military exercises.

### 4.1 WAR AT SEA

Considering the naval battles, the Investigation Area is situated in a relative uneventful zone. This can be explained by the distance between the Investigation Area and the German convoy routes near the Dutch coast, see the figure below.

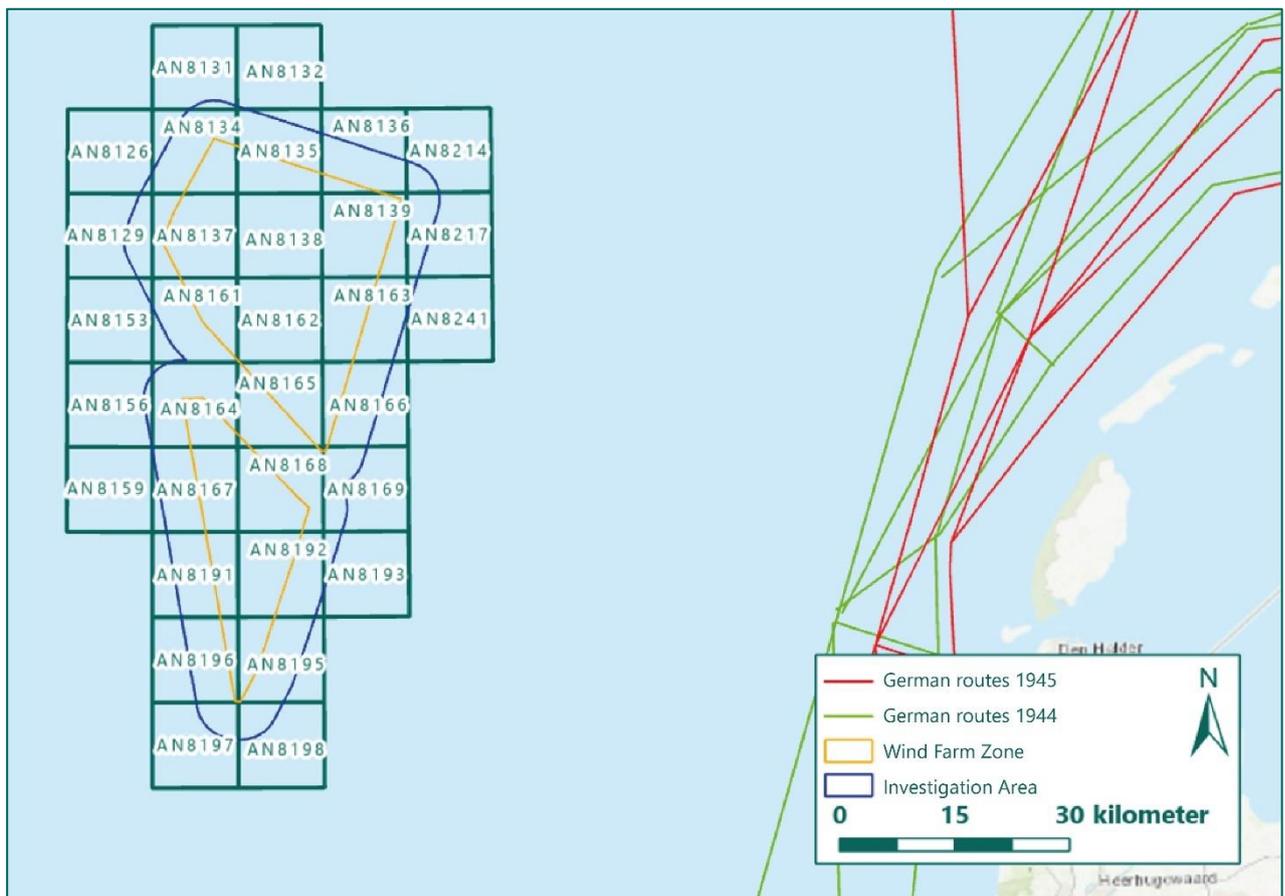


Figure 3: German convoy routes and the relevant quadrants as used by the German navy (Source basemap: Esri).

The records of the Bundesarchiv-Militärarchiv and The National Archives are consulted to get an overview of naval battles within or near the Investigation Area. As shown in chapter 3, the consulted sources mention only one naval battle within the Investigation Area during the Second World War. This battle took place on 11 September 1942.

The website [www.wrecksite.eu](http://www.wrecksite.eu) (see Annex 2) mentions multiple wrecks within the Investigation Area. This website also mentions the cause of sinking for several of the wrecked ships and boats<sup>6</sup>. In two cases, the sinking is caused by naval battles during World War I and II. In the next paragraphs naval battles within or near the Investigation Area are discussed.

<sup>6</sup> Causes of the sinking/crashing of vessels/aircraft have not been found about relevant wrecks indicated in the HP39 Wrakkenregister (see Annex 5).

#### 4.1.1 Sinking of FV Simon, 5 May 1917

According to [www.wrecksite.eu](http://www.wrecksite.eu) the Dutch trawler FV Simon was sunk on the 5<sup>th</sup> of May 1917 by the German submarine UC-71. Specifics of the attack are unknown, but the trawler sank at 53°31'N 03°40'E taking eleven of its crew with her. The UC-71 was equipped with mine tubes, torpedo tubes and one 8,8 cm SK L/30 deck gun. This last gun was used during the attack. Dutch, German, and British archives have been consulted to find additional documentation about the naval battles that preceded the sinking of the vessels. No additional information was found. The attack itself took place about eight kilometres from the Investigation Area. The occurrence of an attack like described above serves as an indication that naval engagements took place in (neutral) Dutch waters during the First World War and presence of munitions from this era cannot be ruled out based on Dutch neutrality.

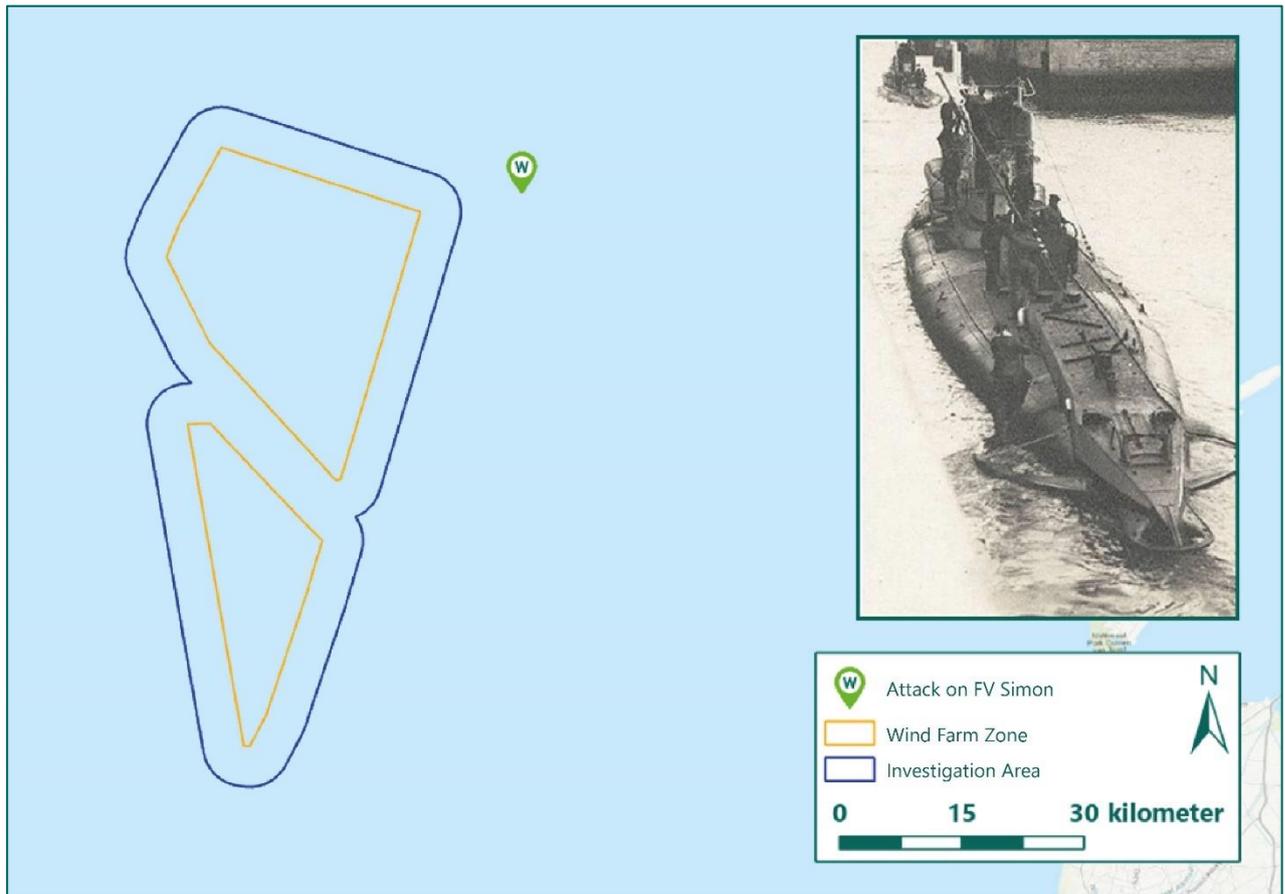


Figure 4: Location of the attack on the FV Simon with a cut-out of the UC-71 (Source basemap: Esri, photo of submarine: wrecksite.com).

#### 4.1.2 Capture of a British Motor Gunboat, 11 September 1942

According to the records of *Marinebefehlshaber in den Niederlanden*, found in the German Bundesarchiv, a German Schnellboot hijacked a 'feindliche Schnellboot' (presumably a British Motor Gunboat). The hijacking took place within Qu. AN8198. This Quadrant has a partial overlap with the Investigation Area (see Figure 5).



Figure 5: Relevant *Quadrant* (Qu. AN8198) where a hijacking of a British MGB took place (Source basemap: Esri).

According to the record, the British MGB was towed back to Den Helder, along with two British prisoners of war. Specifics on the exact dealings during the hijack of the MGB are not specified in the record. The National Archives have been consulted to check if British sources mention the capture of the British MGB. Relevant sources have not been found. Therefore it is unknown how the MGB is captured, however it is to be expected that an exchange of fire between the British- and German boats took place.



Figure 6: Picture of a British Motor Gun Boat (MGB). MGBs are heavily armed, manoeuvrable, and fast boats (Source: Imperial War Museums, A 13631).



Figure 7: Picture of a German Schnellboot (S-Boot or E-Boat). E-Boats are comparable with the MGB's but due to their diesel engines have a larger operational range (Source: Imperial War Museums, A 28558).

In literature and in consulted sources no additional mention is found about this hijacking. Complementary, Wardocs B.V.<sup>7</sup> was contacted regarding this war related event. WarDocs was also unable to deliver additional information.

#### 4.1.3 Schnellboot-attack, 23/24 October 1943

In the night of 23 on 24 October 1943, a torpedo operation of the German 2nd, 4th, 6th and 8th Schnellboot Flotillas took place off Cromer. The British defence had strengthened itself continuously such that the German Flotillas could only sink the trawler, William Stephen. The Schnellboots encountered attacks from British destroyers, Motor Torpedo Boats, and motor launches and during these fights multiple boats were sunk off the coast of Cromer. The commander of the 4th Flotilla (Korv. Kpt. Lützow), the commander of the S-88 and eight men were killed in action, 19 men were rescued by British, 24 men by German boats. The Schnellboot S-73 took three 40 mm hits by British ships. According to the website of Wrecksite, the

<sup>7</sup> WarDocs is a company specialized in gathering and supplying war related source information (mostly British and German archives) for historical research and UXO-clearance (<https://www.wardocs.nl/>).

location of S-74's wreck is 53°08' N, 03°25' E (see Figure 8). It is unknown if the S-74 was attacked within the Investigation Area or that it only sank there. Dutch, German, and British archives have been consulted to find additional documentation about the attack of October 1943, but this was not found.

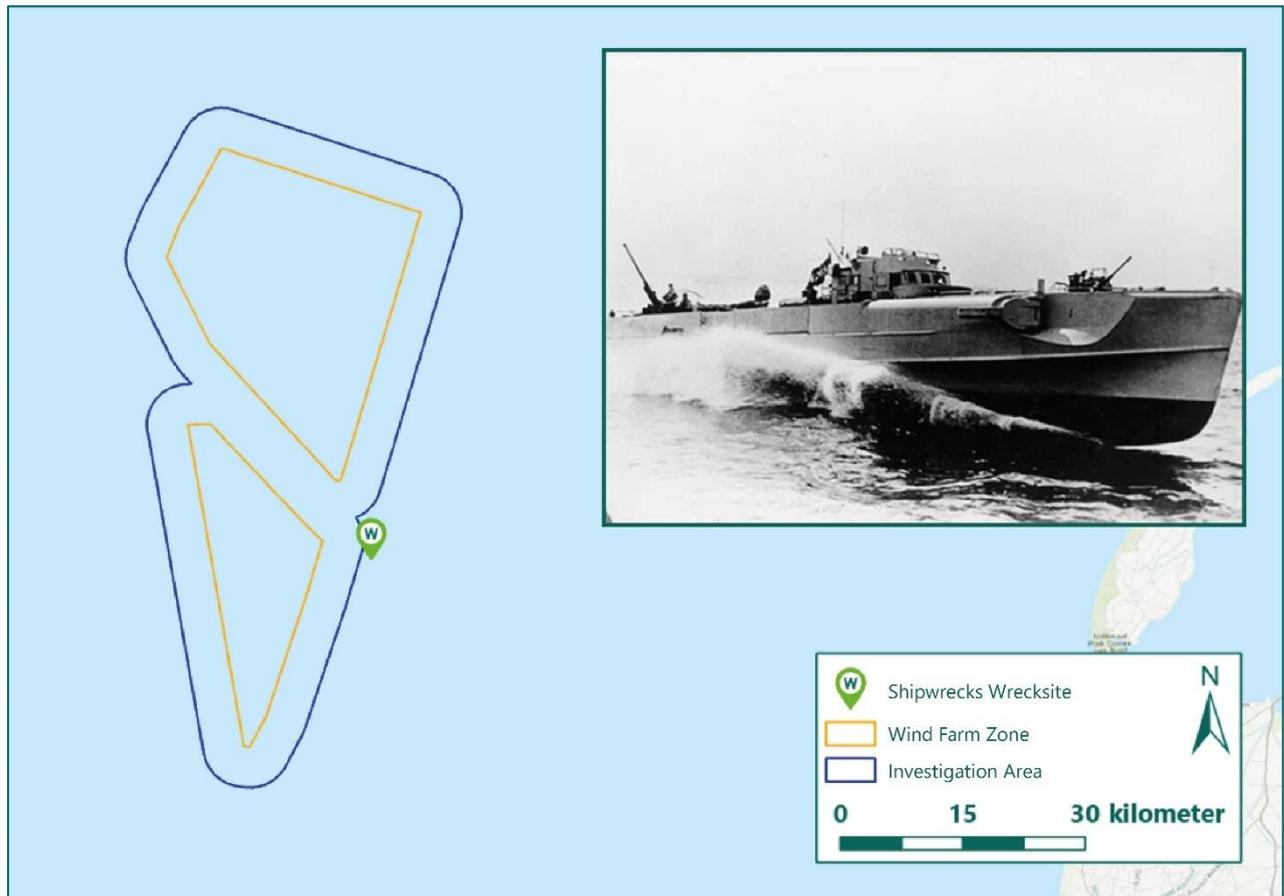


Figure 8: Location of the wreck of S-74 with a cut-out of the boat (Source basemap: Esri, photo of submarine: wrecksite.com).

#### 4.1.4 Activity of submarines

During both World War I and II submarines (both German and Allied) have been present in or near the Investigation Area. This is discussed in both paragraph 4.1.1 (FV Simon sunk after attack by submarines) and 4.4 (submarine U-97 sank within Investigation Area). No additional information about attacks made by submarines (besides the information from the website of Wrecksite) has been found in the consulted archives. WarDocs was also unable to supply additional information about these kinds of attacks. However, the attacks involving submarines within and near the Investigation Area serve as an indication of the presence of submarines. There is a possibility that additional<sup>8</sup> submarine attacks took place within the Investigation Area. Because of the lack of source material proving this, the likelihood of presence of UXO related to submarines is deemed feasible (see Table 14 and Table 15).

#### 4.1.5 Conclusion

Several relevant incidents took place in or near the Investigation Area. A Dutch trawler sank due to a submarine attack, a British Motor Gunboat was hijacked and towed back to the Dutch coast by German Schnellboote and German Schnellboote were attacked with British 40 mm guns within or near the Investigation Area. As a result of these incidents, UXO can possibly be encountered within the Investigation Area. The likelihood of presence of different sorts of UXO will be discussed in paragraph 5.2.

<sup>8</sup> 'Additional' is used in reference to paragraph 4.1.1. In this paragraph there has been mention of one submarine attack near the Investigation Area.

## 4.2 AIR WAR

In and in the vicinity of the Investigation Area many events relating to the air war have occurred. This concerns airstrikes on ships and submarines, the use of anti-aircraft artillery (AAA or flak) and jettisons of bombs. These events are analysed in the following paragraphs, followed by a general conclusion. Airplane crashes will be discussed in paragraph 4.4.

### 4.2.1 Aerial attacks on surface vessels and submarines

As stated in paragraph 4.1 there are no known German convoy routes within or near the Investigation Area. However, according to the British Operations Record Books (ORBs) of Coastal and Bomber Command, multiple attacks on ships during the Second World War within the Investigation Area took place. Coastal Command was tasked with protecting allied ships and Britain's coast, but also attacked German vessels on the North Sea. Bomber Command was tasked with bombing strategic targets and urban areas. Apart from this, German ships were incidentally attacked by Bomber Command planes.

The locations of air strikes mentioned in the records are seldom very accurate. Navigational technology was still developing, and visual marks were rare on the North Sea. Sometimes the location of an attack is specified by adding a name of an island or a city. For example, the following statement was found in the consulted literature (see Annex 1): [an attack took place] '80 km ten westen van Texel (80 km west of Texel)'. These kinds of reports only give indications of attacks but are not precise enough to be thoroughly analysed. Most ORBs found in The National Archives, London, UK, are more specific. Locations of airstrikes at sea are generally displayed using a decimal geographical coordinate system. Between 1940 and 1942, Coastal Command used a code instead of decimal degrees. Several attacks on ships and submarines are mentioned in the ORBs of Bomber Command and Coastal Command. In the figure below all known locations of airstrikes within the Investigation Area are shown. In Table 10 detailed information of each of the attacks is given.



Figure 9: Map showing the locations of known aerial attacks within or near the Investigation Area (Source basemap: Esri).

No./ Coordinate	Date	Summary of events	Munition used
1	5 November 1943	A Bristol Beaufighter (254 Squadron) was in position 52 55' N 03 40' E at 7:32 hrs and saw four "E" boats. "S" [one Beaufighter] then attacked the leading boat in starboard line making strikes amidships with two long bursts from all guns. The vessel was seen on fire amidships by the pilot of another aircraft. The pilot states that there was intense but inaccurate flak on the run-in but ceased afterwards. The Beaufighter "Q" attacked the second vessel in port line. Hits were scored amidships and stern. It did not meet with any flak from the target, but there was firing from leading vessel in port section.	Small calibre munition 20 mm shells  German anti-aircraft artillery is taken into account in paragraph 4.2.3
2	5 November 1943	Three Lockheed Hudson bombers (279 Squadron) were to perform a search on the North Sea. At 12.07 in position 53 06' N 03 23' E an empty dinghy (H type) was seen, partly submerged, but no signs of life were observed. Attempts were made to sink the dinghy by gunfire; hits were made but the dinghy did not sink. Two smoke floats were then dropped but both failed to function.	Small calibre munition  Smoke floats
Qu.8217	15 September 1944	According to a German source, two aerial attacks were made on S-boats. Seven torpedoes were outmanoeuvred, but three acoustic torpedoes detonated between two escort boats. Simultaneously flares and fragmentation bombs were dropped which led to the destruction of one S-boat.	Unknown torpedoes [probably 18 inch torpedoes] Unknown aerial bombs
3	21 February 1945	Multiple Vickers Wellington (524 and 612 Squadron) bombers were to carry out a patrol on the North Sea. At 23.13 hrs some light flak was experienced, and attack instructions were requested by aircraft. At 23.28 hrs in position 53 20' N 03 00' E a visual was obtained of nine E-boats on course 270 dgs at 30 knots. They were in two lines astern 300 ft apart with 450 ft between columns. These vessels were attacked at 23.40 hrs from 1.000 ft, some light flak was experienced. Bomb burst straddled both columns. The first two bombs were seen to burst in area of 3 <sup>rd</sup> E-boat in starboard column. The last four bombs burst in area of 3 <sup>rd</sup> boat of port column and one boat dropped 6 miles astern. Captain bombed before receiving attack instructions as target had been established as enemy. The aircraft was armed with G.P. bombs fused 44 Pistol Tail .025 secs delay.	Unknown (probably 250 or 500 b.) General Purpose bombs fused with a tail pistol No. 44, .025 seconds delay  German anti-aircraft artillery is taken into account in paragraph 4.2.3
4	1 March 1945	One Vickers Wellington (524 Squadron) with the name Yamak 47 was to attack E-boats on the North Sea. At 01.47 hrs a radar contact was obtained, and the plane homed to the position 52 49' N 03 28' E at 01.48 hrs. It attacked with six 250 lb. bombs from a height of 1500 feet.	6 x 250 lb. bombs  German anti-aircraft artillery is taken into account in paragraph 4.2.3

No./ Coordinate	Date	Summary of events	Munition used
		The bombs were seen to fall well short of the target. Intense accurate light flak was encountered.	
5	17 March 1945	At 3.40 hrs in position 53 02' N 03 11' E an attack was made by radar bombing graph from 1,500 feet with six 250 lb. bombs. The rear gunner saw the bombs burst 200 ft short of water of wakes [probably 'waves' caused by E-boats].	6 x 250 lb. bombs
6	18 March 1945	Multiple Vickers Wellington (524 Squadron) and Bristol Beaufighter (254 and 296 Squadron) bombers were to carry out operation 'Percolate'. At 3.22 hrs six Target Identification bombs were dropped and at 3.34 hrs four flares were dropped in position 53 07' N 03 14' E. The Yamak 38 [name of one of the planes] was seen to attack five E-boats in line astern but bombs undershot about 35 yards astern of last.	Unknown (probably 250, 500 or 1,000 lb.) bombs 6 x Target Identification bombs 4 x flares
7	18 April 1945	Two Bristol Beaufighters (236 and 254 Squadron) were to fly patrol 'L'. At 7.23 hours in position 52 27' N 03 12' E one Beaufighter sighted a cigar shaped object. This was attacked with cannon fire, and it proved to be a drop tank.	20 mm shells

Table 10: Details about airstrikes within the Investigation Area.

As can be seen in the table above, attacks were carried out within or near the Investigation Area with a multitude of subtypes and calibres of munition. Furthermore, TNA also contains other information on air operations specifically against E-boats and submarines. Certain areas of the North Sea have been demarcated to be patrolled regularly by Coastal Command. These areas changed monthly. In the figure below, the patrol areas of March 1945 are shown. The anti-E-boat and anti-submarine areas intersect with the Investigation Area. During these patrols, apart from bombs, machineguns and -cannons, anti-ship bombs were regularly used against German shipping. There is a possibility that these kinds of explosives have also been used within the Investigation Area.

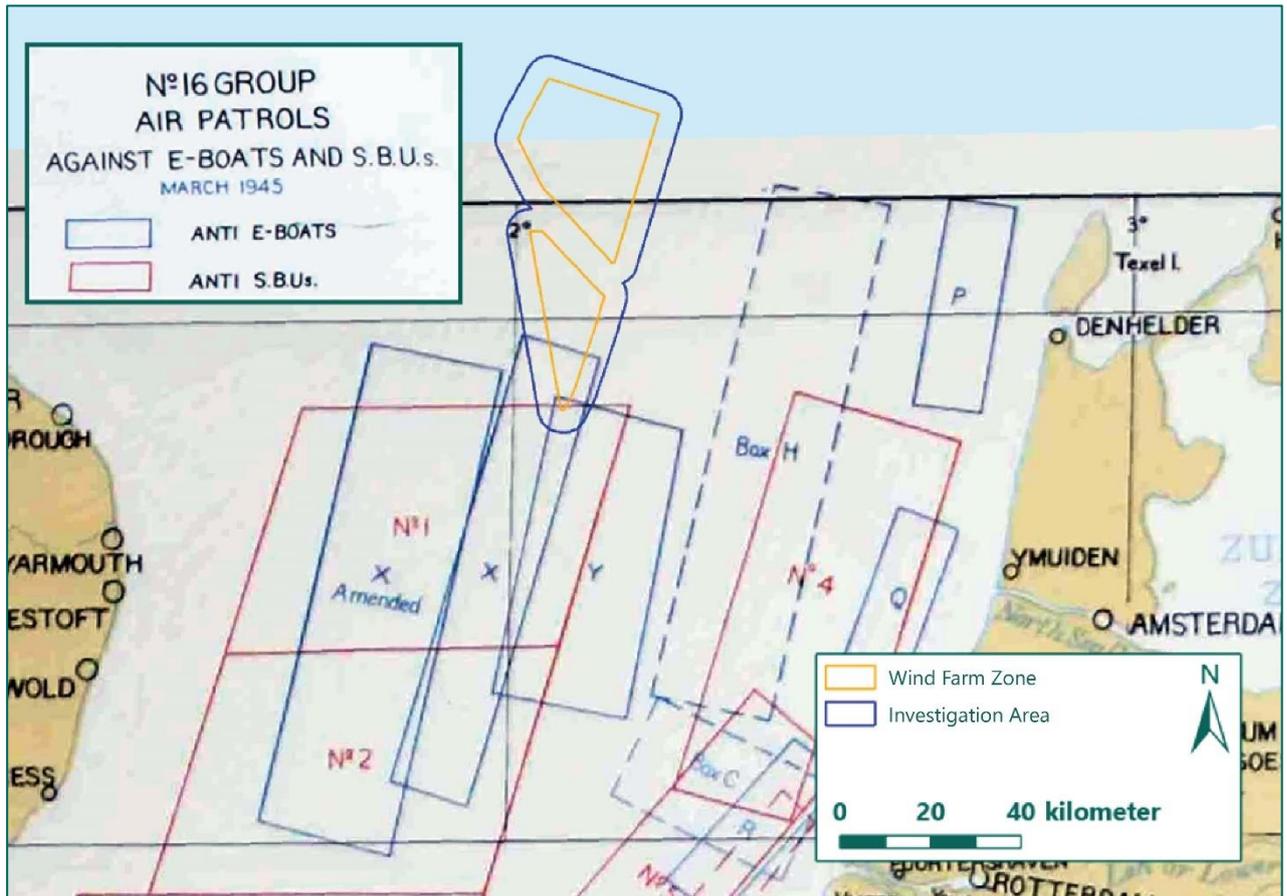


Figure 10: Locations of anti-E-boat and anti-submarine patrols within the Investigation Area (Source: TNA, CAB 101/32)

As a result of the aerial attacks within and near the Investigation Area, UXO can be encountered within the Investigation Area. Conclusions about possible UXO encounters related to the air war are given in paragraph 4.2.5.

#### 4.2.2 Jettisoned bombs

During the Second World War daily (day and night) bombing raids by British and American bombers on Germany or German occupied territories took place. Especially after Allied air superiority<sup>9</sup> above the Channel after the *Battle of Britain* (October 1940) and even air supremacy<sup>10</sup> from 1944. The flight paths towards targets and back to base (in the United Kingdom) ran across the North Sea. An example is displayed in the following figure.

<sup>9</sup> The Allied side was in a more favourable position than its opponent.

<sup>10</sup> The Allied side holds complete control of the skies.



Figure 11: Example of a flight path over the Investigation Area of bombers from Bomber Command, 14/15 January 1944 (Source: TNA, AIR 24/264)

Allied bombers were often attacked by German fighter airplanes to prevent the Allied aircrafts reaching their targets. Consequently, hundreds of Allied and German planes were hit and/or shot down. Procedure was implemented by the Royal Air Force (RAF) that in the event of an aircraft not being able perform its bombing mission and thus bringing back its bomb load (due to engine problems, enemy attack, difficult weather etc.), the captain of the aircraft needs to decide if it was safe to land with all, a portion or no bombs. In the case of the latter two, bombs could be jettisoned to reduce the weight of the bomber, enabling it to increase the speed and manoeuvrability, and thus the crews' chance to survive. The procedure called for jettisoning the bombs in a 'safe' position. When bombs are dropped 'safe', the bombs are unarmed and would normally not detonate after dropping. This procedure is documented in a record from The National Archives.

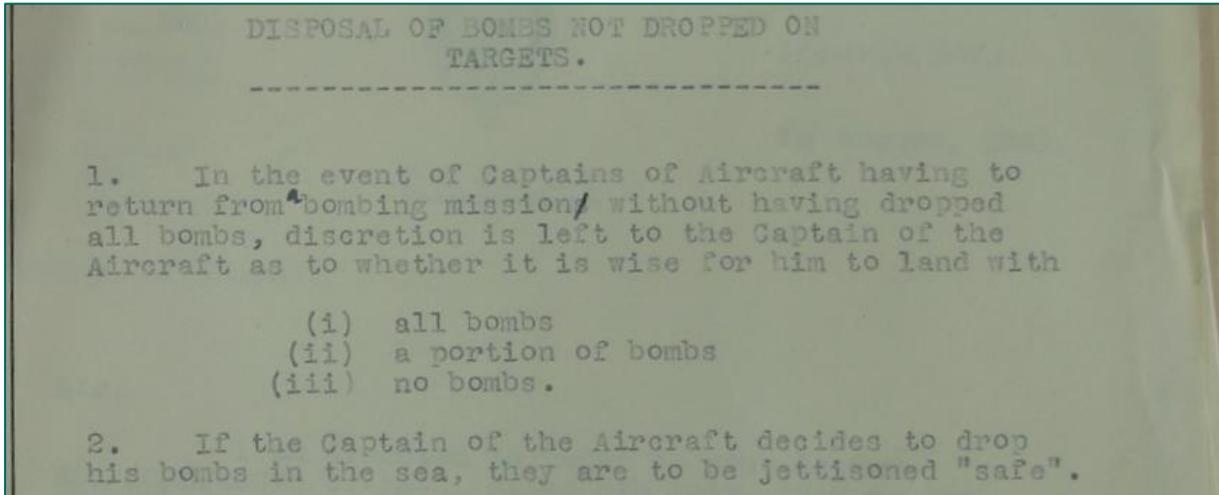


Figure 12: Extract from report regarding the 'Disposal of bombs not dropped on allotted targets' (Source: TNA, AIR 14/110).

Jettisons happened regularly at sea as well. These types of jettisons were rarely documented accurately, see figure below.

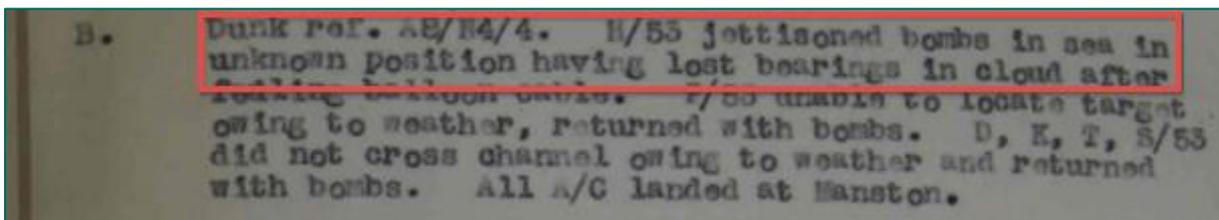


Figure 13: Extract from Bomber Command logs on the jettisoning of bombs within the North Sea (Source: TNA, AIR 24/375).

Multiple instances of 'live' or armed jettisons are found in TNA records as well. Three jettisons have exact locations mentioned that are within the Investigation Area, see Chapter 3 and Annex 4. During at least one of these jettisons, the bombs were being released live. It is not clear how many times such actions occurred apart of the instances found in TNA. As displayed before, many flight paths crossed the Investigation Area. Because of this, multiple undocumented jettisons within the Investigation Area have probably taken place.

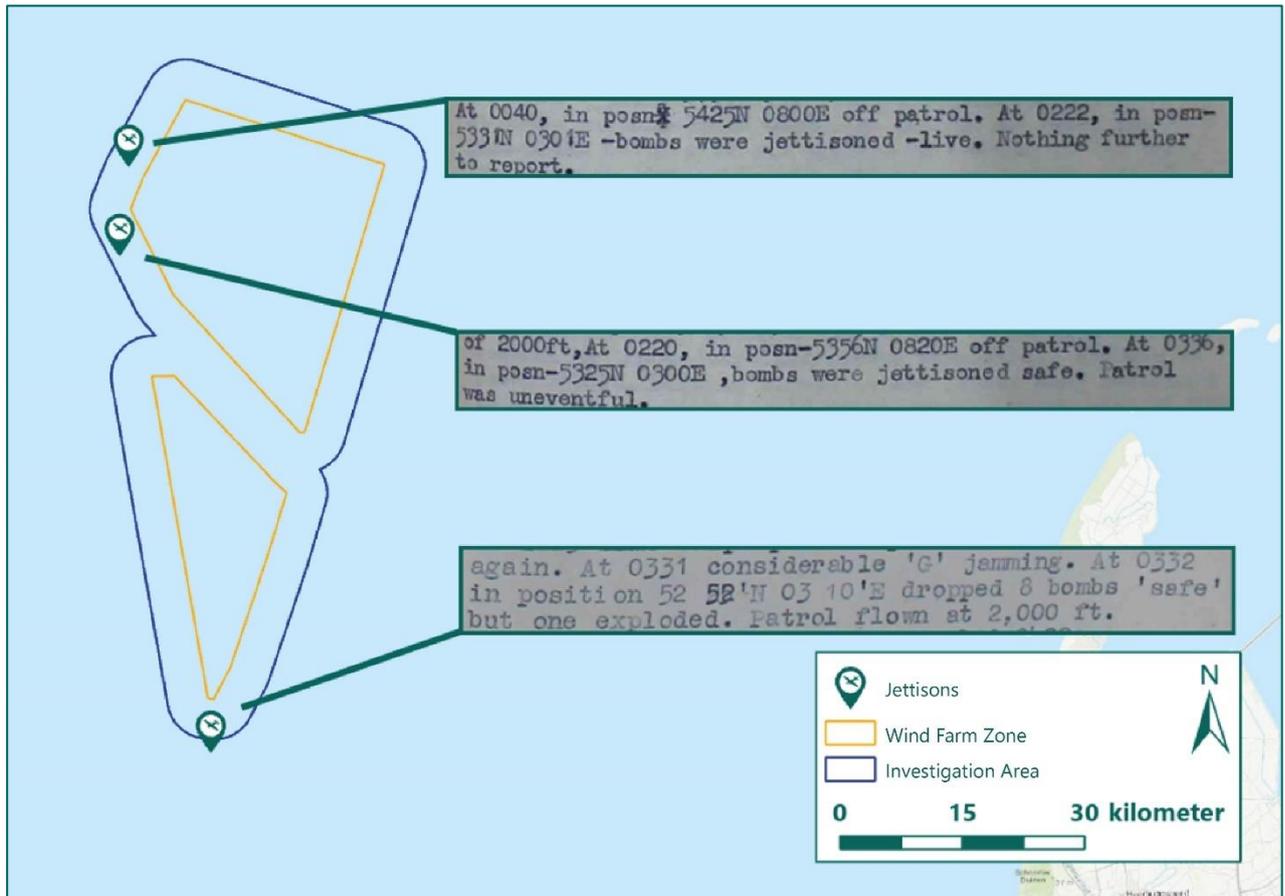


Figure 14: Exact locations of jettisons with cut-outs of ORBs (Source basemap: Esri, source cut-outs: TNA).

According to the consulted sources, multiple jettisons of bombs took place within the Investigation Area. When jettisoned bombs do not detonate, they can reach the seabed and remain there as UXO. It is not possible to define all calibres exactly, since not all jettisons are reported or that not all calibres are specified in the records. The primary armament of the Allied air forces ranged from 250 lb to 4.000 lb bombs. Submunitions from 4 lb and up were also common. Conclusions about possible UXO encounters related to the air war are given in paragraph 4.2.5.

#### 4.2.3 Anti-aircraft artillery

In the records of Coastal Command (see Annex 3 and paragraph 4.2.1), three instances of the use of 'flak' have been described (the numbers 1, 3 and 4 in Figure 9). 'Flak' is a commonly used term for anti-aircraft artillery and stems from the German name for these types of artillery; "Flugabwehrkanone" or "Fliegerabwehrkanone". The term Anti-Aircraft Artillery or AAA is also commonly used.

On the 5<sup>th</sup> of November 1943, two Bristol Beaufighter bombers attacked four Schnellboote during which the planes received intense but inaccurate flak. After one of the ships was attacked, no more flak was experienced.

On the 21<sup>st</sup> of February 1945, multiple Vickers Wellingtons were to carry out a patrol on the North Sea. Nine E-boats or Schnellboote were spotted, after which the planes received some light flak. There are no mentions of casualties on the British side due to this AAA-fire.

One Vickers Wellington was to attack E-boats on the North Sea on the 1<sup>st</sup> of March 1945. One ship was attacked with six bombs after which the plane received intense and accurate light flak. No British damage or casualties are reported.

Considering the amount of air strikes on ships, UXO of anti-aircraft weapons might be present in the Investigation Area. Unexploded shells could come down on the surface and sink to sea bottom. German ships were equipped with AAA of calibres ranging from 20 mm up to and including 8,8 cm. Conclusions about possible UXO encounters related to the air war are given in paragraph 4.2.5.

#### 4.2.4 Post-war UXO encounters

As shown in Annex 4, one aerial bomb was found within, and multiple bombs were encountered close to the Investigation Area. Since a major accident with the OD-1 'Maarten Jacob' fishing trawler, where an aerial bomb was caught in a net, deposited on the deck and subsequently detonated<sup>11</sup>, the Dutch Coast Guard keeps track of munitions encountered offshore. As can be seen below, at least thirteen aerial bombs have been encountered and disposed of since 2005. It must be noted that the coordinates that the Dutch Coast Guard provides indicates the moment that UXO were noticed and that this does not necessarily relate to the original location of the UXO on the sea floor. It is however indicative information about UXO found directly in or nearby the Wind Farm Zone.

The bombs cleared by the Dutch Coast Guard could originate from air strikes and/or jettisons. Next to aerial bombs, some unknown UXO have been cleared, which might be a result of anti-aircraft gunfire. In the figure below encountered UXO are shown. The encountered UXO closest to the Investigation Area are shown in blue.



Figure 15: Overview of UXO encounters within and near the Investigation Area (Source: Dutch Coast Guard).

<sup>11</sup> Trouw, 250-ponder was 'lichtere soort', <https://www.trouw.nl/nieuws/250-ponder-was-lichtere-soort~bd1558b9/> (Version 8<sup>th</sup> April 2005).

#### 4.2.5 Conclusion

Several aerial attacks and the jettisoning of bombs took place in and near the Investigation Area. Furthermore, a couple of instances have been reported of the use of flak or AAA-fire within the area. It is also probable that more than the reported jettisons, attacks and experienced flak took place during the Second World War. As a result of these incidents, UXO are likely to be present within the Investigation Area. The likelihood of presence of different sorts of UXO will be discussed in paragraph 5.2

### 4.3 NAVAL MINES

Naval mines were laid in the North Sea during the First and Second World War. The purpose was twofold. Mines were used in a defensive way to protect one's own waters and ports, and to hold off enemy ships. At the same time, mines could be used to harass enemy shipping, block shipping lanes, and obstruct military movements. Mines could be laid by surface ships, submarines, and aircraft. Only moored contact mines were used during the First World War. Moored mines float beneath the water surface and are kept in position with an anchor and anchor cable. This technique was also used during the Second World War. Besides contact mines, the belligerent parties developed influence mines. These mines were laid on the sea bottom and would detonate if sensors in the mine detect a difference in pressure, sound, or magnetism caused by a passing ship.

The Investigation Area has overlap with a suspected German minefield from the First World War and both British and German minefields from the Second World War. These minefields and the post-war clearance are discussed in the next paragraphs. A conclusion is added in paragraph 4.3.4.

#### 4.3.1 First World War

According to the book *The Hidden Threat* (see Annex 1), a German minefield was present within the Investigation Area. The following figure illustrates the location of the minefield where 240 mines were laid. Further specification on the types of the mines is not given in the book, nor in the other consulted material. While just one map confirms the location of this German minefield, other sources confirm accidents related to mines within and near the Investigation Area. The map is therefore deemed a credible source.

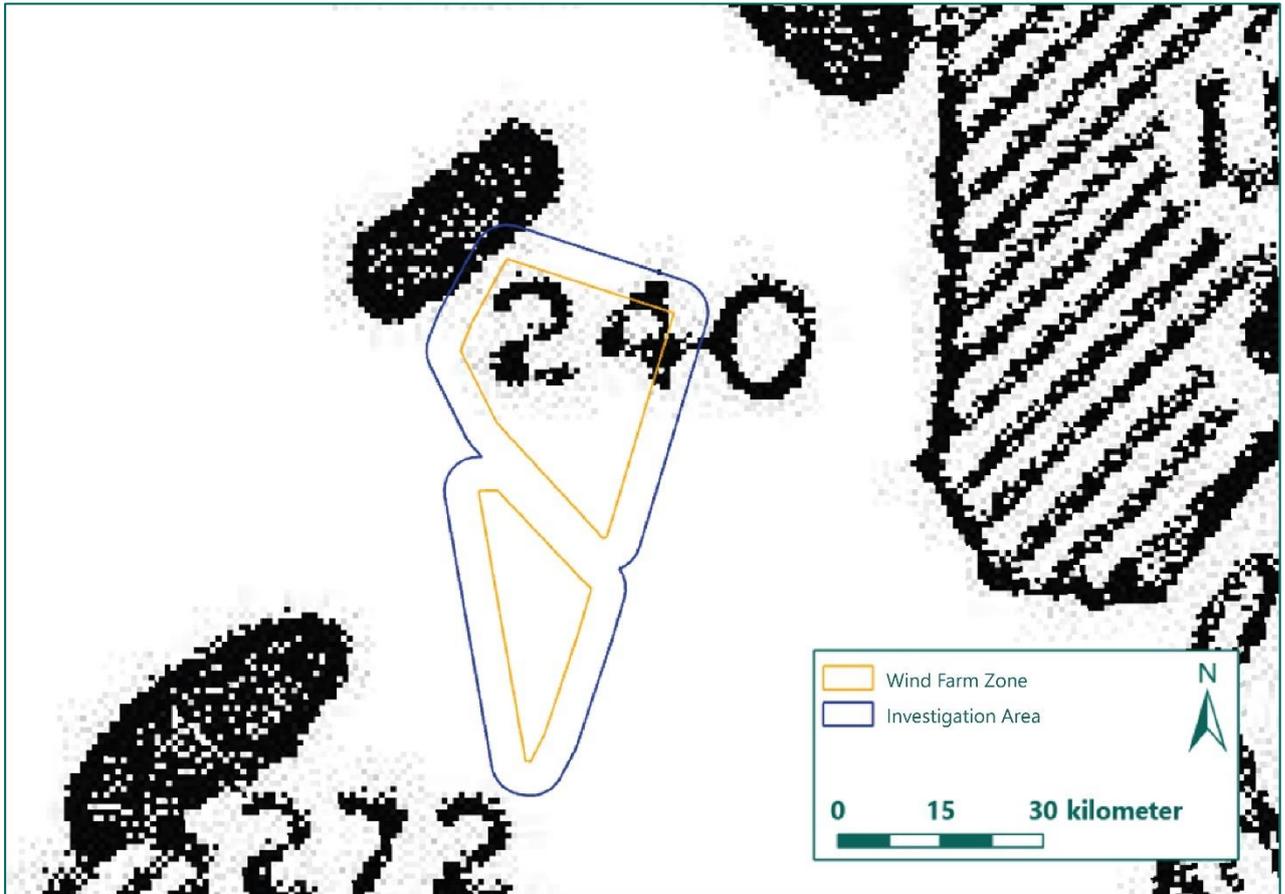


Figure 16: German WWI-minefield with 240 mines within the Investigation Area (Source: CRO 62).

A map from the Library of Congress (see Annex 6) shows one British minefield (east of the Investigation Area) on relatively large distance from the Investigation Area. The border indicates an area in which multiple smaller minefields were laid. The mined region, the German Bight, was a major theatre of naval warfare during World War I. British forces laid 42.899 naval mines in the Bight (red line in figure below). The green line indicates a divide in different sectors of the North Sea, it doesn't relate to UXO. Only few German minefield can be found in the German Bight.

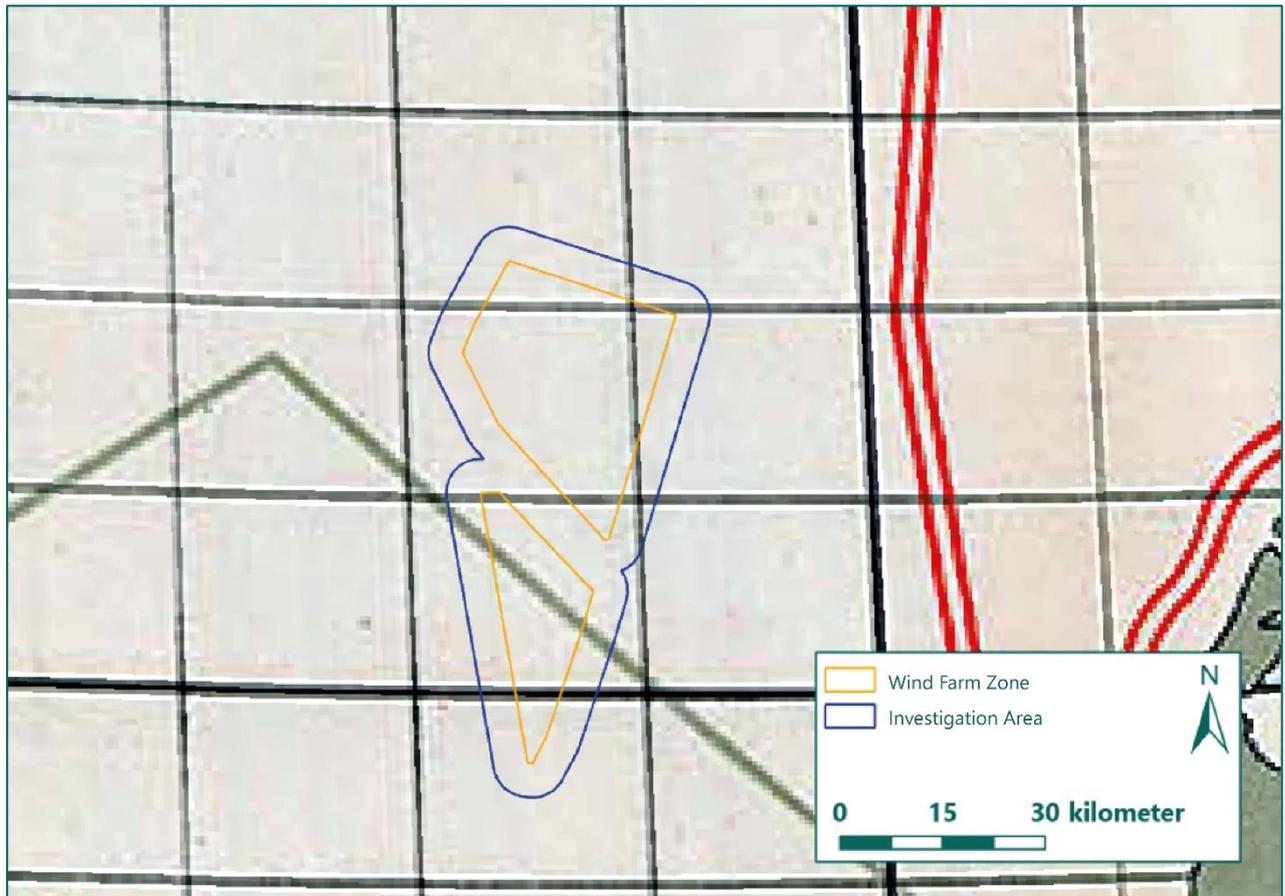


Figure 17: British Islands. Approximate position of British minefields (red double line), 19th August 1918. The green line indicates a reference to specific zones which are drawn on the map, this is irrelevant in relation to the location of minefields (Source: Library of Congress).

During the First World War, thousands of mines broke loose from their anchor, sunk to the bottom or drifted from its original position. In this period, more than 6,000 mines washed ashore on the Dutch beaches. Amongst those mines 4,981 were from British origin, 431 were German, 81 were French, and 500 mines were from foreign origin. It is estimated that no less than 240,000 mines had been laid in the North Sea.

Multiple records from The National Archives contain indications of mines drifting from their minefields and into the Investigation Area. These reports mention accidents that occurred because of encounters with mines or the spotting of mines in "safe" locations. For example, on the 8<sup>th</sup> of May 1915, the British trawler "Hellenic" was sunk by a mine that was caught while trawling. It is believed that the mine was towed for about three miles west, before detonating.

British Trawler "HELLENIC" was sunk by a mine caught in her trawl in 53° 38' N., 3° 01' E. on 8th instant. The mine is believed to have been towed about 3 miles in a Westerly direction before exploding.

Figure 18: Report on the sinking of the Hellenic due to an encounter with a naval mine (Source: TNA, ADM 137/1066).

Specific types of encountered mines are seldom reported. British fishermen were generally able to differentiate between German and British mines, but exact types were not common knowledge. Nonetheless, one report by the British Harwich Force, a Royal Navy Squadron, was found which specifies the type of mine found within the Investigation Area. On the 5<sup>th</sup> of June 1918 a German Type IV naval mine was encountered, which was then sunk by machine-gun fire. One horn of the mine was hit, but the mine itself did not detonate. This practice of firing on naval mines to sink them was common in both the First and Second World War, but, as can be read in the report, did not always cause detonation. These mines sank to the sea floor but can still detonate when hit or moved years later. More information on mine clearance will be provided in paragraph 4.3.3.

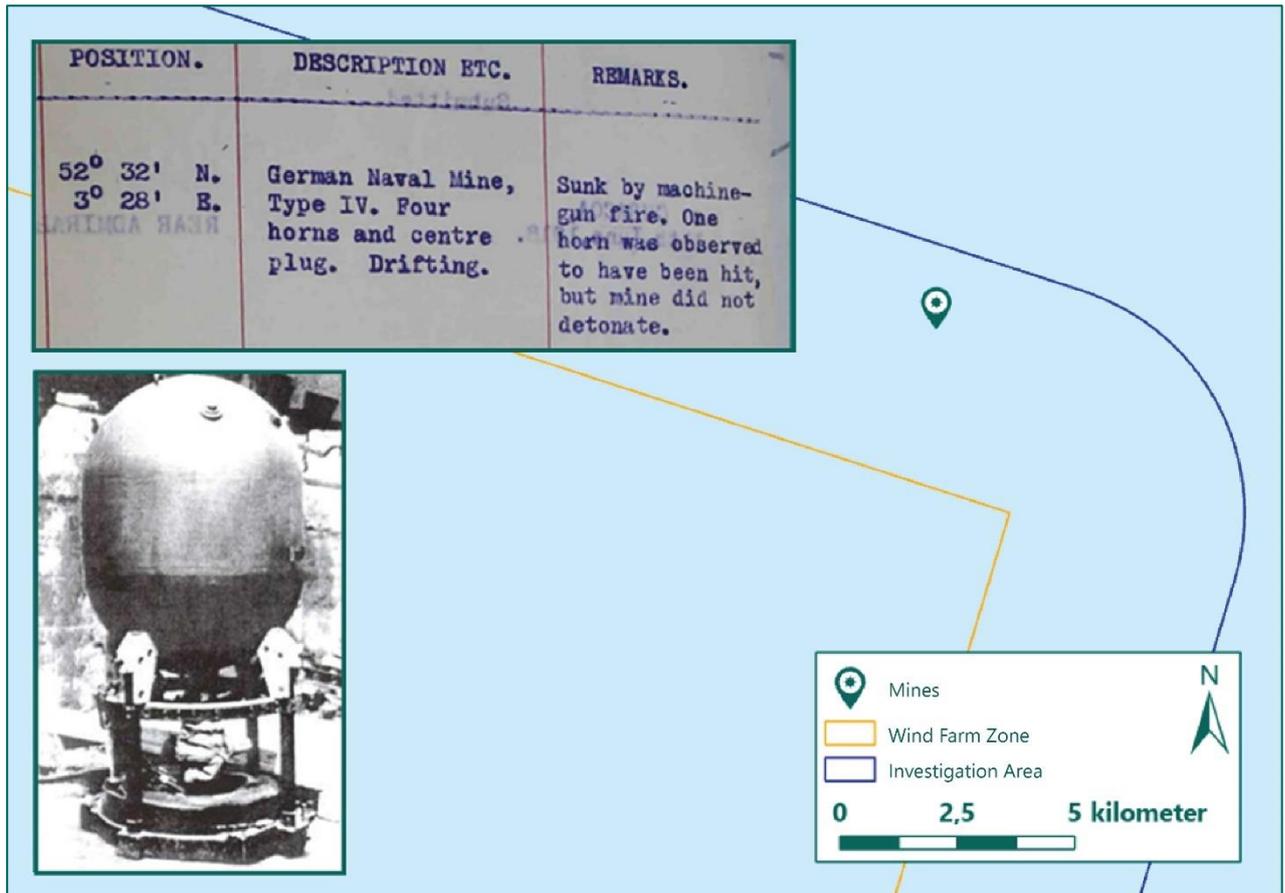


Figure 19: Location of the encountered German Type IV mine, with a cut-out of the report and an image of this type of mine (Source basemap: Esri, source record: TNA, source mine: REASeuro-database).

In the following figure, locations of mines spotted by pilots and wrecks caused by mines are displayed. Only wrecks mentioned in the sources from TNA are shown in the figure. The southernmost location is based on a report about at least five moored mines, which were freshly painted. While no documentation of a minefield at this location is known to REASeuro, it is possible that a minefield (German or British) was created near the Investigation Area. Because no documentation about this possible minefield is known to REASeuro, it is unknown whether the possible minefield overlaps with the Investigation Area.

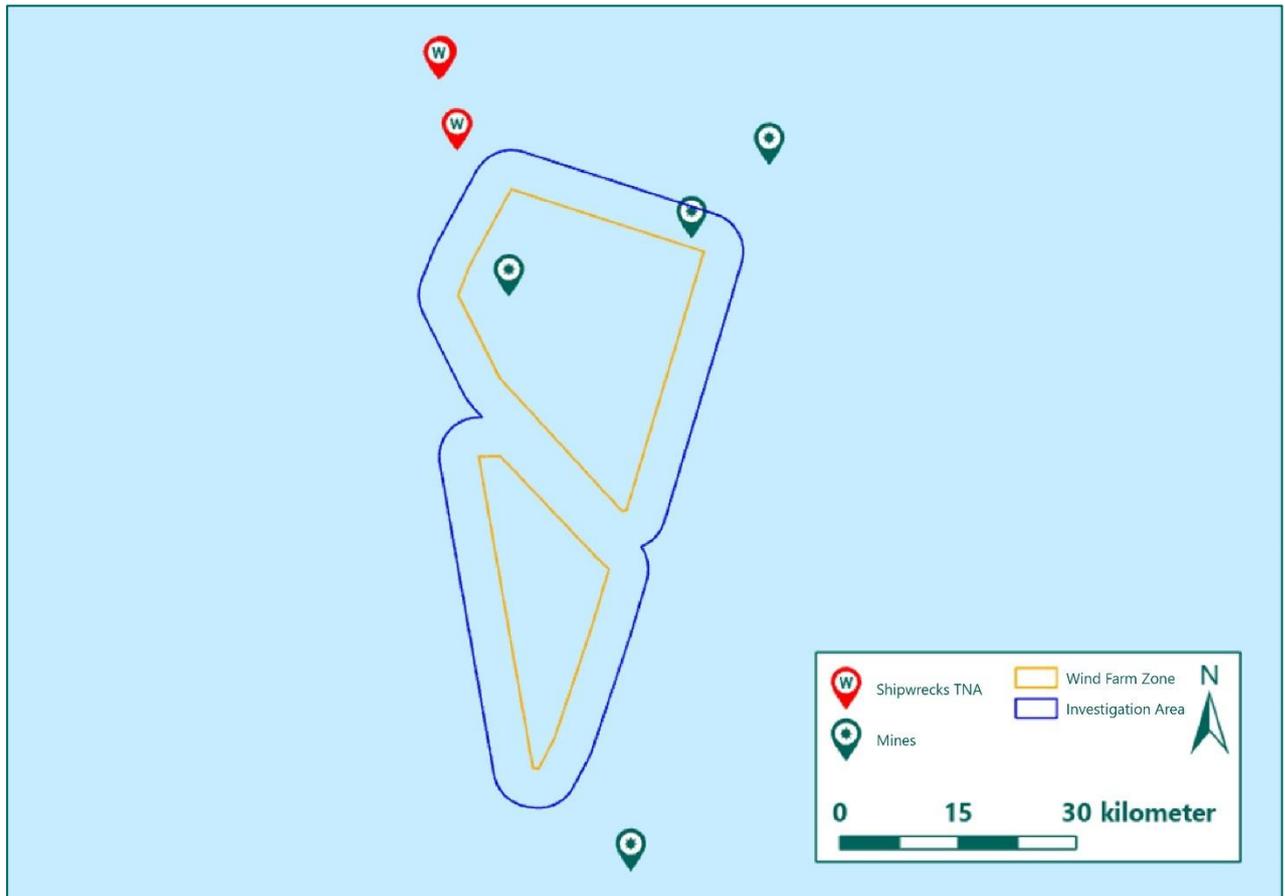


Figure 20: Shipwrecks and mines encountered in the First World War near or in the Investigation Area (Source basemap: Esri, source: TNA).

Records from The Dutch National Archives (see Annex 3) also contain evidence that mines were present in the Investigation Area during the First World War. On a map obtained in the Nationaal Archief (Dutch National Archives) it is shown that during 1914-1916 multiple Dutch ships ran into mines. These accidents happened outside of known minefields. Six wrecks caused by naval mines are visible within and multiple near the Investigation Area. No details have been provided about the ships that sunk at these locations except for their names and the dates of the incidents.

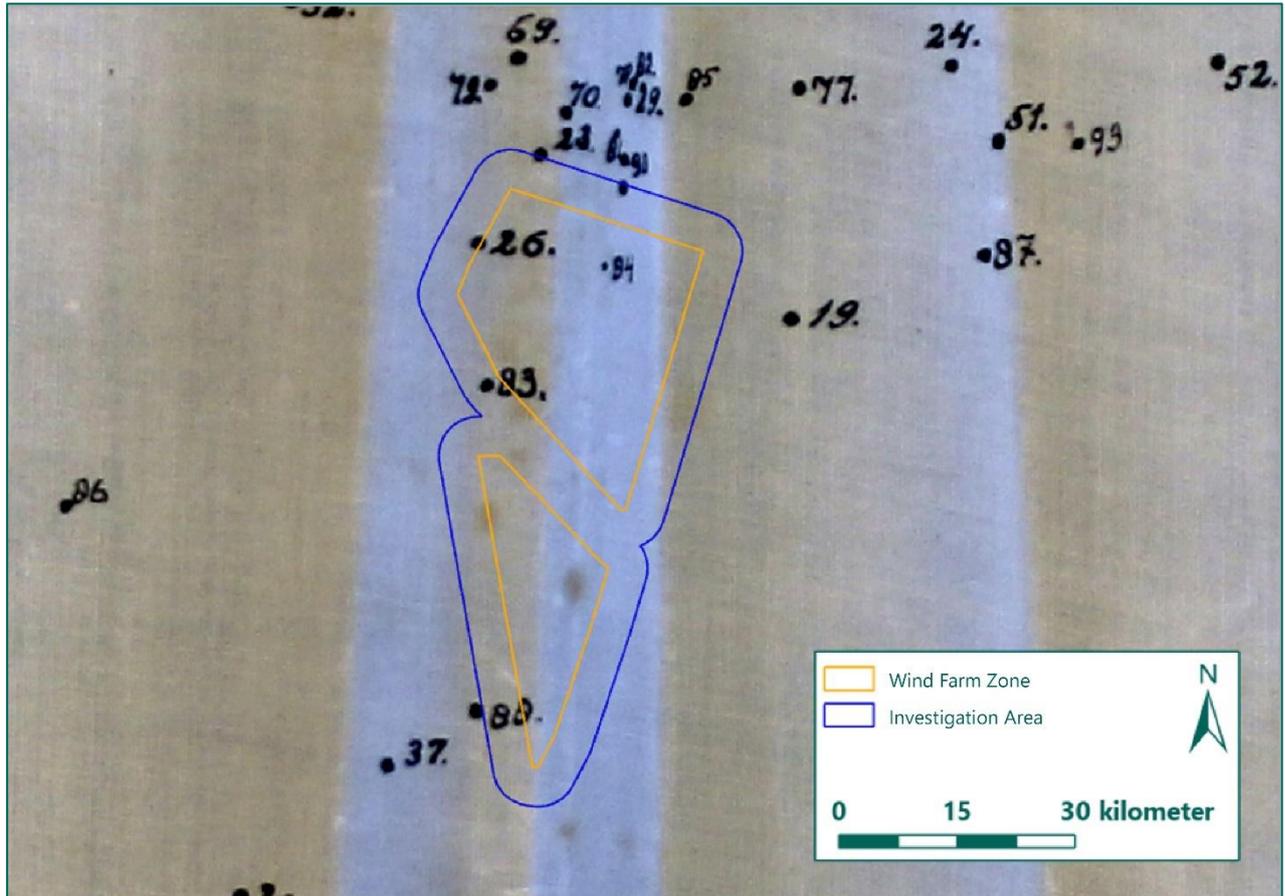


Figure 21: Map showing locations where Dutch ships ran onto mines during 1914-1916 (Source: NA, 2.05.32.09, file 44).

The website [www.wrecksite.eu](http://www.wrecksite.eu) also shows two locations of ships sank due to mines in and near the Investigation Area. The ship, the 'FV Don', was sunk within the Investigation Area on 6 May 1914 by a mine. On the 25<sup>th</sup> of December 1915, the ship 'SS Rigi' also hit a mine and sunk near the Investigation Area subsequently. In the figure below the locations of both wrecks are shown.



Figure 22: Wreck locations of the 'FV Don' (right) and 'SS Rigi' (left) within and near the Investigation Area. The ship suspected sank after running onto a mine (Source basemap: Esri).

According to the consulted literature, a German minefield overlapped the Investigation Area during the First World War. Furthermore, multiple mines were encountered outside of the reported minefields and multiple wrecks were caused by contact with these mines. Based upon this information, First World War British and German contact mines could be present in the Investigation Area. An encounter of a Type IV German naval mines was reported. This is a type of E-Mine or *Elektrische Minen*. Since no information is found about the precise types of British mines, it is estimated that the most common types of British mines are left in the Investigation Area (Vickers / British Elia and the H Mark II moored contact mines). Conclusions about the UXO Risk Area because of naval mines is given in paragraph 4.3.4.

#### 4.3.2 Second World War

During the Second World War several British and German minefields were laid in the Investigation Area. British offensive minelaying was aimed against German convoy routes sailing near the Dutch Coast. The German minefields were laid in a defensive role, with the intention to hinder allied ships from approaching the Dutch Coast.

The National Archives contains multiple maps with information about the British East Coast Minefields, laid in 1939 and 1940 (see Annex 4). One of these maps shows the laying of a "Dummy Minefield" within the Investigation Area, between September 1939 and April 1940. Dummy mines are drums filled with sand or concrete designed to look like genuine naval mines. The drums laid in similar fashion as genuine naval mines and function as inexpensive false targets. The dummy mines are laid to be a nuisance to enemy mine clearance operations. It slows the clearing process by forcing minesweepers to investigate all contacts picked up on the sonar. The laying of dummy mines in the Investigation Area might result in encountering

these types of mines during future activities on the seabed within the area. However, because of its contents, dummy mines do not pose a UXO risk.

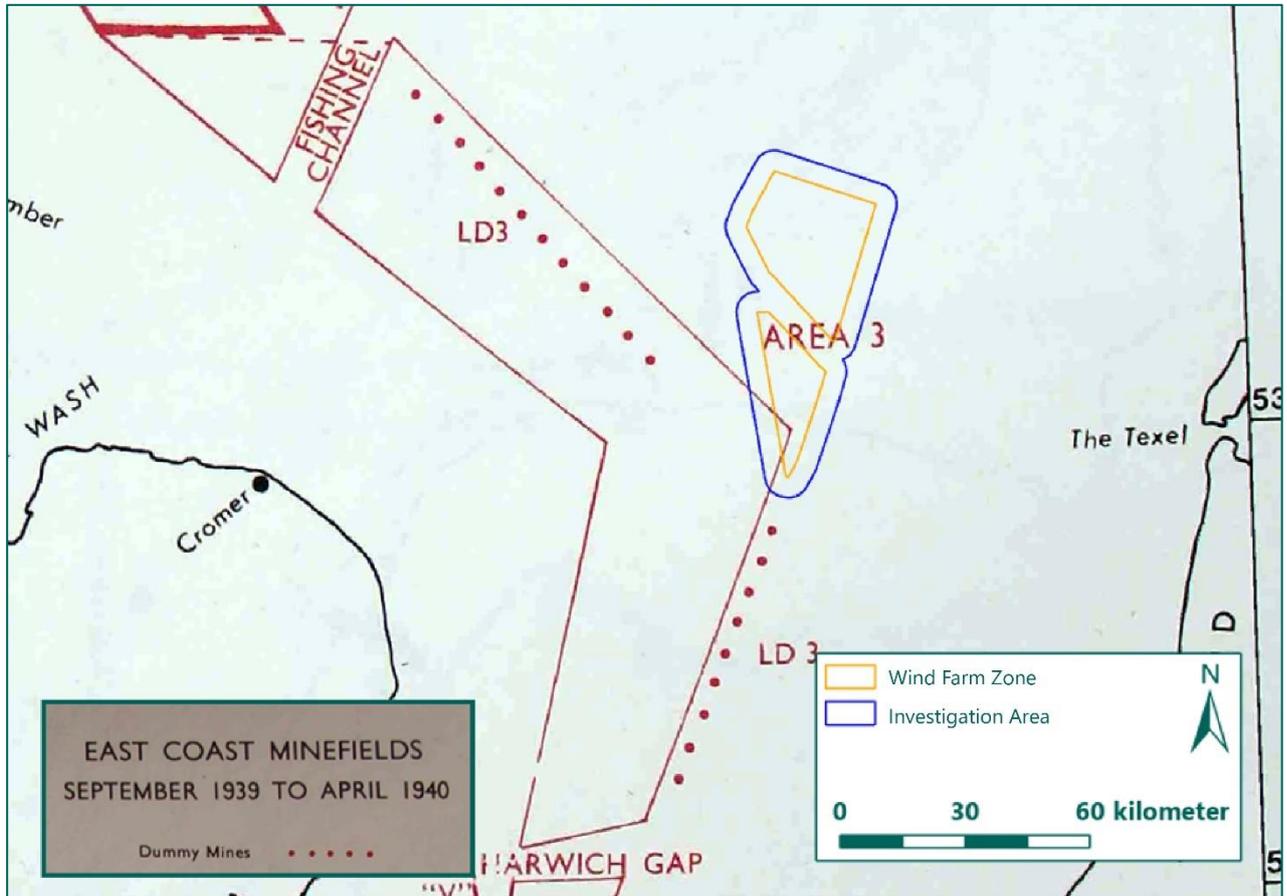


Figure 23: Map showing the British East Coast Minefields from September 1939 to April 1940 with Dummy Mines in the Investigation Area (Source: TNA, ADM 234/561).

The same record also contains a map of genuine minefields laid in 1940 with names, amounts of mines laid, and specified mine-types. According to this map, at least two minefields are present within and three other minefields immediately near the Investigation Area. This map and a table specifying the minefields is displayed below.

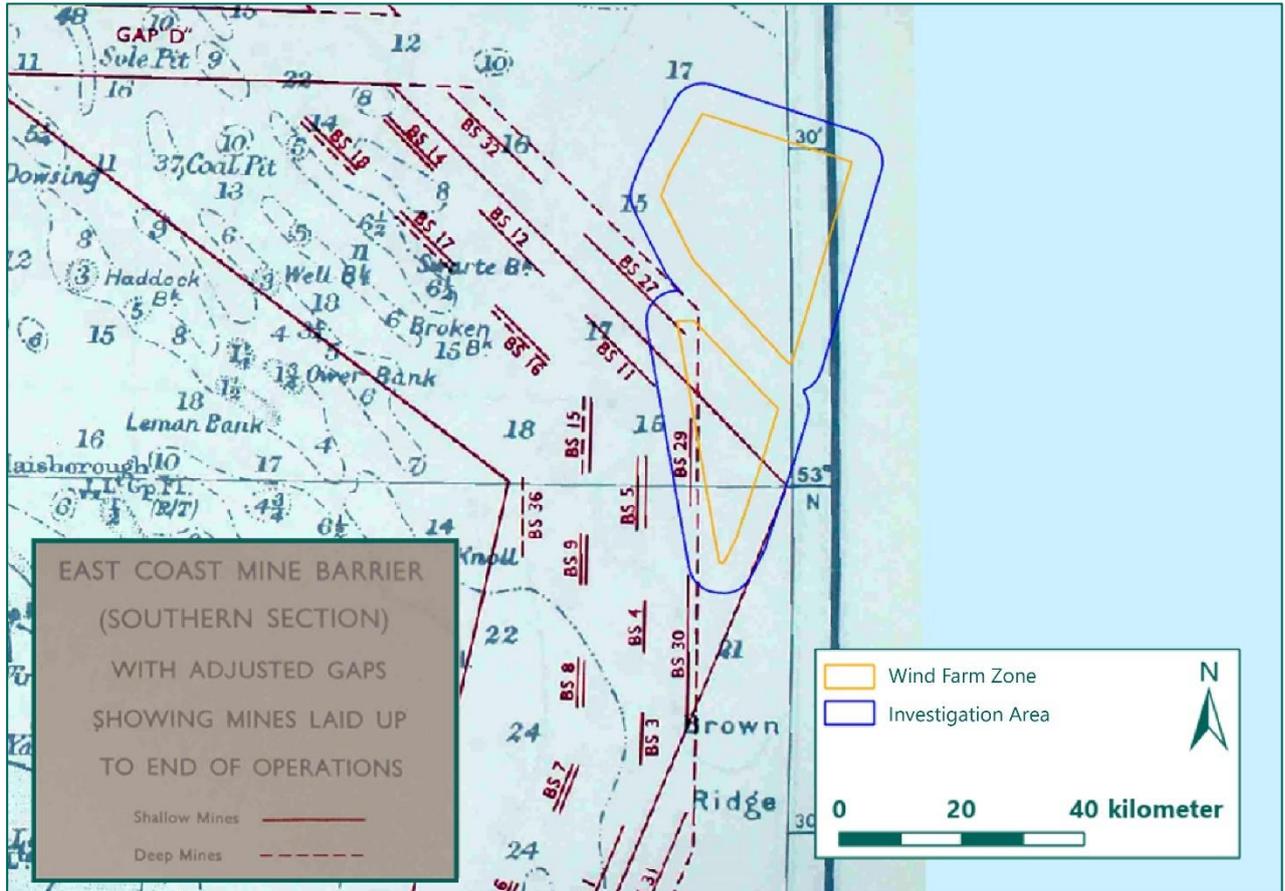


Figure 24: Map showing the British East Coast Mine Barrier laid in 1940 with in and near the Investigation Area (Source: TNA, ADM 234/561).

Minefield code	Date laid	Mines laid	Intersecting with Investigation Area?
BS 5	18 May 1940	540 Mk XIV/XVII mines	No
BS 11	6 June 1940	340 Mk XIV/XVII	No
BS 27	24 July 1940	250 Mk XX/XVII	Yes
BS 29	30 July 1940	164 Mk XX/XVII	Yes
BS 30	2 August 1940	300 Mk XX/XVII	No

Table 11: Details about the minefields intersecting with or close to the Investigation Area.

The German minefields within the Investigation Area are also well documented. During the war the British authorities were quite aware of the locations of British and German minefields, as can be seen in the figure below. The British minefield 138X/382X has already been discussed in the previous section. German minefield 404X overlapped with the Investigation Area. The large minefield 404X exists of many smaller minefields. Detailed information about these, and other, minefields that overlap with the Investigation Area can be found in the German Bundersarchiv.

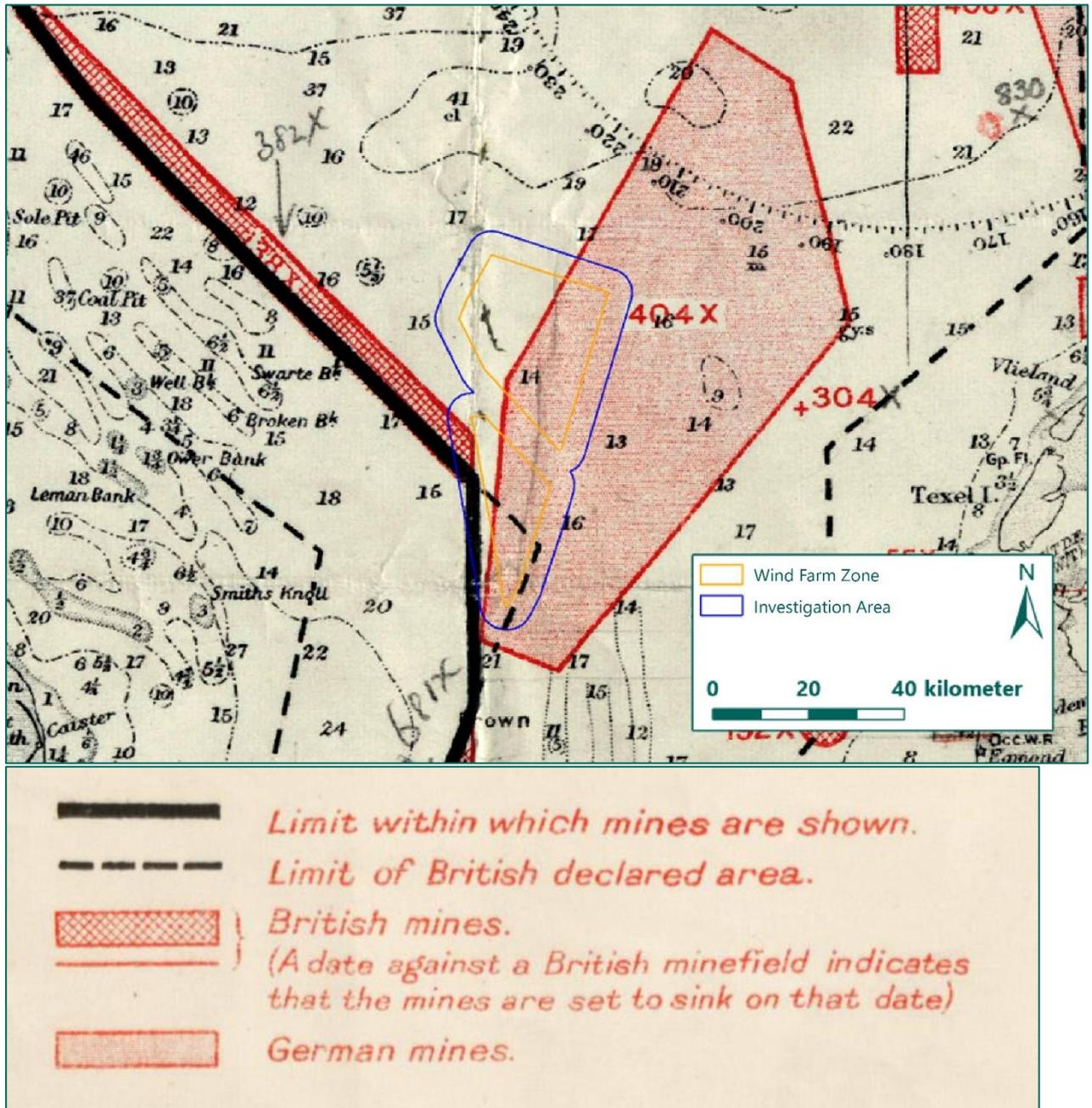


Figure 25: British map showing a large area in which German mines are to be expected (Source: TNA, ADM 239/304).

The German minefields within the Investigation Area were defensive and exclusively contained moored contact mines of the EMD and EMC type and sweep obstructors (both explosive, and non-explosive anti sweep devices). Surface vessels laid the fields between January 1942 and July 1943. Two minefields (coded C24 and C27 in the post-war Summary of Enemy Minelaying (see Annex 4)), intersects directly with the Investigation Area. Seven other minefields were laid close to the Investigation Area (C17, C18, C23, C24, C26, C29, C30 and C31). The accuracy of the minelaying was poor, resulting in an estimated inaccuracy of 2 miles for fields in which mines were laid. In the post-war Summary of Enemy Minelaying, it is said that fields with solely sweep obstructors, are laid without inaccuracy. In the figure below the relevant minefields are shown.

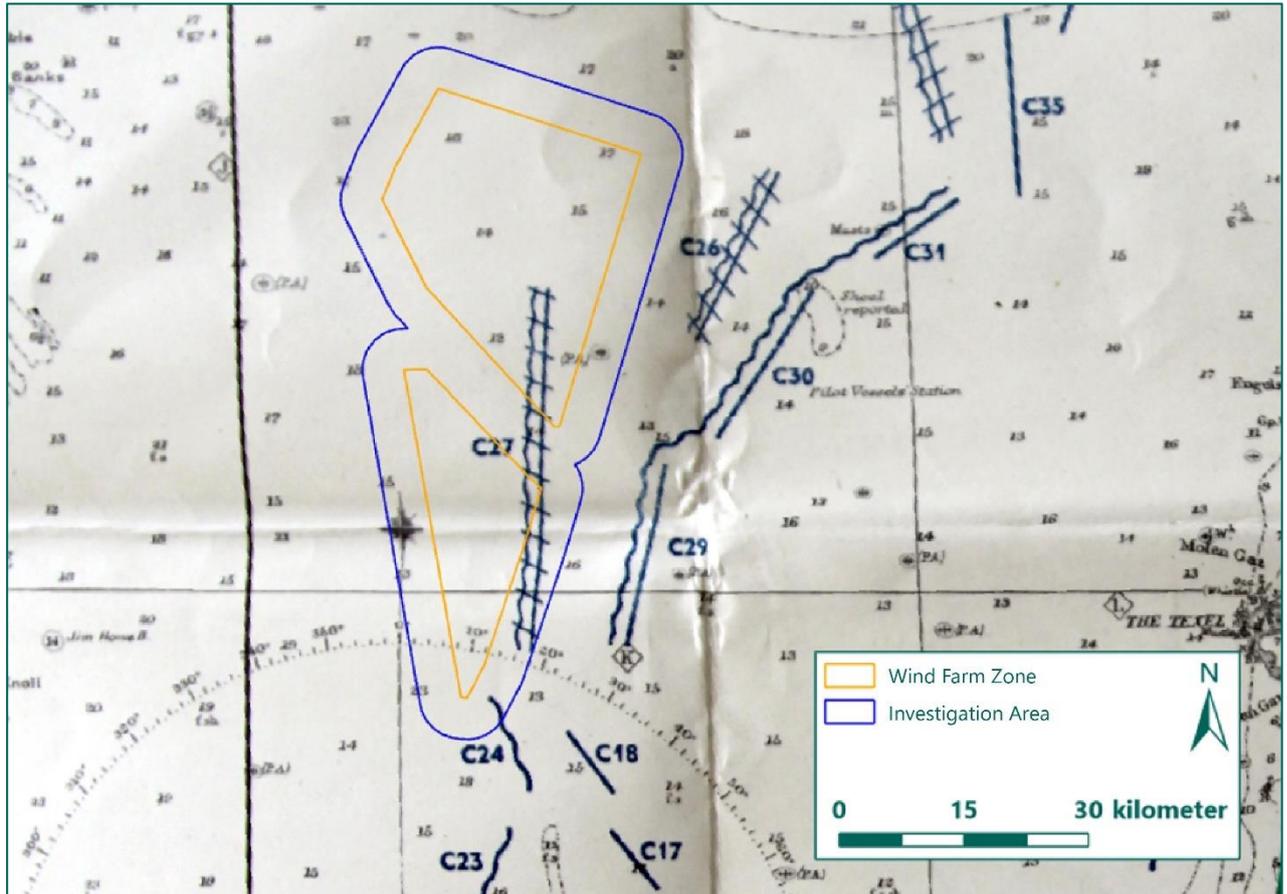


Figure 26: German minefields that intersect with or are laid near the Investigation Area (Source: BAMA, ZA 5/48).

In the table below, details are given about the minefields that intersect with the Investigation Area and those who are laid near the Investigation Area.

Minefield code	Date laid	Mines laid	Additional details
<b>Minefields within Investigation Area</b>			
C24	July 1943	64 sweep obstructers [non-explosive]: static cutters.	-
C27	August 1940	742 EMD and EMC mines 1040 Ex-FI [explosive floats, German: <i>Sprengboje</i> ].	The AE Switch was "OFF" and thus considered 'safe'.
<b>Minefields close to Investigation Area</b>			
C17	January 1942	112 EMC mines.	110 Fathoms mooring wire. With tombac sheathing.
C18	January 1942	112 EMC mines.	110 Fathoms mooring wire. With tombac sheathing.
C23	July 1942	64 sweep obstructers [non-explosive].	-
C26	August 1940	742 EMD and EMC mines 1040 Ex-FI [explosive floats, German: <i>Sprengboje</i> ].	The AE Switch was "OFF" and thus considered 'safe'.
C29	July 1942	226 EMC mines, 100 sweep obstructers, 400 Xp-FI [explosive floats, German: <i>Sprengboje</i> ].	The EMC mines were laid with 50 feet lower antenna. The 400 Ex-floats are for lines C29, C30 and C31. They are in the space between the mine lines.

Minefield code	Date laid	Mines laid	Additional details
C30	July 1942	214 EMC mines, 400 Xp-FI [explosive floats, German: <i>Sprengboje</i> ].	The EMC mines were laid with 50 feet lower antenna. The 400 Ex-floats are for lines C29, C30 and C31. They are in the space between the mine lines.
C31	July 1942	120 EMC mines, 400 Xp-FI [explosive floats, German: <i>Sprengboje</i> ].	The EMC mines were laid with 50 feet lower antenna. The 400 Ex-floats are for lines C29, C30 and C31. They are in the space between the mine lines.

Table 12: Details about the minefields intersecting with the Investigation Area.

Coastal Command planes regularly observed locations of naval minefields when performing missions on the North Sea. When mines were spotted, this information was sometimes passed on to the Coastal Command Headquarters. According to the ORBs found in TNA, on the 21<sup>st</sup> of May 1943 five Avro Anson planes on a sea rescue mission spotted a mine in position 53 12' N 02 56' E. The type of mine was not observed or specified. The location of the spotted mine and a cut-out of the ORB is displayed below. This mine was spotted at the location of British minefield BS 11 and is therefore probably a Mk XIV or XVII mine.

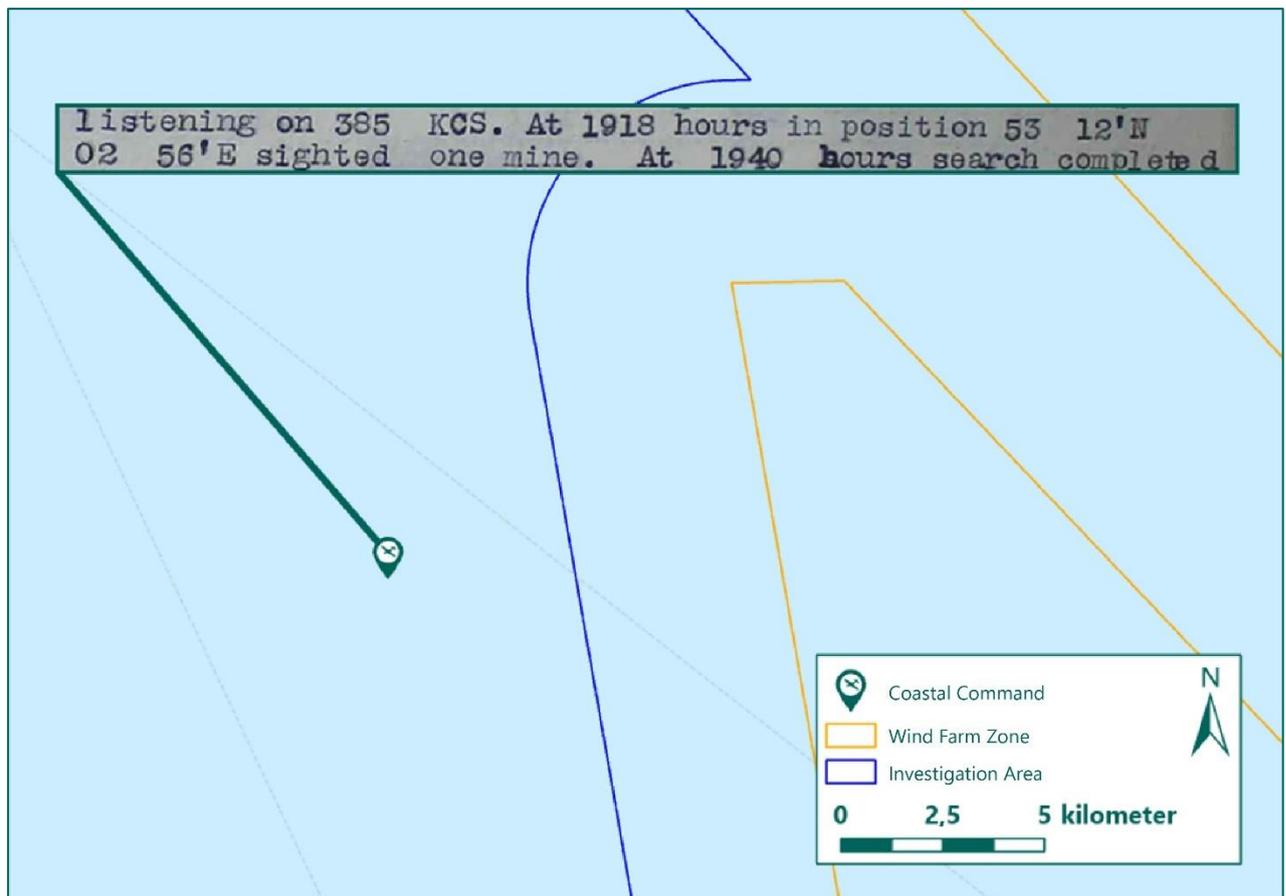


Figure 27: location of coordinate 52° 59' N 03° 55' E, where a contact mine was spotted (Source basemap: Esri).

According to British and German sources, multiple minefields were laid within and near the Investigation Area during the Second World War. Within these fields British Mk XX moored mines, and Mk XIV and XVII contact mines were laid. Furthermore, German EMD-, EMC-mines, Explosive floats (*Sprengboje*), and non-explosive sweep obstructors (static cutters) were laid. Conclusions about the UXO Risk Area because of naval mines is given in paragraph 4.3.4.

### 4.3.3 Post-war mine clearance

After the First World War, a large effort was made to clear shipping lanes of naval mines. It took several months and a fleet of minesweepers to clear the mine fields. Sweeping was carried out by sweeping a cable with anchors below the water surface. The cable was dragged by two ships. Same operations were also performed during the First World War itself.

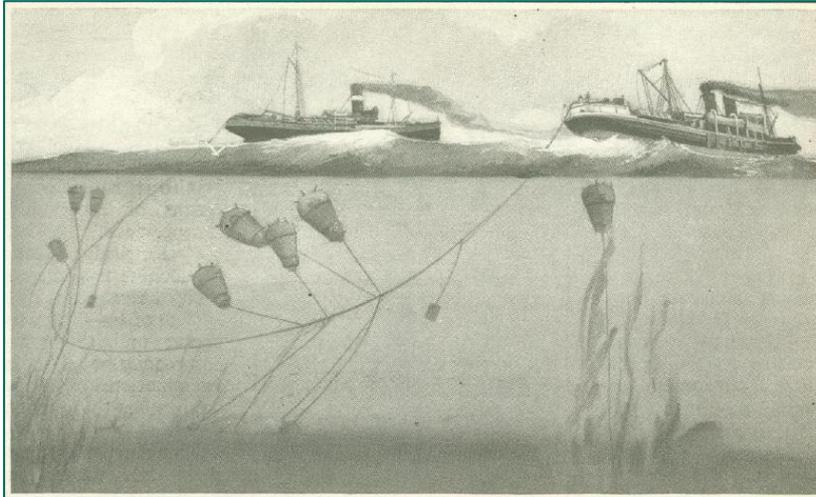


Figure 28: Post WWI-mine sweeping (Source: <http://www.digitalhistoryproject.com/2012/06/submarine-mines-in-world-war-i-byleland.html>)

Mines also continued to pose a danger to shipping after the Second World War. To combat this threat, a large-scale minesweeping campaign was set up. The Investigation Area was situated in the Dutch sweeping zone. Details about minesweeping within the Investigation Area have not been found in the consulted sources. Minesweeping was conducted with a variety of methods. Moored mines were usually swept with Oropesa sweeping gear<sup>12</sup>.

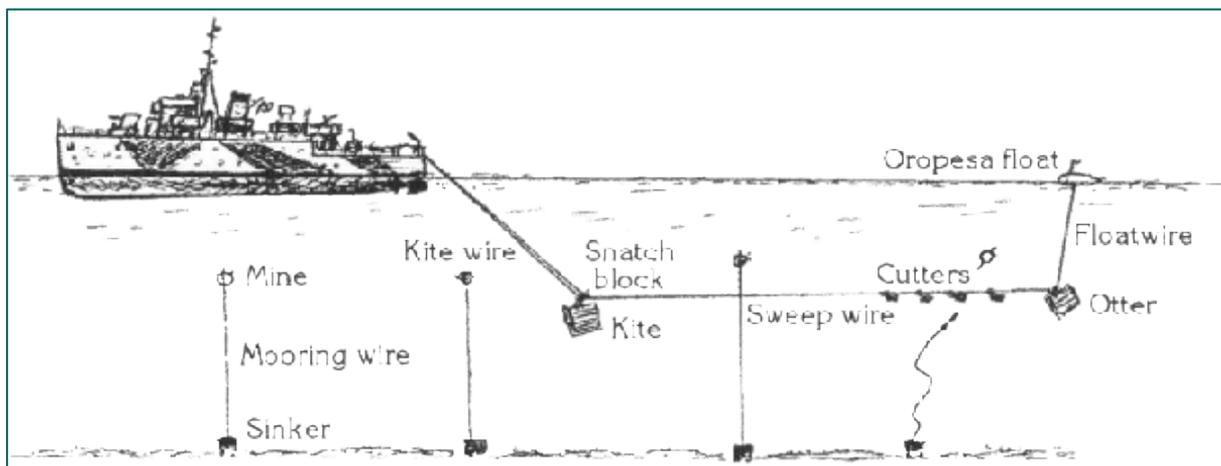


Figure 29: Oropesa sweeping (source: 'The 'Art' of Minesweeping', 27 May 2013, <http://www.minesweepers.org.uk/sweeping.htm>, consulted 2 August 2019).

The moorings of the mines were cut with cutters dragged on a wire behind a ship. Cutting the mooring wires/cables caused the mines to float to the surface, where the mines could easily be shot with cannon or rifle fire. Shooting the mines caused them to sink or to detonate. Ground mines were swept with acoustic hammer boxes, triggering the acoustic mines, or by magnetic sweeping gear to trigger magnetic mines.

<sup>12</sup> So named after the World War I trawler in which the technique was first developed. Till then all sweeping was done using two ships joined by a single wire.

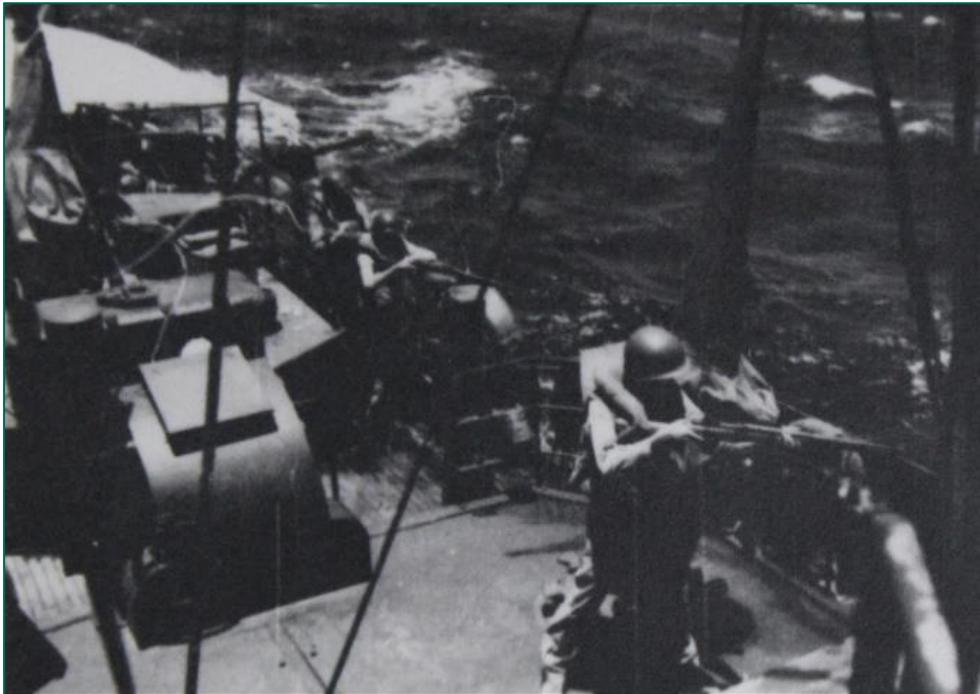


Figure 30: Mine disposal team preparing to fire on swept mines (Source: TNA, ADM 199/154).

Minesweeping was not synonymous to mine clearance. Objective of the operations was to clear the shipping lanes for navigation. The sea bottom is still littered with unexploded mines, including swept and sunken moored mines, self-disarmed mines<sup>13</sup> and ground mines with empty batteries. Nowadays, fishermen and dredging ships still encounter these naval mines on a regular basis. For example, the SS Sonata hit a mine on the 25<sup>th</sup> of June 1947 and sunk afterwards, according to Wrecksite. In the Dutch Nationaal Archief a report from the Dutch trawler IJmuiden 51 (Nora) was found regarding the encounter with a “drijvende contactmijn”, a floating contact mine. No accident was reported.

<sup>13</sup> According to international laws, mines are obligated to include mechanisms to automatically disarm or ‘self-sterilize’ them after a set time. Moored mines were to sink to the seabed after a given time through, for example, a soluble plug, while ground mines disarmed automatically through a timing mechanism or simply at the end of their battery life. These mechanisms move the mine out of harm’s way, but do not disable mechanical fusing mechanisms like *herz horns* and anti-handling devices.

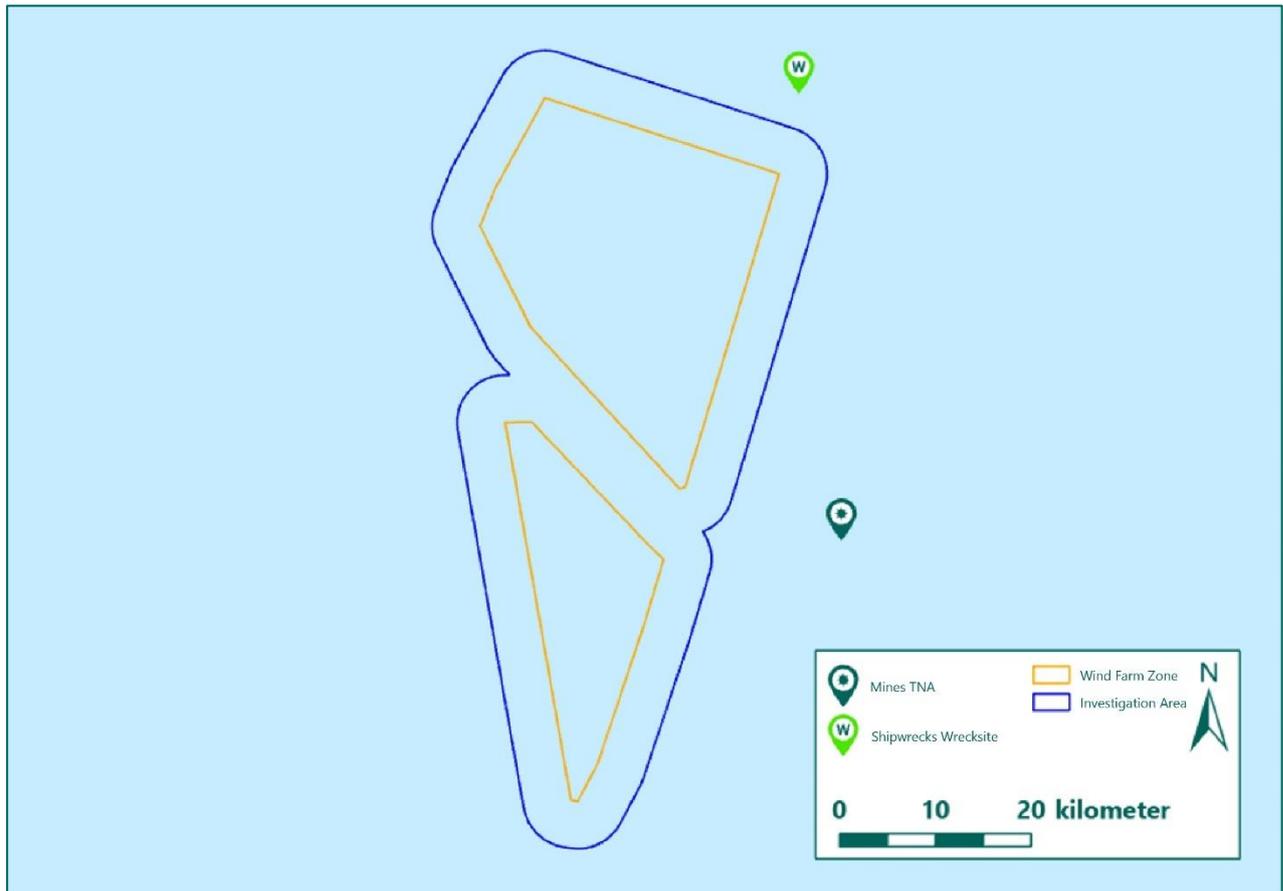


Figure 31: Location of post-war encounters with naval mines near the Investigation Area (Source: Esri).

As a cause of clearance operations, tidal and other weather conditions, moored mines could break loose from their anchor and migrate. Furthermore, due to extensive pair- and beam trawling there is often no clear relation between the positions of encountered mines and the locations of historical minefields. This observation is confirmed in the paragraphs 4.3.1 and 4.3.2. These paragraphs show mine incidents/ encounters outside known minefields.

#### 4.3.4 Conclusion

The Investigation Area intersects several historical minefields. During World War I, a suspected German minefield intersects within the Investigation Area. Multiple mine related incidents occurred in and near the Investigation Area outside of this suspected minefield. During the Second World War the British navy laid two minefields directly in and three immediately near the Investigation Area. Furthermore, two German minefields were laid in the Investigation Area with seven nearby. No direct information on the clearance of these fields is known to REASeuro.

Post war minesweeping succeeded in securing the shipping lanes but did not manage to dispose of all mines. Many mines still litter the seabed, with mechanical fusing mechanisms still in place. Sweeping, trawling and extreme tidal and weather conditions caused these mines to migrate over the years, resulting in a situation in which there is no longer a clear link between the original minefields and the current positions of naval mines. As a result of this, UXO can possibly still be encountered within the Investigation Area. Because of minefields laid during the First World War, E-mine Type IV (German) and contact mines Vickers Elia and Type H Mk II (UK) can be found. During the Second World War, moored mines Mk XX (UK), contact mines Mk XIV and XVII (UK), EMD- and EMC contact mines (German), Explosive Floats 'Spreboje' (German), static cutters (German) were laid in or near the Investigation Area. These types can also be found. The likelihood of presence of UXO of naval mines will be discussed in paragraph 5.2

#### 4.4 WRECKS DUE TO (POSSIBLE) UXO-RELATED EVENTS

According to consulted sources (literature, SGLO, archival documents, PH39 Wrakkenregister and the website of Wrecksite), various airplanes crashed, and vessels sunk within the Area of analyses. For many crashes and shipwrecks the exact location is not known. The Register of Losses (SGLO) only gives a vague indication like "crashed in the North Sea 65 km west of IJmuiden". The same goes for some reports about sunken vessels and/or crashed airplanes as stated in the literature. The website of Wrecksite, the wreck register (HP39 Wrakkenregister), archival documents from TNA and the Dutch Nationaal Archief show a total of 29 (ship)wrecks in and 40 near the Investigation Area. These are shown in the figure below. Additionally, data from the SonarReg (*Sonar Registratiesysteem*), made available by the Cultural Heritage Agency of the Netherlands, had been conducted (See Annex 2). The SonarReg data does not show specific information about the possible wrecks. Therefore this data is not included in the figure below.

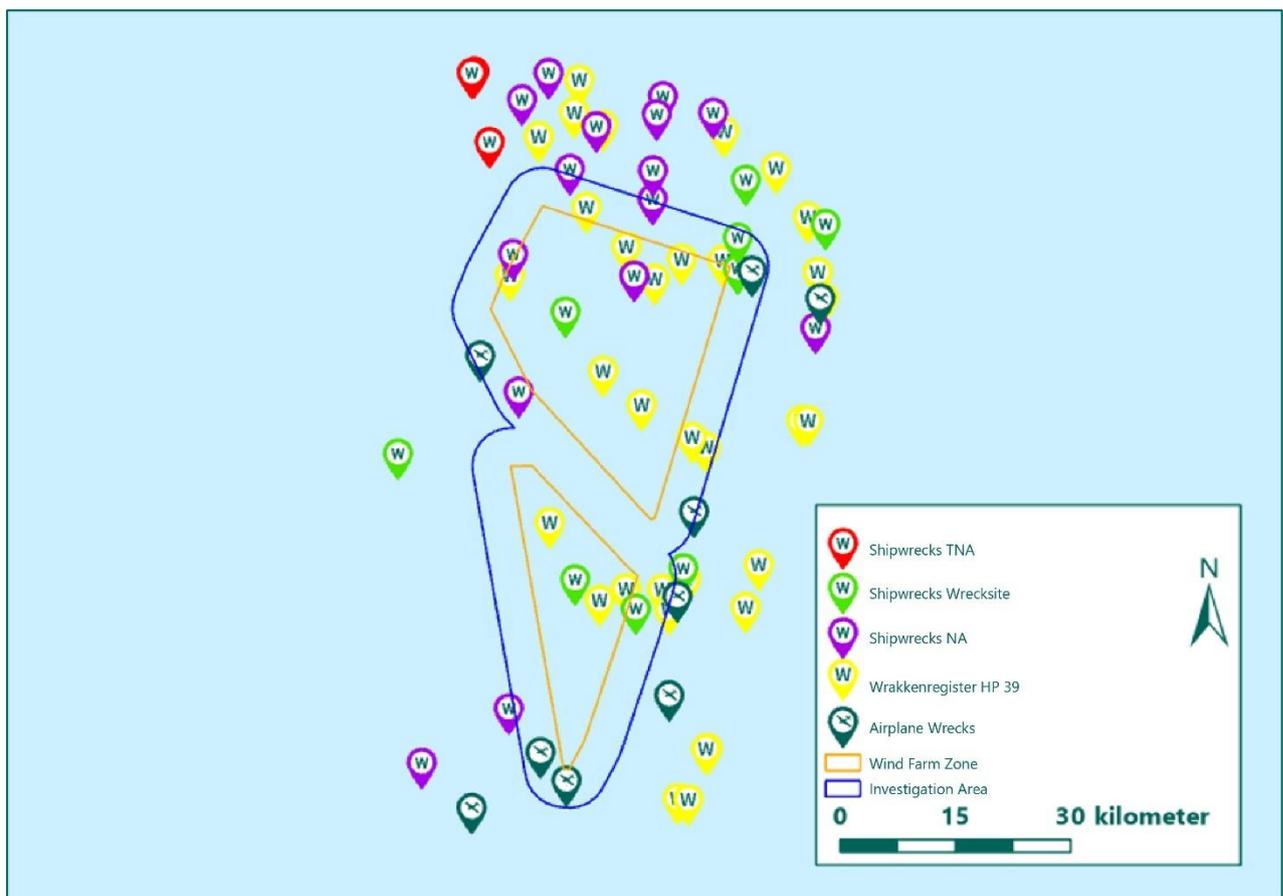


Figure 32: Wrecks of vessels and aircraft as stated on the website of Wrecksite, the wreck register (PH39 Wrakkenregister) and archival documents from TNA and Nationaal Archief (Source basemap: Esri).

The ship name of most wrecks is unknown, but some have been identified. The identified wrecks within the Investigation Area are checked for UXO-related information. This yielded the following relevant results:

Name/type	Details	Source
HMS Ivanhoe (D16)	Damaged by mine in German minefield when attempting to assist HMS Express, which had also been damaged. After an attempt to proceed to the west stern first, was abandoned by crew about 12 hours later and left adrift with every expectation she would sink within 30 min. Vessel was sighted still afloat but listing heavily some 3 hours after being abandoned and was sunk by a torpedo fired by HMS Kelvin.	WRE

Name/type	Details	Source
	(Possible) UXO from the HMS Ivanhoe: Small-calibre munition, 4.7 inch shells, 21 inch torpedoes, depth charges, mines UXO shot by HMS Kelvin: 21 inch torpedo.	
Vickers Wellington Ic W5666	On 11/12 June 1941, a British Wellington Ic W5666 crashed in the North Sea, at 53°06,898'N 03°12,004'E. The bomber was on her way from Swinderby to Düsseldorf. There were no casualties among the Polish crew, all became POW. The exact bomb load of this plane is unknown.	SGLO T1052 WRE
Handley Page Hampden I AE127	On 13 June 1941, the British Hampden I AE127 crashed at 53°05,118'N 03°19,235'E. The aircraft had departed from Waddington and targeted Soest. 1 crew member died. The exact bomb load of this plane is unknown.	SGLO T1054A WRE
U-97 (Mittel U-class)	German submarine U-97 sank by accident at 53°28,34'N 03°23,72'E while on passage to surrender. It is unknown if the submarine still carried its 50 cm torpedoes and munition for its 10,5 cm SK L/45 deck gun.	WRE
SS Rigi	On December 25th, 1915, the Norwegian cargo ship SS RIGI, owned at the time of her loss by Camillo Eitzen & Co., Oslo, was on a voyage from Charleston Sc to Göteborg with a cargo of oilcake, when she was lost on a mine, at 53°28'N 03°30'E. No UXO is suspected to be present in the wreck.	WRE
Bristol Blenheim (139 Squadron)	One Bristol Blenheim (139 Squadron) bomber crashed in the sea at 53 23' N 03 00' E after an attack made by a German Messerschmitt Me 109. It is unknown if the Blenheim dropped its four 250 lb. S.A.P. bombs before being shot down.	TNA, AIR 24/232
Handley Page Halifax III (192 Squadron)	Four Lockheed Hudson (279 Squadron) bombers were to carry out a search at sea. At 16:29 hrs they received the message "Home on Rooster to Position". At 16:38 hrs three Hudsons at 52 55' N 03 07' E were sighted circling aircraft wheels and seven dead bodies. A Lindholme sea rescue dinghy was dropped by one Hudson. A high-speed launch (HSL) sea-rescue boat picked up all visible bodies by 18:10 hrs. It is unknown of the Hudsons carried UXO during its search, but it can be expected that munition for its .303 machine guns was present to repel enemy attacks.	TNA, AIR 25/359 SGLO T3555
YM 60	Cause of sinking due to moored mines	Nationaal Archief
KW 163	Cause of sinking due to moored mines	Nationaal Archief
YM 253	Cause of sinking due to moored mines	Nationaal Archief
VL 155	Cause of sinking due to moored mines	Nationaal Archief
YM 232	Cause of sinking due to moored mines	Nationaal Archief
Interocean 2	Cause of sinking and possible UXO onboard unknown	HP 39
Nicolaas	Cause of sinking and possible UXO onboard unknown	HP 39
Jannie Jacoba (KW 4)	Cause of sinking and possible UXO onboard unknown	HP 39

Table 13: Wrecks within the Investigation Area of which ship names are known.

Because of the many wrecks within the Investigation Area, (parts of) ship and airplane wrecks may be encountered, near or within some of these wrecks UXO might still encountered. Due to the inaccuracy of the sources, it is deemed impossible to project a UXO Risk Area as a result of these wrecks.

## 5 GAPS IN KNOWLEDGE AND UXO RISK AREA

### 5.1 GAPS IN KNOWLEDGE

During the analysis and review of historical sources some gaps in knowledge occurred that could not be filled in with the consulted sources:

- Knowledge of previous UXO clearance operations is often absent. Therefore, it is not fully known if during the period 1914-2005 UXO were encountered in and/or removed out of the Investigation Area. Since the incident with the vessel OD-1 'Maarten Jacob' in 2005 encountered UXO are reported by the Beneficial Cooperation. Most of the encountered UXO at sea is not identified thoroughly.
- REASeuro has data of the Beneficial Cooperation at its disposal. This data ranges from 2005 to 2019. REASeuro tried to get hold of data from 2019 to the present day, but at the time of drafting this final report we have not heard back from EGUERMIN<sup>14</sup>.
- Pinpointing exactly where war-related events at sea is difficult. This problem is partly solved by defining a large Investigation Area. Events that took place within this area could have led to a UXO risk area.
- Compared to land, the North Sea offers few reference points. Therefore, specific information about locations is often lacking. Furthermore, it must be noticed that specific information can be inaccurate.
- Information on naval combat during World War I is only sparsely available. A part of this information is consulted by REASeuro. However, the REASeuro-database regarding naval combat during World War I is not complete.
- WarDocs was consulted concerning war related events that occurred in the Investigation Area. WarDocs was unable to supply documentation about these events due to an error in the WarDocs-Database. REASeuro considered WarDocs again for the final version of the report. However, it was concluded that it would only result in indicative information which would be of no influence on the final conclusion. Therefore, it was not added to the final report.
- Because of the systematic destruction of the *Luftwaffe* archives, there is only sporadic information available on German Air Force activity.
- It is unclear whether the source material concerning German convoy routes is complete. The consulted sources mention several attacks on convoys sailing outside the convoy routes that are known by REASeuro.
- There is no exact information about the locations, amounts, conditions, and types of dropped bombs during aerial attacks or jettisons above the North Sea.
- Crash locations of planes during World War II are not always exactly known. This is also the case for many shipwrecks, which are also unknown in the Register of Wrecks (Wrakkenregister).

### 5.2 UXO RISK AREA

Based upon the analysis of historical sources it is evident that different war related events took place within and nearby the Investigation Area. Because of these events it's expected that UXO are present in the Investigation Area.

Within the Investigation Area there are multiple types of UXO that are deemed to be present:

- Small calibre ammunition
- Artillery shells
- Torpedoes
- Aerial bombs
- Naval mines

The likelihood of presence for each type of UXO is determined and motivated in Table 14 and Table 15.

<sup>14</sup> The Ecole de Guerre des Mines (EGUERMIN) is the Belgian-Netherlands Naval Mine Warfare school. The EGUERMIN controls the archive of cleared UXO by the Belgian-Netherlands Navy.

Figure 33 presents an overview of all identified war related events near the Investigation Area. The likelihood of presence and state of the expected UXO is elaborated in paragraphs 5.2.1 and 5.2.2 of this report.

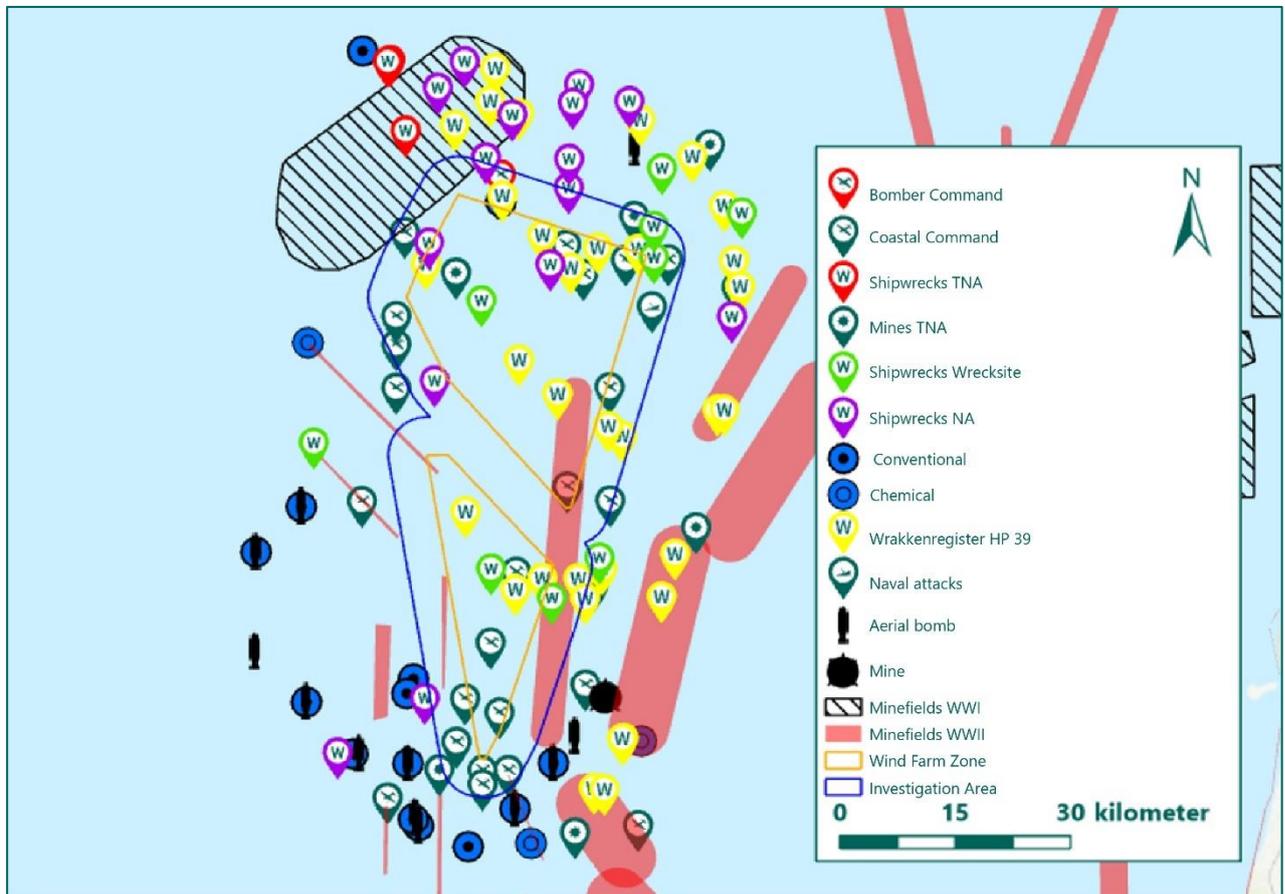


Figure 33: Overview of war related events (Source basemap: Esri).

### 5.2.1 Defining the UXO risk area

The UXO items considered most likely to be present within the Investigation Area are shown in Table 15. Note that the table shows the probable presence of generic UXO types within the site based on the evidence gathered about potential UXO sources. It's important to recognise that the presence of a UXO type does not necessarily mean that it will be encountered. The likelihood of presence (i.e., a positive interaction with the UXO during a specific project activity), will generally be less than the probability of items of that particular UXO type being present across the whole Investigation Area; given that the actual footprint of wind farm installation operations will be less than the total investigation area volume. In Table 14 the terminology is shown, Table 15 is used to indicate the likelihood of presence of a specific type of UXO in the Wind Farm Zone and Investigation Area. No discernible difference between the northern and southern Project Area has been found.

Multiple wrecks are present within the Investigation Area, but these will not be included in the table below due to its limited area of influence and uncertainty of the present UXO. The wreck-locations will be provided digitally.

"Presence" Term	Meaning
Negligible	No evidence pointing to the presence of this type of UXO within an area, but it cannot be discounted completely.
Remote	Some evidence of this type of UXO in the wider region but it would be unusual for it to be present within the area of study.
Feasible	Evidence suggests that this type of UXO could be present within the area.
Probable	Strong evidence that this type of UXO is likely to be present within the area.
Certain	Indisputable evidence that this type of UXO is present within the area.

Table 14: Definitions of terminology used for the likelihood of presence of UXO.

UXO type	Likelihood of presence	Subtype / calibre	Remarks
Small calibre munition	Remote	Miscellaneous	Similar to the remarks about artillery shells, small arms munition could be fired by German and British vessels. German ships could use machineguns to repel allied aircraft. It is also known that multiple attacks with machine guns have been carried out within the Investigation Area by British aircraft.
Anti-ship bombs	Remote	Airborne versions (UK)	Both anti-E-boat and anti-submarine patrol areas intersect with the Investigation Area. Multiple patrols are reported to be carried out during the Second World War. Depth charges were often used by planes in an anti-submarine warfare. Because there are no direct indications of the dropping of anti-ship bombs within the Investigation Area, the likelihood of presence is deemed remote.
Artillery shells	Remote	20 mm up to and including 8,8 cm	German ships passing through the Investigation Area are known to have fired on allied aircraft on at least three occasions. The intensity of flak fire may have led to the presence of artillery shells of common flak calibres in the Investigation Area. There is at least one know surface craft battle between British and German vessels. It is to be expected that artillery shells were fired during this battle. Furthermore, it is known that Allied aircraft fired 20 mm shells on German vessels within the Investigation Area. Because the reports of the use of AAA within the Investigation Area relatively scarce, the likelihood of presence of these types of UXO is considered 'remote'.
Torpedoes	Feasible	18 inch (45.7 cm) 21 inch (53.33 cm)	During both the First- and Second World War, some reports of the presence of submarines have been encountered. Furthermore, one torpedo attack has been carried out within or immediately near the Investigation Area (the sinking of the HMS Ivanhoe). There are also multiple mentions of the sinking of vessels that carried torpedoes. The multitude of reports of the presence of torpedoes within the Investigation Area has led to believe that there is a feasible chance of encountering UXO from torpedoes.
Naval mines (WW1)	Probable	WWI: E-mine Type IV (German), contact mines Vickers Elia and type H Mk II (UK)	German maps show a suspected German minefield within the Investigation Area during the First World War. At least one German mine was encountered within the Investigation Area but outside of this minefield. Furthermore, several mine accidents are known to have happened within the Investigation Area. There is a lack of

UXO type	Likelihood of presence	Subtype / calibre	Remarks
			detailed information about the clearance of these mines. The presence of a minefield and multiple encounters (accidents or the spotting of mines) with mines outside this area, lead to the conclusion that the presence of naval mines is probable.
Naval mines (WW2)	Probable	WWII: moored mines Mk XX (UK), contact mines Mk XIV and XVII (UK), EMD- and EMC contact mines (German), Explosive Floats 'Sprenboje' (German), static cutters (German)	The Investigation Area was situated between the British Coast and the German occupied Dutch Coast. During the Second World War this region was a theatre of mine warfare. Multiple German and British minefields (filled with mines and minesweep obstructors) were laid within or immediately near the Investigation Area. This resulted furthermore in several mine accidents that occurred within the Investigation Area. After the Second World War, still multiple mines were encountered near the Investigation Area. It is therefore concluded that the evidence of the presence of naval mines is probable.
Aerial Bombs	Negligible	German bombs	The consulted sources do not state the use or jettison of German bombs within the Investigation Area. However, as stated in paragraph 5.1, the <i>Luftwaffe</i> archives were systematic destroyed. Therefore, there is only sporadic information available on German Air Force activity. Hence, no conclusive evidence of German aerial bombs is at hand and the likelihood of present is deemed negligible.
	Probable	Allied bombs: Ranging from 4 lbs up to and including 4,000 lbs	According to the analysed sources, multiple allied airstrikes took place in the Investigation Area. Beside airstrikes, allied aircraft often jettisoned bombs over the North Sea. At least three direct indications of jettisons in the Investigation Area have been derived from the historical sources. Furthermore, multiple aerial bombs have been lifted immediately near the Investigation Area after the Second World War. This leads to the conclusion that the likelihood of presence of allied aerial bombs is probable.

Table 15: Summary of UXO likely to be present within the Research and Project Area.

### 5.2.2 Condition of expected UXO

The majority of the expected UXO are likely to be in an armed condition. This means that the safety devices preventing the UXO from premature detonation, 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 and can be different for each type of UXO:

- In case of aerial bombs which were dropped by aircraft in distress situations, the bombs could have been dropped with safety features still in place, however they still present an explosive risk, e.g. as a result of corrosion of vital safety features.
- Some of the expected UXO, e.g. naval munitions, contain a large quantity of explosives and may be encountered in very poor condition as the thin metal casings may have been severely eroded. In many cases, the explosive capability could remain more or less undiminished. Some explosive charges neither absorb nor dissolve in water, and some charges do. However, stability of the explosive may have deteriorated with age.
- Naval contact mines from the period of interest typically contained a dry cell battery with an electrical detonating circuit which was connected to external conventional switch horns. These batteries will have

now deteriorated and no longer have the ability to supply sufficient power to function the mine. However, the condition of the explosives after decades of exposure cannot be determined beforehand and therefore caution is advised.

- Contact mines with Hertz Horns were also common from WWI onwards. Each horn contains a container of acid. Heavy contact with the horn can breach the acid container within, which subsequently energizes a battery and starts the explosive train. In this instance again the condition of individual detonators cannot be determined beforehand. Conditions may range from poor to nearly untouched.

Although corrosion can make a UXO more sensitive, it can also make it less likely to detonate, as i.e. electrical wiring may have corroded resulting in a break in the explosive train, As a wide range of UXO can be expected, the exact state of encountered UXO can only be determined after positive identification by an EOD-expert.

## 6 UXO BURIAL ASSESSMENT

In dynamic sediment conditions, UXO items are likely to become buried; the depth of burial is depending on a number of variables that will be analysed in this Risk Assessment. In the offshore marine environment, UXO burial is predominantly due to one or a combination of the following three mechanisms:

- Initial impact;
- Scour;
- Bedform migration.

### 6.1 BURIAL ON IMPACT

The first mechanism for UXO burial to consider is that due to initial impact. In the marine environment, an aerial bomb energy is rapidly attenuated by the water it passes through and its geometry is changed substantially. The depth of water, therefore, is also an important factor in estimating the likely burial depth on impact.

To determine burial depth, data was used from experiments conducted with post-war Mk 84 bombs<sup>15</sup> (see Figure 34). The data shows that the trajectory of a bomb falling into water at an optimal angle of entry of  $\sim 90^\circ$  is rapidly altered by the new medium. The bomb rotates and orientates to near horizontal at a water depth of around 5 meters, only to return to a vertical position at a depth of 12 meters. At a depth of around 20 meters it has returned to a horizontal position and has lost the initial momentum.

It should be noted that Mk 84 aerial bombs have a more aerodynamic shape than generic aerial bombs used during World War II. Hence data of the Mk 84 is considered to be a worst-case scenario as they would penetrate more easily into a body of water than most common World War II vintage aerial bombs.

From the bathymetric data it was determined that the water depth within the investigation area varies from -24 to -37 meters (LAT). This is considerably deeper than the point where most bombs would have lost their momentum. Burial on impact is therefore assessed to be negligible.

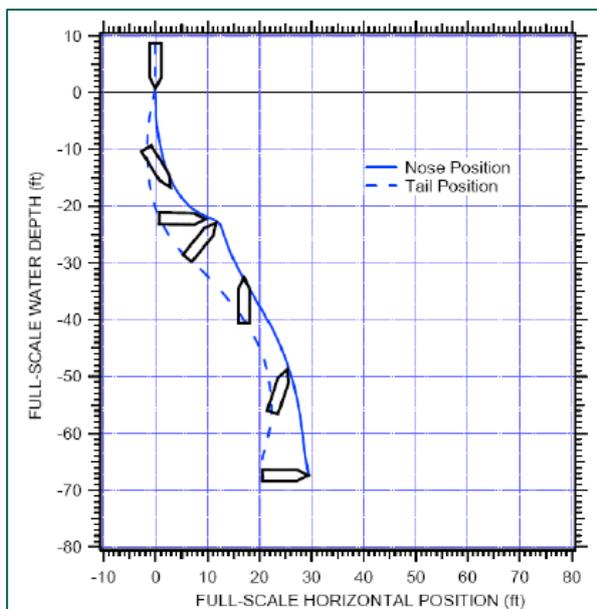


Figure 34: Trajectory of Mk 84 with no tail section and water-entry velocity of 296 m/s. Note that unit of measurements are in feet (ft).

<sup>15</sup> Chu P.C. et al, *Semi Empirical Formulas of Drag/Lift Coefficients for High Speed Rigid Body Manoeuvring in Water Column*, May 2008.

## 6.2 SCOUR

Scour is the change in bed configuration due to the change in flow pattern around an object such as a UXO placed on or near the surface of a dynamic seabed. The presence of the object modifies the flow pattern around the object, generating vortices that locally increase and decrease the bed's flow stresses (see Figure 35)<sup>16</sup>. The vortices cause depressions and mounds to form on the bed surface. Objects placed on beds where the flow caused no apparent motion can locally increase the bed stress behind the object and induce bed motion and scour.

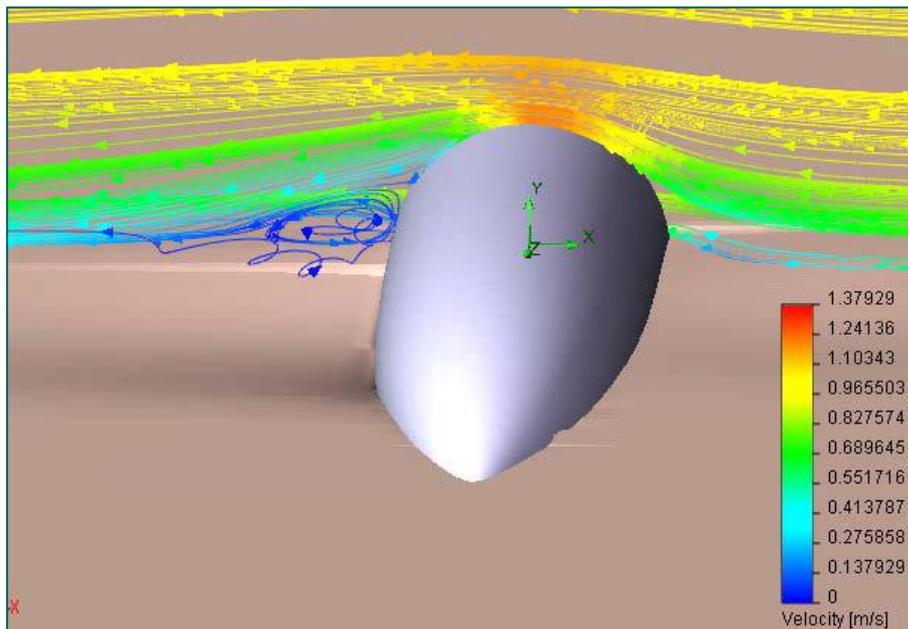


Figure 35. Example of flow stresses and subsequent vortices around a surrogate UXO.

Studies of UXO surrogates placed on a sandy sea floor show that subsequent burial occurs through a series of scour events, followed by rolling or sliding of the UXO into the scour depression<sup>17</sup>. It has been shown that the amount and rates of scour and burial of objects on the sea floor under the influence of waves and currents is a combination of their size, weight, and shape. Shape is an essential variable because scour is related to the intensity of the vortex system that forms around the object as the current flows past it. Thus, streamlined objects scour less rapidly than blunt objects. Once scour depressions develop around a UXO, burial increases incrementally by the movement of the UXO into the depressions formed by the scour process, either by rolling or sliding in (see Figure 36).

<sup>16</sup> Predicting the Mobility and Burial of Underwater Unexploded Ordnance (UXO) using the UXO Mobility Model. Report CR-10-012-ENV. NavFac, 2009.

<sup>17</sup> Douglas L. Inman et al., Scour and burial of bottom mines, A Mine Burial Primer, September 2002.

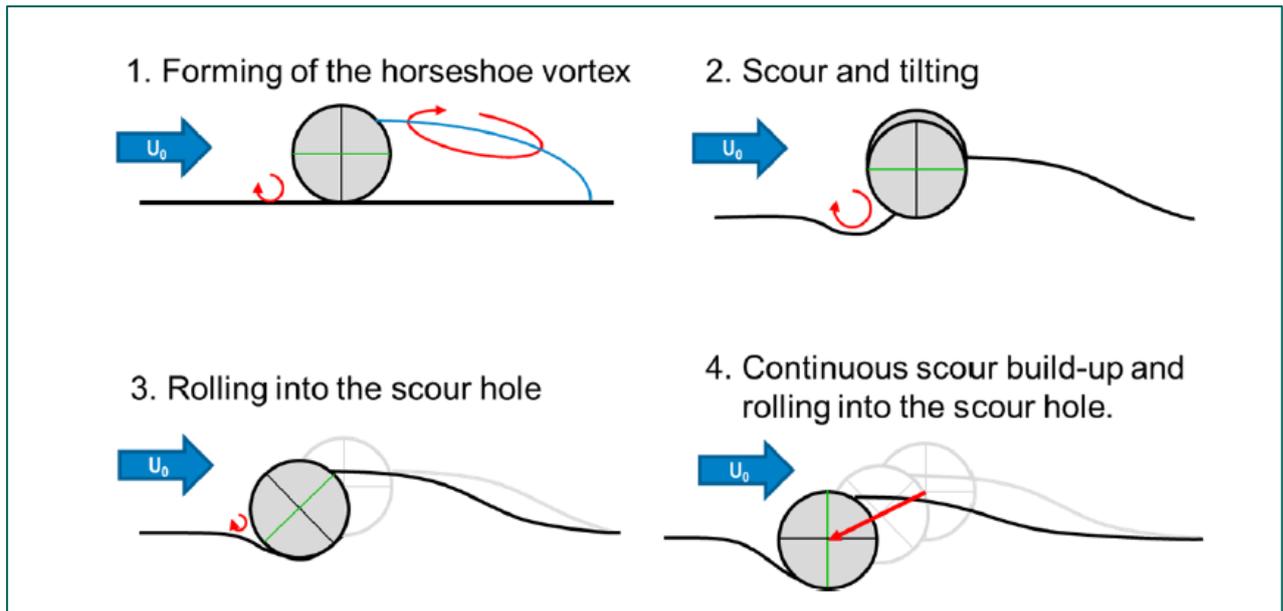


Figure 36. Example of scour mechanism and self-burial in constant inflow conditions.<sup>18</sup>

In general, small UXO items scour and bury deeper relative to their diameters than large UXO, while absolute burial as measured from sediment surface to UXO keel is greater for large UXO. Streamlined UXO (f.e. torpedoes) bury more slowly than blunt objects (f.e. cylindrical depth charges/anti-ship bombs).

The scour process stops when the UXO is at a depth where it is protected against the scour. Experiments and modelling have shown this depth to be approximately 0.6 x diameter for large objects in sandy sediments<sup>19</sup>. UXO burial due to scour to the maximum scour depth is to be expected in the investigation area. The largest diameter UXO possibly to be present is a German EMC moored mine. This mine has a diameter of 1.2 m and can be buried due to scour up to approximately 0.7 m below seabed.

### 6.3 BEDFORM MIGRATION

Assessment of possible UXO burial requires insights in the behaviour of the mobile morphological features within the investigation area. UXO burial (and exposure) may be caused by the formation and migration of bedforms. An example of this mechanism is shown in Figure 37.

<sup>18</sup> Menzel, P. et al., D.R. Mobilization of Unexploded Ordnance on the Seabed. *Toxics* 10, 389, July 2022.

<sup>19</sup> Douglas L. Inman et al., Scour and burial of bottom mines, *A Mine Burial Primer*, September 2002.

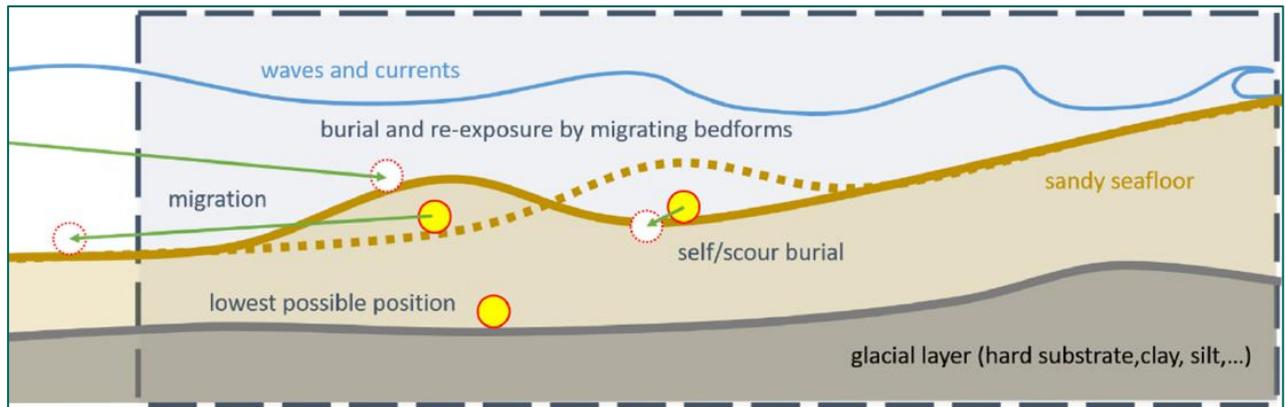


Figure 37. Bedform migration showing the original position of the UXO in yellow and in white the position after migration has taken place.

The spatial scale of the bed forms ranges from several meters to several kilometres and migration speeds range from < 1 m/year to > 100 m/year. Table 16 summarizes the six different types of bed forms can be distinguished on the Dutch continental shelf.

Bed form	Length (m)	Height (m)	Migration speed (m/year)	Evolution time scale
Ripples	0.1 - 1	0.01 - 0.1	100 - 1,000	Hours
Mega ripples	1 - 10	0.1 - 1	100 - 1,000	Hours - days
Sand waves	100 - 1,000	1 - 5	1 - 10	Decades
Long bed waves	1,500	5	Unknown	Centuries
Shore face connected ridges	5,000 - 8,000	1 - 5	1 - 10	Centuries
Tidal sand banks	5,000 - 10,000	1 - 5	< 1	Centuries
Sand ridges	10,000 - 60,000	5 - 30	< 1	Centuries

Table 16: Overview of bed forms located at the Dutch continental shelf.<sup>20</sup>

The ripples and mega ripples are too low to be of major importance for the burial assessment. Long bed waves, shore face connected ridges and tidal sand banks migrate too slow to be of importance for the burial assessment. Due to their height and migration rates sand waves are the predominant bed forms in regard to the burial depth of UXO.

The available bathymetry covers the investigation area in a grid density of approximately 50 x 100 meters in horizontal dimensions and in 1 meter increments in depth. The seabed shows sand ridges in an approximately north-south direction with an elevation change of up to 13 meters from top to bottom. These ridges are approximately 30-60 km long, 1-4 km wide and around 5-10 km apart from each other (Figure 38). Such ridges exist in zones where the tidal velocity exceeds 0.5 m/s.

The bathymetry data seems to show sand waves perpendicular to the sand ridges especially in the southern part of the project area. For the northern part of the project area the available bathymetry data is not detailed enough to determine the presence of sand waves. The sand waves are smaller with a height of roughly 4 m, a length of several hundreds of metres to 6 km and an orientation approximately perpendicular to the sand ridges. Burial depth of UXO due to the migration of sand waves is maximum 3 m.

<sup>20</sup> Menninga J., 2012. Analysis of variations in characteristics of sand waves observed in the Dutch coastal zone: a field and model study. MSc dissertation thesis. Utrecht University, 2012.

Bedform	Wavelength/Length	Height	Direction
Sand waves	100 – 5000 m	1 – 4 m	Perpendicular to main current direction
Sand ridges	30-60 km	3 – 30 m	Parallel to main current direction

Table 17. Classification scheme for bedforms within the Nederwiek WFZ.

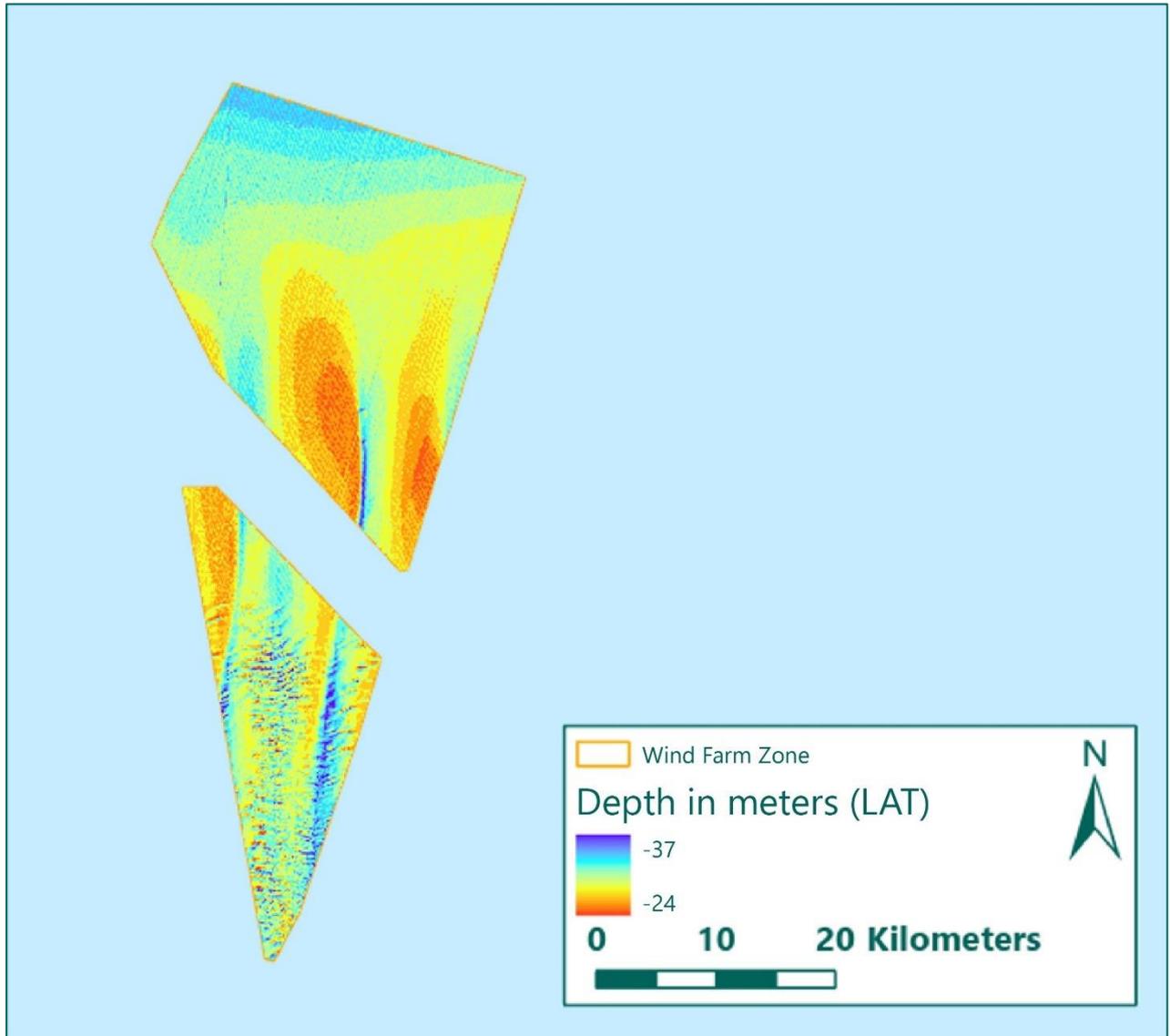


Figure 38: Available bathymetry of the investigation area.<sup>21</sup>

## 6.4 CONCLUSIONS

Based on the mechanisms outlined in the previous paragraphs, the likely maximum burial depth (MBD) for an item of UXO can be calculated using the basic formula:

$$\text{MBD} = (0 \text{ (burial on impact)}) + (0.6 \times 1.2 \text{ (UXO diameter)}) + (4 \text{ (height of bedform)}) = \mathbf{4.7 \text{ meter}}$$

This calculation is based on data available at the moment of conducting this risk assessment. The calculation should be verified when more information on bedform height becomes available

<sup>21</sup> GEBCO bathymetry data 2021

## 7 UXO MIGRATION ASSESSMENT

In preparation for the geophysical surveys, the potential migration of UXO needs to be assessed. UXO migration is highly relevant in determining the maximum permissible safe time interval between the conclusion of a geophysical UXO survey, UXO clearance operations and the commencement of construction works.

Migration can occur due to environmental and natural causes and also human activity. In this chapter the possible migration of UXO is assessed.

### 7.1 MIGRATION BY NATURAL CAUSES

Migration by natural causes may occur due to hydrodynamics and/or morphodynamical behaviour. In this paragraph these aspects will be assessed.

#### 7.1.1 Hydrodynamics in the wind farm zone

To establish the hydrodynamic characteristics in the Nederwiek WFZ, data was used from the Hollandse Kust study<sup>22</sup>. This comprehensive study examines circumstances that have been found to be similar in the current project area. The hydrodynamics within the wind farm zone are characterized by tide and wind generated currents and waves. The tide is predominantly semidiurnal tide.

The average tidal current on the sea floor during normal weather conditions reaches speeds up to 0,7 m/s, whereas maximum speeds during adverse weather conditions can reach speeds up to 1,7 m/s.

The shapes, dimensions and weight of the UXO that can be expected in the investigation area are such that they are not likely to be transported over long distances by normal wave and tidal conditions. The forces on the objects are relatively low and the objects are not likely to migrate a great distance from their original resting position.

#### 7.1.2 Morphodynamical behaviour

Migration or erosion of the slopes of sand waves may cause UXO migration. An object may for example be buried in a side slope that erodes over time until a point that supporting soil is gone and the object is free to roll further down. The object is likely to roll down the side of the slope towards the deepest section of the through, where it will remain or become buried by vortex scouring or bedform migration. The process of migration through erosion of sandwaves is indicated earlier in this report in Figure 37.

Observed sand wave migration rates in the Dutch Princess Amalia Wind Park were assessed to be in the order of 4 m/year<sup>23</sup>. Similar long term migration rates are expected in the Nederwiek WFZ. This would mean that sand waves have migrated approximately 250 – 300 m since the war. The width of the crests of the sand waves, from trough to trough, is in the same order as the post war migration of the sand waves. Due to the migration rate and width of the sand waves it is assessed that present-day sand waves crests are mainly sediments from the post war period. Therefore, it is not likely that UXO are present above the elevation of the deepest level of the troughs between these sand waves.

The distance of UXO migrating due to morphological behaviour is dependent on the height of the sand waves. The maximum migration in this case can be assessed to be at least within 300 m, which is marginal by comparison to the surface area of the project area. Therefore, UXO migration due to morphodynamic behaviour is an insignificant factor in the migration assessment.

<sup>22</sup> Van de Rest, P., Morfodynamica en hydrodynamica van de Hollandse kust. MSc Thesis. TU Delft, 2004.

<sup>23</sup> Deltares, Seabed mobility study for route comparison Windpark Hollandsche Kust Zuid, reference 1221505-000, March 24, 2016

## 7.2 MIGRATION DUE TO HUMAN ACTIVITY

Human activity is shown to have a more significant impact on UXO migration than natural causes. Especially dredging and fishing activities have the capacity to move items of UXO over longer distances. Particularly in areas where beam and pair trawling is prevalent UXO migration is to be expected.

The Nederwiek Wind Farm Zone is open to fishing activities. Data on fishing activities has shown that several hotspots for beam trawling (sole) are present in the area (Figure 39) and other trawling activities are conducted on a regular basis in the area. 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 (48 km) from their original location<sup>24</sup>.

This migration factor cannot be quantified but is found to be one of the most influential factors for the risk assessment. Fishing activities might drag UXO from other areas into the wind farm zone from substantial distances and nullify results from previous UXO clearance operations.

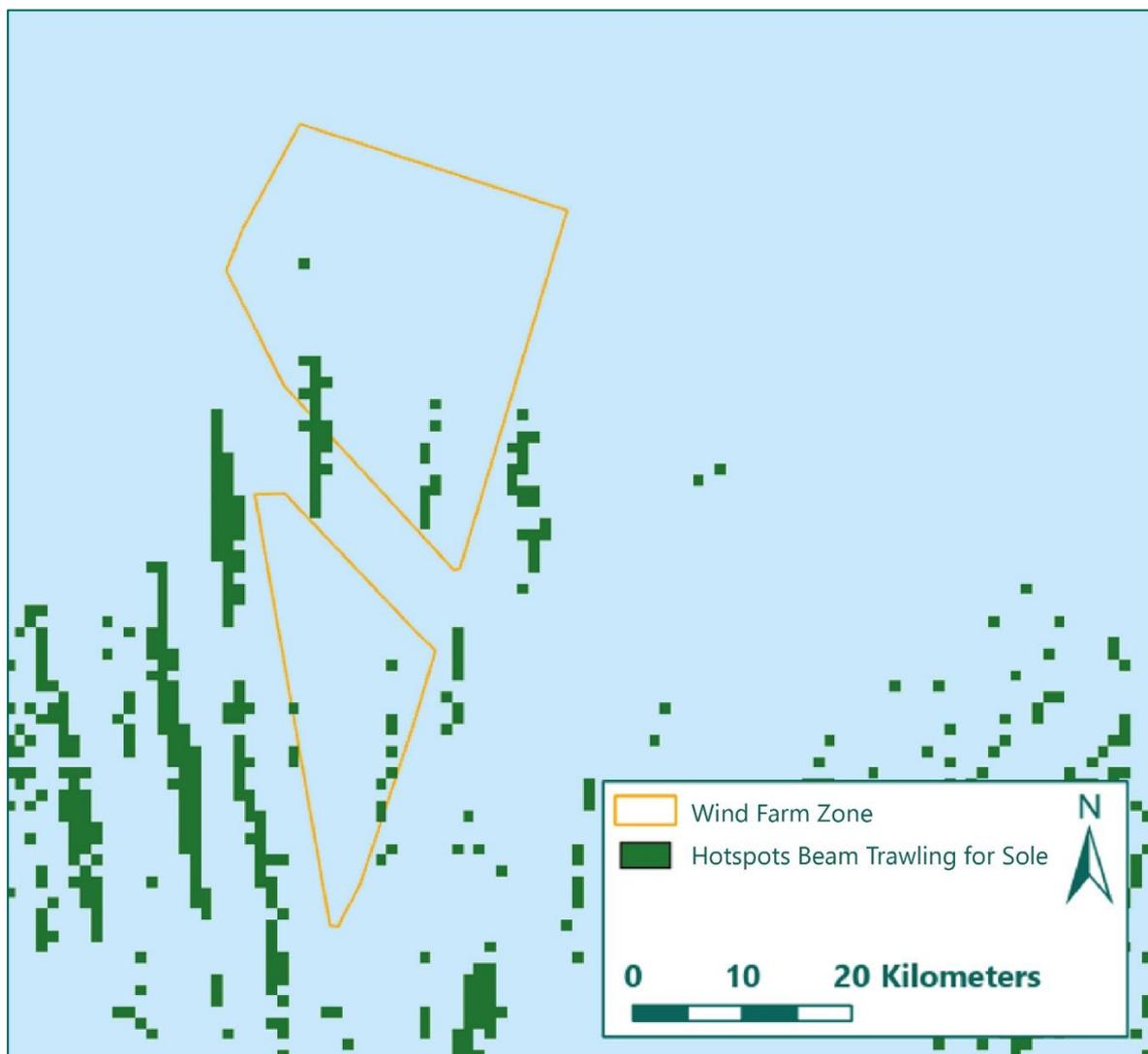


Figure 39. Hotspots for beam trawling for sole.

<sup>24</sup> Unexploded Ordnance Munitions Migration Assessment, Report Number: P3872-E3MMA, August 2014

### 7.3 MAXIMUM PERMISSIBLE SAFE TIME INTERVAL

In general, due to the possibility of UXO migration, the time periods lapsed from completion of the geophysical survey, UXO/anomaly investigation, UXO disposal phase and installation operations, must be kept to an absolute minimum. This is to ensure that UXO migration cannot nullify the validation period of the final ALARP clearance certification. It is therefore imperative to manage and plan the phases of the project, in an educated and calculated manner. This can be achieved by ensuring that vessel planning, vessel availability, weather windows, vessel/contractor capability, project phase execution and management are carefully planned and implemented to guarantee that the operations are carried out within the specified time scale reflective of the UXO migration assessment information.

For the investigation area horizontal migration of UXO is most likely to occur due to human activity. However, it proved not to be possible to quantify the horizontal migration rate caused by human activities.

REASeuro advises a maximum permissible safe time interval of two years between the conclusion of a geophysical UXO survey, UXO clearance operations and the commencement of construction works. It is however recommended that the time interval is kept as short as possible to ensure that the chance of UXO migrating into the surveyed area after UXO operations have been completed is kept to a minimum.

## 8 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 8), the planned intrusive activities (see chapter 9) and the specific characteristics of the site form the input for outlining the UXO mitigation strategy (see chapter 11).

### 8.1 AERIAL BOMBS

An aerial bomb is a type of munition 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 outfitted with a high explosive charge, although incendiary bombs were also used in large numbers.

The deployed fuzes are important to determine 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 detonating before it has reached the intended target.

The fuzes are armed during and after the bombs are dropped. Fuzes are usually equipped with a firing pin or an electrical circuit that detonates the bomb upon impact. If the fuze has a firing pin, that pin is driven into a small firing cap that sets off the explosive train, resulting in detonation of the main charge. An electrical fuze uses an electrical detonator to start the explosive train.

Fuzes can have various time-delaying devices to make the timing of the blast more effective. Some function at a given time after arming, f.e. chemical long delay pistol such as tail pistol No. 37 Mk.I (see Figure 40). More common are short delay fuzes that only delay the detonation for a few fractions of a second, or impact fuzes that cause a nearly instant detonation.

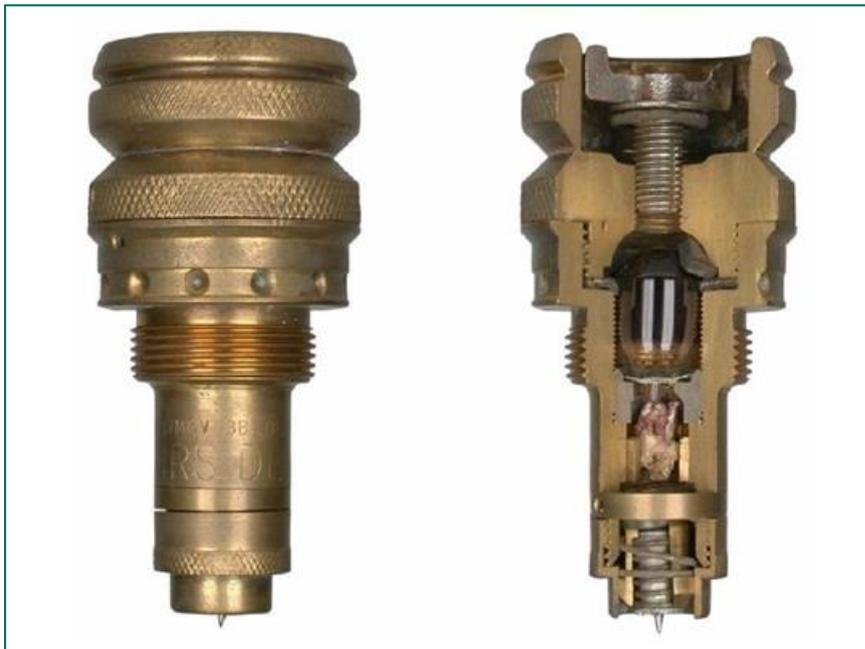


Figure 40. Tail fuze No. 37 Mk.I.

Once a fuze is armed, shock, movement or manipulation can cause the bomb to detonate. Fuzes, and chemical long delay fuzes in particular, can be sensitive to movement and accelerations in the surrounding soil. This kind of accelerations can occur as a consequence of vibrations caused by piling operations.



Figure 41. One of several aerial bombs encountered during clearance operations in the Hollandse Kust Zuid (HKZ) wind farm zone in 2020.<sup>25</sup>

## 8.2 TORPEDOES

A torpedo is a self-propelled weapon with a large explosive warhead, launched above or below the water surface, propelled underwater towards a target, and designed to detonate either on contact with or in proximity to the target. Torpedoes in the Second World War were generally propelled using either steam or electric propulsion systems.

Torpedoes could be equipped with contact or magnetic detonators. The torpedo would explode upon impact with a target or when it was in close proximity to a magnetic object like the hull of a ship. If neither of these two events would occur a torpedo would eventually run out of propulsion after several kilometers and sink to the bottom. Detonators might still be intact and active.

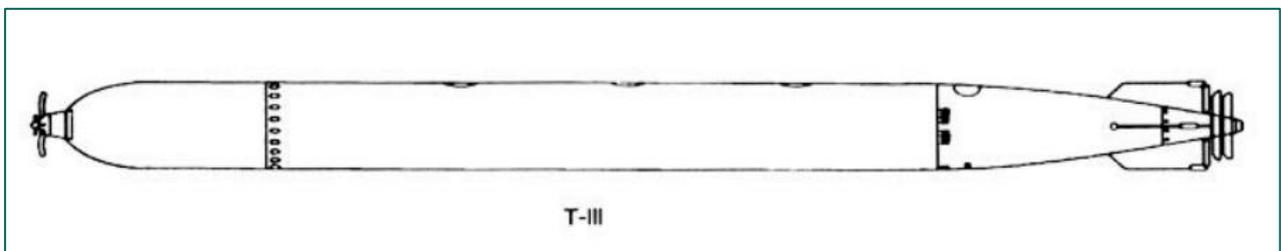


Figure 42. The standard German T III/G7e torpedo. This torpedo design would be widely copied by Allied nations.<sup>26</sup>

<sup>25</sup> Hollandse Kust Zuid I & II Team Gets Rid of WWII UXO, 3 november 2020. Offshorewind.biz.

<sup>26</sup> Milford, F. US Navy Torpedoes, Part 3: WWII development of conventional torpedoes 1940-1946.

### 8.3 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;

Moored mines and ground mines are the most commonly used. Practice 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 practice mines cannot be ruled out.

#### 8.3.1 Contact mines

The earliest mines were commonly of this type. Contact mines need to be in direct contact with the target to detonate with the direct effects of the explosion 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 activate 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.
  - o Hertz Horn: these fuzes use a chemical principle and can work reliably even after the mine has been in the sea for several decades. 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.
  - o 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.
  - o Antenna or Galvanic Horn: this type of horns works on the principle of creating battery power based on the saltwater environment. A copper antenna or horn fitted to the mine casing acts as positive electrode. When another metallic object (i.e.: ship's hull) makes contact with the antenna or horn.

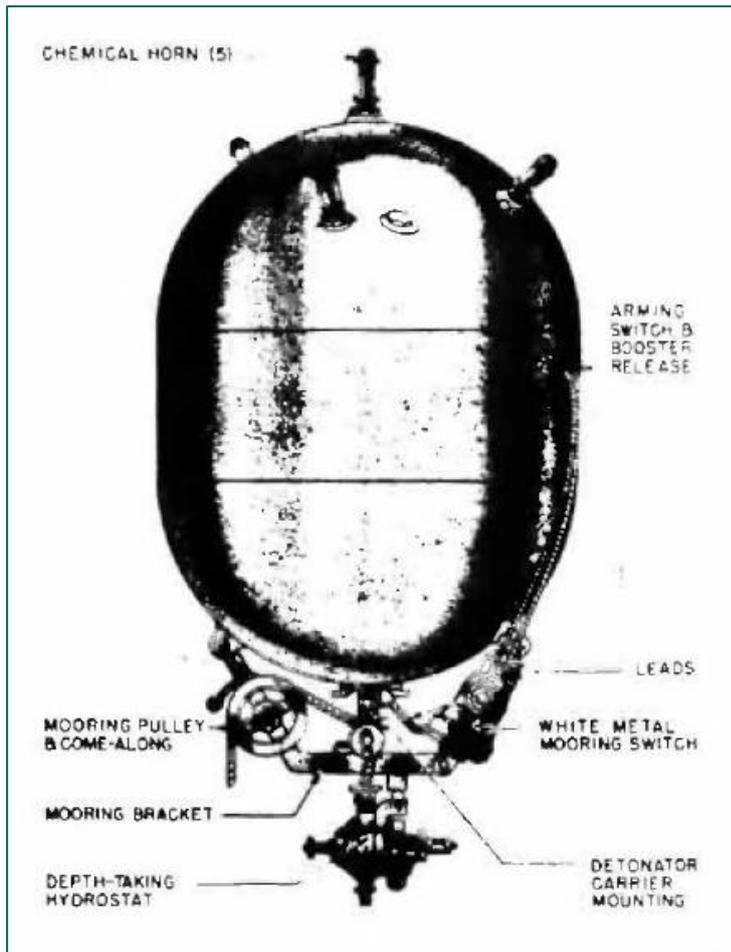


Figure 43. German moored EMA contact mine introduced during World War I.<sup>27</sup>

### 8.3.2 Influence mines

These mines have detonators that are activated by the influence of a ship or submarine, rather than direct contact. Influence mines incorporate detonators designed to detect the presence of a vessel and detonate when it comes within the effective range of the mine. The detonators used on these mines may include one or several of the following types: magnetic, water displacement pressure or acoustic.

Certain designs incorporated a clockwork into mine fuzes that would count vessels passing by. These would set the mine to ignore the first or second ship to pass over it (which could be mine-sweepers deliberately trying to trigger mines) but detonate when a subsequent ship passes overhead, which could be a high-value target such as an oil tanker.

## 8.4 ARTILLERY SHELLS

Artillery shells were deployed in aircraft cannons, coastal defences, submarines and warships. Artillery ammunition can be deployed with different kinds of fuzes.

The types of fuzes most commonly used would cause the shell to detonate on impact with a target, a time fuze set to detonate after a set period of time, a combination of both impact and time fuze or a proximity fuze set to detonate within a certain distance of a target or surface.

<sup>27</sup> German Underwater Ordnance, Mines, OP 1673A, United States Navy Bureau of Ordnance, 1946.

## 8.5 ANTI-HANDLING DEVICES

Some fuzes, like 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 anti-handling or anti-withdrawal mechanisms in fuzes f.e. the German ZUS40 anti-removal bomb fuze or the British No. 17 Tail Pistol. These devices pose an additional hazard.

## 8.6 SELF-DESTRUCTION DEVICES

The Hague Conventions of 1907<sup>28</sup> 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. Because washed up mines were falsely considered safe they claimed many casualties during and after the wars. Despite the prohibitions of The Hague conventions, naval mines and torpedoes must be considered dangerous at all times.

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<sup>28</sup> Laws of War: Laying of Automatic Submarine Contact Mines (Hague VIII); October 18, 1907.

## 9 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.

### 9.1 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 the distance between the target and the detonation. When taken in reference to a vessel's 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 vessel will have a lower value of KSF<sup>29</sup>. The effect of a detonation mainly depends on the amount of explosive content of an explosive device, called the 'Net Explosive Quantity' (NEQ) and the type of explosive content (e.g. TNT, amatol, etc.). The type of high explosive in case of an underwater explosion is of less determining factor than during a surface detonation.

In underwater explosion effects we distinguish between 'direct underwater damage' and 'close proximity underwater damage'. Direct underwater damage is caused by fragments or projectiles launched by the explosive device while close proximity underwater damage is caused by pressure fluctuations and vibrations.

#### 9.1.1 Fragmentation

Fragmentation damage is direct damage that can occur to vessels and platforms that are in very close proximity of or in direct contact with an explosive device when it detonates. Fragments from the metal casing of the explosive device or metal structure of the receiving vessel can cause wounds among the crew. These fragments can puncture the hull and cause damage to equipment or flooding as well.

For the area of investigation, UXO is normally only present in or on the seabed, unless brought to the surface. Fragments from explosives devices in water quickly lose energy, it is therefore unlikely that fragmentation damage to a vessel will occur due to intrusive activities in the seabed, unless operating in very shallow water or when having limited under keel clearance. Damage to jacked up vessels and platforms is possible as well.

The water depth needed to detain fragmentation of explosives with up to 1,000 kg Net Explosive Weight is illustrated in Figure 44. Based on this chart and the water depths within the area of investigation it is concluded that it is unlikely lethal fragments will be ejected above the surface of the water.

<sup>29</sup> The Response of Surface Ships to Underwater Explosions. DSTO-GD-0109, September 1996

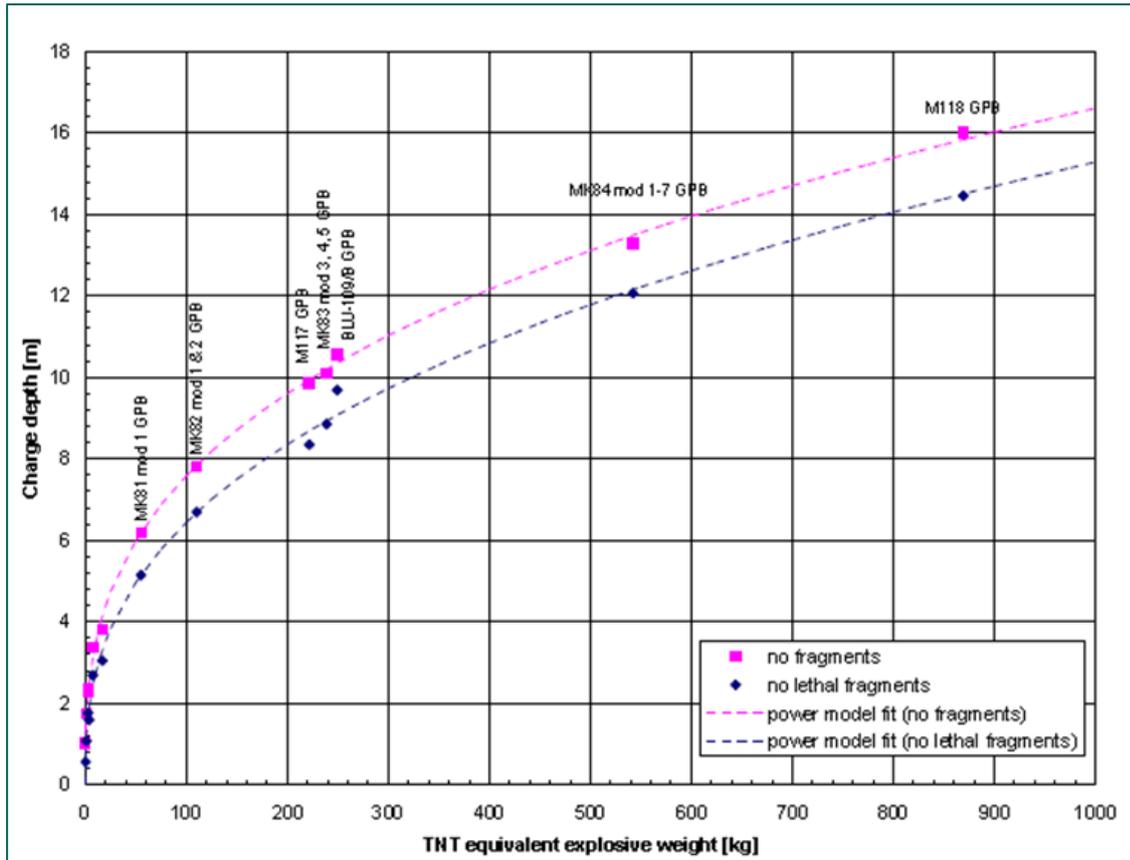


Figure 44: Minimal water depth to detain fragmentation of explosives with a Net Explosive Weight of 0-1,000 kg TNT equivalent.<sup>30</sup>

### 9.1.2 Bubble jet effect

An underwater explosion also results in a gas bubble, which contains about half of the explosive energy and, therefore, can also cause damage to vessels. The gas bubble exhibits a low frequency oscillation and migration. Because of its large size, gas bubble oscillation goes together with large motions in the surrounding water, which in turn solicits vessel hull vibrations. This hull response is known as whipping. For heavy scenarios, thus for high HSF values, whipping may cause extensive damage. Whipping may be even worse, when the lowest hull bending natural frequency is close to the bubble frequency.

When a detonation happens close to a vessel's hull, there may be additional gas bubble effects influencing the vessel. The detonation gases are enclosed in a bubble that alternately grows and shrinks during an upward movement to the water surface. The bubble may migrate toward the hull, which considerably worsens whipping and may result in overall hull failure. If the bubble collapses on the surface at close proximity to the vessel's hull the vessel can be severely damaged, resulting in fatal loss of buoyancy and/or hydrostatic stability and fatalities to the crew within the affected areas.

### 9.1.3 Shock effect

The shock effect is a close proximity effect that occurs when an explosive detonates at a distance from a vessel and the change in water pressure will cause the hull of the vessel to resonate. As the entire vessel will resonate, it is possible that leaks will form over the entire hull surface. Damage to external parts of the vessel like rudders and propulsion systems are likely. Damage to on-board equipment and injury to crewmembers starts to occur at far larger distances from the explosion. Due to the vibrations unsecured equipment and items on board can be thrown around inside the vessel, mounted equipment and

<sup>30</sup> Handboek EOD LAND-ENG-EOD-01, 2020

machinery can be dislodged from their positions, creating dangerous circumstances for the crew. The crew can suffer injuries from the vibrations themselves as well, especially when they are nearby the impact area or standing on a vibrating surface that is directly connected to the hull.

A single detonation can produce a shock wave that will strike a vessel multiple times through reflection of the surface and the sea floor as shown in Figure 45

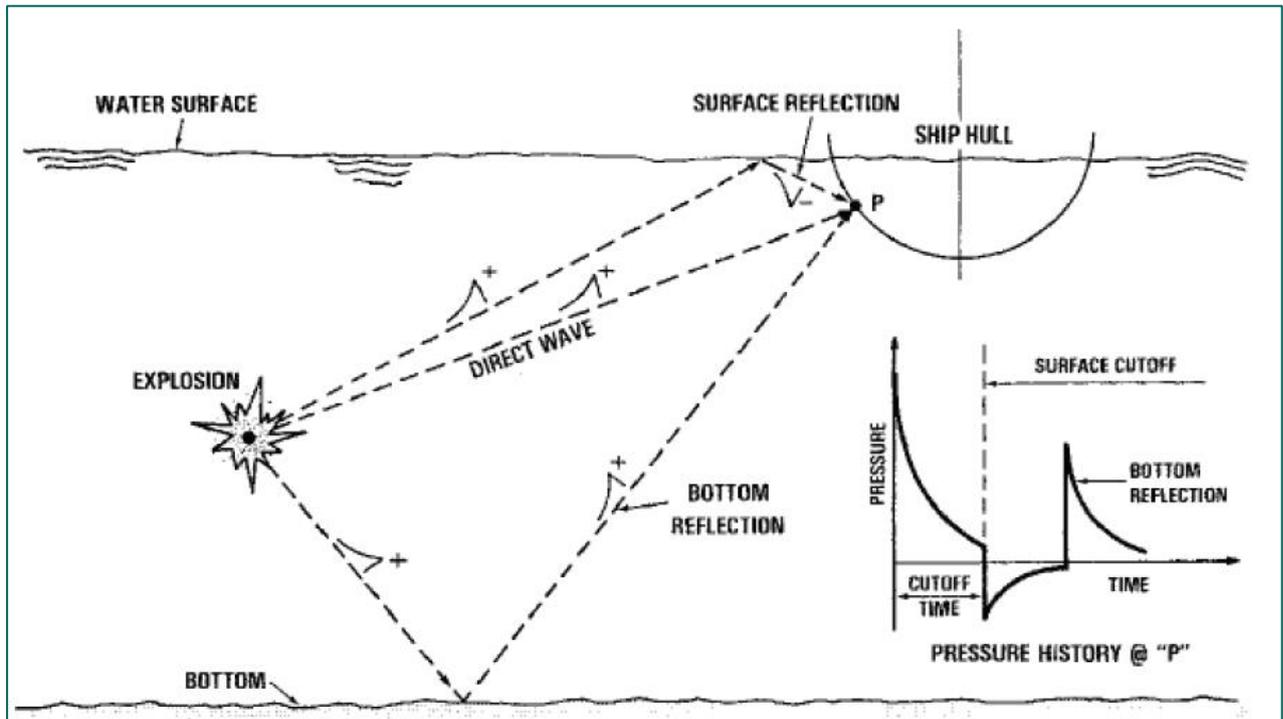


Figure 45. Multiple shock wave strikes caused by a single explosion.<sup>31</sup>

In Table 18 distances where a certain amount of shock damage is expected are shown for several of the most common calibres of allied aircraft bombs. The distances are calculated by TNO<sup>32</sup>. Leakage is to be expected in case of a Hull Shock Factor (HSF) > 0.3 kg<sup>0.5/m</sup>. Damage to equipment is to be expected in case of a HSF > 0.02 kg<sup>0.5/m</sup>. A detonation within these distances may cause severe damage and injury.

Caliber [lbs]	NEQ [kg]	Leaks [m]	Damage to equipment [m]
250	51	29	430
500	105	41	617
1.000	270	66	989

Table 18. Distances for shock damage due to detonation.

#### 9.1.4 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

<sup>31</sup> Costanzo F. , Underwater Explosion Phenomena and Shock Physics, 2011

<sup>32</sup> TNO-rapport Beveiligd 'baggeren Maas, stuwpand Sambeek', 11th may 2012

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 filled cavities such as ears, lungs and intestines.

## 9.2 SAFE DISTANCES

Within the Dutch continental waters, the Dutch Navy EOD is the authority responsible for all maritime UXO disposal operations. When the EOD concludes that identified UXO's are unsafe to transport, these shall be detonated on site under appropriate conditions. The EOD has predetermined safe distances at which UXO can be detonated without causing damage or injury. These distances are displayed in Table 19.

Safe distance from detonation center	Meters	Nautical Miles
Vessel (e.g.: RHIB) assisting UXO disposal team, during detonation of UXO's	250	0.14
Operational vessel and/or guard vessel	925 – 1,850	0.5 – 1.0
Other vessels, subsea cables, oil wells, wrecks	3,700	2.0
Coastline (UXO <500 lbs/250 kg)	5,550	3.0
Pipelines and pump stations	7,400	4.0
Offshore installations (Platforms)	9,250	5.0
Coastline (UXO >500 lbs/250 kg)	9,250 - 14,800	5.0 – 8.0

Table 19. Safe distances from detonation centre.

## 9.3 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<sup>33</sup>:

- a)  $R = 270 \sqrt[3]{W}$  diving is not allowed;
- b)  $R = 24\sqrt{W}$  civilian shipping is not allowed;
- c)  $R = 36\sqrt{W}$  tankers are not allowed;
- d)  $R = 12\sqrt{W}$  warships are not allowed.

R : Radius in meters

W : Net Explosive Weight (NEW) in kg TNT-equivalents

In Table 20 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 and torpedoes).

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

Table 20: Safe distances for controlled demolition.

<sup>33</sup> Handboek EOD LAND-ENG-EOD-01, 2020

## 10 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 the most likely intrusive survey, construction and maintenance activities during the preparation, execution and operational phases of Nederwiek WFZ are summarized. In the current stage of the project an execution plan is not yet available. The information presented here is derived from open sources. Therefore, the activities described in this chapter only provide a range of possible activities that could occur.

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

### 10.1 PREPARATION PHASE

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

- Geophysical investigations:
  - o multibeam echo sounder;
  - o side scan sonar;
  - o magnetometer;
  - o ultra high resolution sonar;
  - o grab samples
  - o sub-bottom profiler.
- Geotechnical investigations:
  - o cone penetration tests, covering the whole area;
  - o vibrocores;
  - o boreholes covering the whole area for sampling purposes;
  - o box core samples;
  - o grab samples.

#### Potential UXO risks

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 during set-down of frames on the sea floor.
- Direct contact between a UXO and the cone or drill during the geotechnical investigations.
- Direct contact between a UXO and ROV's during inspections and as-built checks.

### 10.2 EXECUTION PHASE

For the wind farm a variety of structures are planned. The following elements are identified and briefly described:

- Wind turbines.
- Converter- and transformer substations.
- Scour protection.
- Cable routes.

#### 10.2.1 Wind turbines

A wind turbine consists of a nacelle with rotor blades, a support structure and a foundation. For the UXO risk assessment only intrusive activities that influence possible UXO 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 46 shows three possible foundation types. Suction anchors may also be a suitable solution.

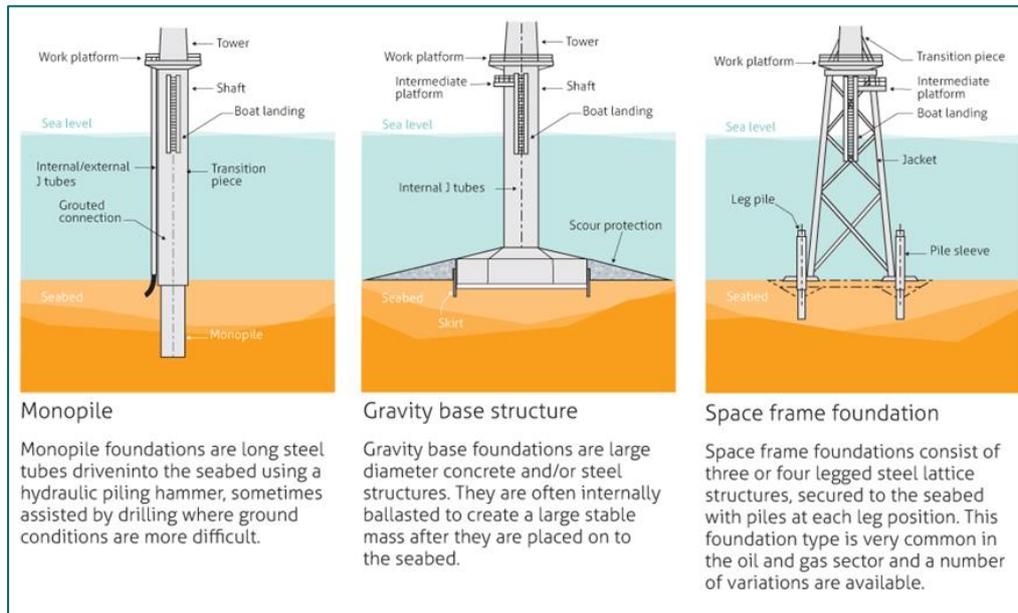


Figure 46: Example of suitable foundation types.<sup>34</sup>

### 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.
- Vibrations in the soil surrounding a UXO 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 divers during cable connection operations.
- Direct contact between a UXO and divers/ROV's during inspections and as-built checks.

### 10.2.2 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.

<sup>34</sup> Source: [www.navitusbaywindpark.co.uk](http://www.navitusbaywindpark.co.uk)

- 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  $> 1 \text{ m/s}^2$  in the soil surrounding a UXO during the placement or removal of the foundation (depending on the type of foundation, there are techniques that are vibration-free).

### 10.2.3 Scour protection

Sandy soils, such as present in the Nederwiek WFZ, can be more or less susceptible to a type of erosion called scour as mentioned before. Due to tidal currents, a significant section of the soil around the piles can erode away 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.

#### Potential UXO risks

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).

### 10.2.4 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.

### 10.3 OPERATIONAL PHASE

The North Sea is a highly dynamic morphological system. The action of the tides and the waves and human activity may move objects on the seabed and over a period of time an area which was previously cleared, may no longer be deemed to be clear. In 2011 a WWII 1,000 lbs high explosive bomb was discovered lying against the side of the monopile base of a UK offshore wind farm under construction<sup>35</sup>. Another noticeable example is a torpedo being discovered in 2002, having moved against a North Sea oil pipeline<sup>22</sup>.

During the operational phase of the wind farm maintenance activities will be required throughout. Intrusive activities may be conducted, e.g. cable laying and anchoring of working vessels.

Because of the likelihood of a UXO moving or being moved 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 conducting 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.

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<sup>35</sup> Unexploded Ordnance Risk, Considering Unexploded Ordnance Risk on and around the British Isles, 27-04-2011

## 11 UXO RISK ASSESSMENT

In assessing the overall UXO risks for the project a Semi Quantitative Risk Assessment (SQRA) process was applied. SQRA is widely considered best practice in the offshore industry. The risk factor values assigned in the SQRA are determined by UXO experts and are consequently subjective and open to different interpretation.

In this assessment the following parameters were assessed:

- Likelihood of Presence,
- Likelihood of Occurrence,
- Hazard severity.

### 11.1 RISK ASSESSMENT MATRIX

The following matrix is used to quantify the risk. Each generic UXO hazard is assessed for hazard severity and likelihood of occurrence. This model is generally considered best practice for assessing risk in the marine environment, although it has been modified where required to ensure it is UXO centric.

		Hazard severity				
		1 = Negligible	2 = Slight	3 = Moderate	4 = High	5 = Very High
Likelihood of occurrence	1 = Very unlikely	1 LOW	2 LOW	3 LOW	4 LOW	5 LOW/MODERATE
	2 = Unlikely	2 LOW	4 LOW	6 LOW/MODERATE	8 MODERATE	10 MODERATE/HIGH
	3 = Possible	3 LOW	6 LOW/MODERATE	9 MODERATE	12 MODERATE/HIGH	15 HIGH
	4 = Likely	4 LOW	8 MODERATE	12 MODERATE/HIGH	16 HIGH	20 HIGH
	5 = Very likely	5 LOW/MODERATE	10 MODERATE/HIGH	15 HIGH	20 HIGH	25 HIGH

	Unacceptable
	ALARP with reduction measures
	ALARP
	Acceptable

Table 21: UXO risk assessment Matrix.

The high probability, high severity combinations are ranked in the category 'Unacceptable'. This means mitigation measures are required to reduce the risk to a level that is considered ALARP. The mitigation measures for this category of risk is mainly source orientated. The source of risk is eliminated usually by consecutively: surveying the area, identifying potential risk targets, avoiding potential risk targets when possible, positive identification of objects that cannot be avoided of which targets that have been positively identified as UXO should be cleared.

The medium probability, medium severity combinations are ranked in the category 'ALARP', or 'ALARP with reduction measures'. ALARP essentially means the risk is accepted at the present level.

'ALARP with reduction measures' means risk reduction measures may be required to achieve ALARP. The risk reduction measures for this category are mainly aimed at mitigating the effects. This can be achieved by e.g. procedural measures, applying shrapnel protection, etc.

The low probability, low severity combinations are ranked in the category 'Acceptable'. This indicates the risk of an event is not high enough to legitimize mitigation measures, or that the risk is sufficiently controlled. No action is usually taken for this category.

## 11.2 RISK ASSESSMENT RESULTS NEDERWIEK WIND FARM ZONE

Table 22 shows the UXO risks within the Nederwiek WFZ prior to mitigation measures. The resulting risk for each source item is a function of the 'Likelihood of Occurrence' and the 'Hazard Severity'. The 'Likelihood of Occurrence' is the product of the 'Likelihood of Presence' and the likelihood of initiation of an item of UXO. The values assigned to each factor in the risk calculation are subjective and based on many variables, which themselves are difficult or impossible to quantify. Data for a statistical analysis is not available. Therefore, risk calculation results must be treated with caution and an understanding of their origin.

RISK ASSESSMENT RESULTS							
Nederwiek WFZ							
Source	Likelihood of presence	Pathway	Receptor	Type of encounter	Likelihood of occurrence	Hazard severity	Risk result
Small calibre munition	Remote	Touch	Personnel Equipment	Primary	1 = Very unlikely	1 = Negligible	1 = LOW
Anti-ship bombs	Remote	Touch	Personnel Equipment	Primary	1 = Very unlikely	5 = Very High	5 = LOW/MODERATE
Artillery shells	Remote	Touch	Personnel Equipment	Primary	2 = Unlikely	1 = Negligible	1 = LOW
Torpedoes	Feasible	Touch, Movement, Magnetism	Personnel Equipment	Primary Secondary	3 = Possible	5 = Very High	15 = HIGH
Naval mines (WW1)	Probable	Touch, Movement, Magnetism	Personnel Equipment	Primary Secondary	3 = Possible	5 = Very High	15 = HIGH
Naval mines (WW2)	Probable	Touch, Movement, Magnetism	Personnel Equipment	Primary Secondary	3 = Possible	5 = Very High	15 = HIGH
Allied aerial bombs	Probable	Touch, Movement, Vibrations	Personnel Equipment	Primary Secondary	3 = Possible	5 = Very High	15 = HIGH

Table 22: Risk assessment results for the Nederwiek WFZ.

The purpose of the SQRA risk calculation at this stage is only to produce a relative order of merit to provide input for the eventual Risk Mitigation Strategy. Nevertheless, despite its limitations, the risk assessment matrix as currently used is suitable for adequately assessing and grading risks with regards to UXO is an established tool for assessing project risk tolerability.

It is advised that sources with a low to low/moderate risk result require no further mitigation measures. Small calibre munition, artillery shells and anti-ship bombs have been determined to have a remote presence. There is enough evidence to support that torpedoes, naval mines and aerial bombs are present within the wind farm zone. Combined with the hazard severity these pose a risk that is considered unacceptable by REASeuro and it is advised that mitigation measures should be taken to reduce the risk that these types of UXO pose to intrusive activities within the Wind Farm Zone.

## 12 OUTLINING THE UXO MITIGATION STRATEGY

In strategic terms, the UXO risk on the project can either be:

- Accepted by all parties and no further proactive action is taken.
- Mitigated with measures to contain, and/or eliminate the UXO risks.
- Carried with the balance of any residual risk transparently exposed to those parties involved with site operations.

Although mitigation is generally the safest option for dealing with UXO risks, a balanced blend of the options is usually required to comply with best practice. This desk-based study and risk assessment has shown that the risk from UXO to the proposed operations are 'Low', 'Moderate' or 'High'. Mitigation is required to reduce the 'Moderate' and 'High' risks to ALARP. All operations with a 'Low' risk level do not require mitigation measures. It is recommended to accept the residual risk and conduct the operations as planned.

### 12.1 AIM OF THE RECOMMENDED UXO RISK MANAGEMENT STRATEGY

Research for this study has established that there is a UXO hazard as the following three components are present:

- Source – a UXO hazard that exists,
- Pathway – a mechanism that may cause UXO to detonate,
- Receptors – these would be at risk of experiencing an adverse response following the detonation of a UXO.

The purpose of hazard mitigation is to take action to address one or more of these components to reduce the probability of the problem occurring or to limit the impact of the problem if it does occur. Thereby eliminating the hazard or reducing the hazards to an acceptable level. When considering the hazards associated with UXO the most logical approach is to employ measures to reduce the probability of an event occurring. For the Nederwiek WFZ this is best achieved by addressing the source of the hazard.

The primary aim of the recommended UXO risk management strategy is to reduce the health and safety (H&S) risk to personnel to ALARP. The objectives of the mitigation strategy, are:

- Ensure it is technically robust within the bounds of available technology,
- Take account of the potential for buried UXO,
- Provide a solution that is pragmatic and at best value to the future developer.

### 12.2 METHODOLOGY

The conducted historical research has shown that several calibres of aerial bombs, torpedoes, naval mines and anti-ship bombs could be present within the investigation area. The possible effects of a detonation on vessels, equipment, personnel, and surroundings may form an intolerable risk. This means mitigation measures are required to reduce the risks to a level considered as low as reasonably practicable (ALARP) by REASeuro. It is recommended to address the source of the hazard by performing a UXO geophysical survey prior to any intrusive works.

The mitigation measures consist of UXO survey, identification of potential UXO objects and disposal of actual UXO objects.

## 13 UXO SURVEY METHODOLOGIES

The conducted historical research and this additional historical research has shown that several types of UXO could be present within the entire Nederwiek Wind Farm Zone. Due to the types and sizes of UXO likely to be present a few options are available for the UXO geophysical survey.

In order to reduce the risk to ALARP, a dedicated UXO geophysical survey must be carried out to identify objects on the seabed that could potentially be UXO. This chapter briefly considers the types of technology that may be used in such a survey and the key issues that should be considered during the planning phase. Following the survey, data interpretation, contact avoidance and contact investigation/disposal (where avoidance is not feasible) should be the sequential phases of UXO mitigation prior to wind farm development.

UXO survey techniques that might be considered for the Nederwiek WFZ are as follows:

- Magnetometry (MAG);
- Electromagnetic (EM);
- Side scan sonar (SSS);
- Multibeam echo sounding (MBES);
- Seismic sub bottom profiling (SBP).

There are a number of other technologies available to profile the seabed but are yet considered to be either unproven in the commercial sector or employed by the military and cost-prohibitive.

### 13.1 MAGNETOMETRY

Magnetometry is generally considered the most reliable and common method of UXO geophysical survey. The method relies upon the UXO causing a spatial variation in the Earth's magnetic field. Since the majority of WWI and WWII munitions were constructed from iron or steel and were relatively large, this technology is seen as a prime methodology for offshore UXO detection. Either gradiometers or total field sensors can be used. The aim is to detect and interpret objects that meet the determined threshold criteria to the required depth below the seabed (burial depth or depth of the intrusive activities). Large ferrous objects (e.g. large calibres air dropped bombs or a ferrous ground mine) can be detected up to 5 m distance to the MAG sensors, dependent on the type of sensors and the condition of the UXO, e.g. the metal body of moored mines can be corroded for more than 50% and all hazardous components still intact.

#### 13.1.1 Gradiometers

Vertical gradiometers (such as fluxgate magnetometers) require careful vertical alignment. To have good gradiometer data, the system must be stable, with all the sensors keeping their position on the respective axis. This is why gradiometers are usually deployed from a stable platform such as a Remotely Operated Vehicle (ROV). The gradiometer determines the gradient of the "Z component" of the Earth's magnetic field. Motion must be compensated for on all axes in order to be able to re-estimate the proper gradient axis, particularly roll and pitch effects. The Z axis still has to be compensated (altimeter pressure sensor for marine applications) to keep a same reference level.

Gradiometers have shown that they can offer a high degree of immunity from diurnal and external influences in the ambient magnetic field; they can enhance near-surface, small or weak magnetic anomalies; and they can provide obvious improvements in spatial resolution over the total field measurement alone.

### 13.1.2 Total field magnetometers

A total field magnetometer is a single sensor magnetometer that measures the actual magnetic field strength at any given position. The majority of towed marine magnetometers are total field systems, using either proton or caesium vapour detectors. The latter have a higher resolution and sampling rate than proton magnetometers. There are a range of types, configurations and deployment methods of magnetometer systems currently used in the market, which will incorporate different sensitivities, towing characteristics and array mountings. A determination of which configuration is "best for UXO detection" is not easily achieved from a desk-based exercise. The choice of the appropriate instruments depends on the individual site conditions and the UXO hazard in question. Implementation should be preferably in gradient setup.

## 13.2 ELECTRO MAGNETIC

Electromagnetic (EM) systems have the ability to detect all types of conductive metallic materials by observing the induced secondary electromagnetic field produced when the target is stimulated by a primary electromagnetic field. On land these systems are used for the detection of non-ferrous ordnance. However, in seawater the presence of a highly conductive media surrounding the transmitter and receiver coils can substantially reduce the effectiveness of the system. The limiting factors imposed by saline conditions however can be solved by some technological modifications to the system. With these modifications large UXO items can be detected up to approximately 2-4 m distance from the coils.

## 13.3 SIDE SCAN SONAR

Side scan sonar, when used for UXO detection, is a proven and capable remote sensing tool. The low grazing angle of the side scan sonar beam over the target and sea floor results in distinctive shadows being cast behind objects proud of the seabed. For relatively flat and featureless terrain, high resolution side scan sonar will allow the discrimination and identification of large UXO items proud of the seabed. However, the more irregular the seabed morphology as present in the Nederwiek WFZ, the more difficult it becomes to identify man-made debris. Partial burial of objects, short wavelength bedform fields (ripples/mega ripples) and heavy concretion on UXO may also make identification difficult. For detection of relatively small UXO, such as bombs and projectiles, where conditions are suitable a high frequency side scan sonar should be employed; typically, a dual frequency tow fish with a minimum frequency of 500 KHz (nominal value) for UXO identification. The swath width should be set to ensure always 200% data coverage, with the side scan sonar profiles being run in two mutually perpendicular directions to ensure that any targets are illuminated by the sonar from two directions. This technology will ensure that large UXO items (if present) are detected if the seabed conditions are suitable, and the objects are on the seabed or partly buried. SSS on its own is not considered to be a reliable system to mitigate the risks of the presence of large UXO items. This system should always be combined with other survey techniques, for example MAG and EM survey.

## 13.4 MULTIBEAM ECHO SOUNDER (MBES)

MBES, unlike side scan sonars, have their transducers rigidly mounted to the hull of the survey vessel, eliminating almost all chances of casting shadows. Using MBES for object detection requires a focus on the resultant bathymetry rather than shadows. The resolution of a multibeam echo sounding system in shallow coastal waters is such that gridding of data at the 0.2 m bin is required for the detection of potential UXO on the seabed.

The results of a high resolution multibeam bathymetric survey can provide very useful information to assist with the interpretation of side scan sonar imagery, in particular providing improved accuracy for coordinates of targets. However, as an acoustic system, the efficacy of MBES for discriminating targets is also degraded in uneven seabed environments.

MBES on its own is not considered to be a reliable system to mitigate the risks of the presence of large UXO items. This system should always be combined with other survey techniques, for example MAG and EM survey.

### 13.5 SEISMIC (SUB BOTTOM PROFILING)

Seismic sub bottom profiling systems are commonly used for geological profiling but can locate and determine the burial depths of pipelines. Pipeline detection systems rely on wide beam width systems, usually pingers, to produce diagnostic hyperbolic reflections from pipeline structures. High resolution, narrow beam systems such as parametric sources produce very small search footprints on the seabed, which therefore requires greater line density to detect small targets such as UXO. Reflections from features are created by sharp changes in acoustic impedance (product of acoustic velocity and density); metallic objects provide a very strong contrast in acoustic impedance when buried in sediments. Despite this theory, in reality, discrimination between geological and manmade features is difficult when interpreting seismic information. Recent advances in 3D chirp technology have made SBP a much more effective tool in UXO detection. With SBP it is possible to detect large UXO items that are on the seabed or partly buried but SBP on its own is not considered to be a reliable system to mitigate the risks of the presence of large UXO items. This system should always be combined with other survey techniques, for example MAG and EM survey.

### 13.6 COMPARISON OF SURVEY TECHNIQUES

In Table 23 a comparison of the survey techniques explained in the previous paragraphs is provided. The strengths and limitations of the different techniques are given. In general, magnetometry is the most suitable technique for detecting ferrous UXO. In order to enhance the data evaluation, it is recommended to perform survey operations with a spectrum of survey techniques, for example MAG, SSS and MBES. To enhance the evaluation process, it is recommended to correlate the data obtained with the different survey techniques.

Method	Strengths	Limitations
Magnetometry	<ul style="list-style-type: none"> <li>Will detect ferrous UXO either buried or below the seabed (within bounds).</li> <li>Not as susceptible to weather as other methodologies.</li> <li>Ability to model the source target using the anomaly response.</li> <li>Can detect larger ferrous objects at deeper depths than EM methods.</li> <li>Multiple systems can be linked together in an array to enhance production rates and increase efficiency.</li> <li>Data can be analysed to estimate target size and depth.</li> </ul>	<ul style="list-style-type: none"> <li>Influenced by some geological features and manmade features.</li> <li>Small survey footprint per magnetometer.</li> <li>Will not detect non-ferrous UXO.</li> <li>Instrument response may be affected by nearby power lines and cultural features.</li> </ul>

Method	Strengths	Limitations
Electro Magnetic	<ul style="list-style-type: none"> <li>Advanced systems have multiple frequency and time gates.</li> <li>Ability to detect all types of metallic munitions (ferrous and non-ferrous).</li> <li>Additional data can provide information on target shape, orientation, and material properties.</li> <li>Multiple sensors can be linked together in an array to enhance production rates and increase efficiency.</li> <li>EM systems are less susceptible to cultural noise sources, such as utilities, than magnetic methods.</li> </ul>	<ul style="list-style-type: none"> <li>Smaller detection range than a magnetometer.</li> <li>Could be affected by saline conditions.</li> <li>Instrument response may be affected by nearby power lines and cultural features.</li> </ul>
Side Scan Sonar	<ul style="list-style-type: none"> <li>Large swath of data can be captured per run line.</li> <li>Side scan sonar is the most suitable tool when searching for debris lying on the seabed.</li> <li>A wide range of equipment and different frequency tow fish are commercially available.</li> <li>Likely to identify large NEQ items of UXO.</li> <li>200% coverage allows contact position to be improved.</li> </ul>	<ul style="list-style-type: none"> <li>Data quality influenced by marginal weather and water turbidity.</li> <li>If USBL positioning is compromised, then the positioning accuracy of seabed contacts may be limited.</li> <li>Length dimensions may be exaggerated by a number of reasons including tugging.</li> <li>Will not identify buried UXO.</li> <li>Difficult to distinguish between UXO and other seabed feature such as boulders.</li> </ul>
Multi Beam Echo Sounder	<ul style="list-style-type: none"> <li>Ability to identify UXO size targets on the seabed, with better accuracy than the side scan sonar.</li> <li>Positional accuracy is very good, especially as the equipment is hull mounted.</li> <li>Option of exceptionally high sounding accuracy, and a dense pattern of soundings to cover the seafloor in order to reveal small seabed features.</li> <li>In addition to the soundings, the multibeam echo sounders produce seabed image data similar to a side scan sonar image (backscatter).</li> </ul>	<ul style="list-style-type: none"> <li>Will not detect buried UXO.</li> <li>A multibeam system can produce excellent results in this application only when positioned very close to the seabed.</li> <li>The option to use echo sounder backscatter data analysis to characterise the seabed is complex and not commonly used for UXO identification.</li> <li>Discrimination performance is degraded in rocky, uneven seabed conditions.</li> </ul>
Seismic Sub Bottom Profiling	<ul style="list-style-type: none"> <li>Potential to detect buried UXO.</li> <li>Option for LMB threat.</li> </ul>	<ul style="list-style-type: none"> <li>Small survey footprint.</li> <li>Difficult to discriminate between manmade and geological features.</li> </ul>

Table 23: Comparison of survey techniques.

For a dedicated advice regarding survey techniques to be applied for Nederwiek WFZ see chapter 14.

## 14 THRESHOLD LEVELS TO BE APPLIED

The SQRA has shown that certain types of UXO necessitate mitigation measures to reduce the risks to as low as reasonably practicable (ALARP). The mitigation measures consist of UXO survey, avoidance of significant objects<sup>36</sup>, Identification of potential UXO objects that cannot be avoided and disposal of actual UXO objects that cannot be avoided.

In order to set the scope of work for the UXO survey, appropriate threshold level(s) for modelling of anomalies detected by a UXO survey in Nederwiek WFZ need to be determined. This chapter provides the provisional thresholds needed to mitigate the risk to a level that is considered ALARP. The threshold levels needs to be reassessed based on the preliminary design and proposed installation methodologies.

### 14.1 SPECIFICATIONS OF UXO THAT REQUIRE MITIGATION MEASURES

Table 24 provides the known specifications of the UXO likely to be present that require mitigation measures.

Category	Type	Calibre	Origin	Diameter (cm)	Length (cm) (without / with tail section)	Weight (kg)	NEQ (kg) (dependent on type of charge)	Ferrous mass (kg) (dependent on main charge)
Aerial bomb	GP MK I-III	250 lbs	UK	26	70 / 140	112	28.6 / 30.8	83.5 / 81
Aerial bomb	Demolition	300 lbs	US	27.7	100 / 123.4	124	62	62
Aerial bomb	GP	500 lbs	US	36	118.4 / 150	227	120	107
Aerial bomb	GP	1.000 lbs	UK	41	133.4 / 180 or 220	486	151 / 171.5	335 / 314.5
Aerial bomb	MC	250 lbs	UK	26	70 / 133.4	102	37	50-83
Aerial bomb	MC	500 lbs	UK	32.8	94.5 or 104 / 145 or 179	226	92 / 101	124 / 125
Aerial bomb	MC	1.000 lbs	UK	45	133.4 / 183	549	215 / 238	334 / 311
Aerial bomb	HC MK I	2.000 lbs	UK	46	109 / 315	835	500	>250
Aerial bomb	HC	4.000 lbs	UK	76	189 / 279	1707	1006 / 1102	701 / 605
Aerial bomb	SAP	250 lbs	UK	23	802 / 125	111	19	92
Aerial bomb	SAP	500 lbs	UK	33.5	106 / 156	222	41	181
Aerial bomb	Fragmentation	260 lbs	US	21.5	82 / 111	118	15	103
Underwater ordnance	Moored mine EMA type IV	n.a.	GER	86 n.a.	n.a.	282	82 (Gun cotton)	200
Underwater ordnance	Moored mine type H Mk II	n.a.	UK	96.5	n.a.	318	140.6 / 145	>100
Underwater ordnance	Moored mine Vickers Elia	n.a.	UK	104	n.a.	431	227	>150
Underwater ordnance	Moored mine EMC	n.a.	GER	117	n.a.	n.a.	338.5	>150
Underwater ordnance	Moored mine EMD	n.a.	GER	100	100	631	150	480

<sup>36</sup> Objects that meet the set survey thresholds.

Category	Type	Calibre	Origin	Diameter (cm)	Length (cm) (without / with tail section)	Weight (kg)	NEQ (kg) (dependent on type of charge)	Ferrous mass (kg) (dependent on main charge)
Underwater ordnance	Moored mine Mk XIV	n.a.	UK	102	132	460/547	146/227	320
Underwater ordnance	Moored mine Mk XVII	n.a.	UK	101	122	450	147/227	223
Underwater ordnance	Moored mine Mk XX	n.a.	UK	102	132	460	145	320
Torpedo	Mk VII, Mk VIII	18 inch (45.7 cm)	UK	45.7	537	789	202 / 303	>400
Torpedo	G7e	21 inch (53.34 cm)	GER	54	716	1900	280	>1500

Table 24: Specifications of UXO possibly to be present.

## 14.2 THRESHOLD LEVELS FERROUS UXO

Taking the results of the SQRA into account, it is assessed that the 250 lb bomb is deemed by REASeuro to be the smallest ferrous threat item for an ALARP sign-off. These items are cylindrical/tear-drop in shape, made of steel and, depending on the variant, contain 28 to 37 kg of NEQ. The ferrous weight can range from 50 to 83 kg dependent on the make, modification and type of munition. Assuming these items can be successfully detected and identified within the geophysical datasets, larger objects will also be detectable. The provisional magnetometer (MAG) threshold is considered to be 50 kg ferrous mass.

It should be noted however that due to oxidation and erosion that the ferrous mass of a UXO can be significantly reduced compared to when it was originally used. It is well known that especially naval mines with their large floatation chambers have lost much of their ferrous mass over time, often exposing the main charge of the mine. Based upon the readings of the magnetometer it can be decided that a target less than 50 kg of ferrous mass needs to be investigated when sonar readings or other indications are present that it concerns a potential UXO item. The 50 kg threshold is deemed sufficient to detect most UXO that pose a risk to the project activities.



Figure 47. Example of a naval mine found in the North Sea in poor condition where its ferrous mass has been significantly reduced by erosion. The main charge chamber is exposed.

### 14.3 REQUIRED DETECTION RANGE

Based on the burial assessment it is likely that most UXO will be present until a depth of 4.7 m from the sea floor. The required detection range for UXO is this 4.7 m Main Burial Depth. When intrusive activities are planned to be less than 4.7 m than the required detection range is to the intended installation depth plus a 0.5 m safety margin.

### 14.4 AREAS TO BE SURVEYED

The size of the exclusion zones and the areas to be surveyed is dependent on the actual design, installation methodologies and geophysical parameters. The size of the areas to be surveyed needs to be determined once the (provisional) design of the wind farm and the relevant site data are available. The exact scope for the survey, identification, removal and disposal operations needs to be determined in a detailed UXO mitigation strategy.

### 14.5 VALIDATION OF GEOPHYSICAL UXO SURVEY EQUIPMENT

It is not recommended to prescribe a certain technique in the specifications for the UXO geophysical survey. The selection of the appropriate detection techniques and devices is the full responsibility of the contractor. It is mandated by the CS-000 that all detection devices used during the geophysical UXO survey are to be subjected to a thorough UXO validation. The purpose of the validation is to establish the maximum detection range limits for the specified thresholds of objects. This detection range threshold may then be used to check for achieved detection depths below seabed and/or 'coverage achieved' on completion of the data acquisition. The variables which influence the degree of coverage are primarily

sensor altitude, horizontal separation between adjacent lines, distance between the sensors and clearance requirements as specified by the wind farm zone developer.

The relevant survey parameters such as sensor altitude and line spacing can only be determined on the validation results of the actual survey equipment (combination between survey array and vessel/ROV). The survey contractor needs to assess the line spacing required based on the applicable thresholds, the required detection depth, the proposed MAG/EM system and the validation results of these systems.

#### 14.6 REGULATION AND STANDARDS

The applicable regulation on EOD-surveys by civilian enterprises in the Netherlands is the "Certificatieschema-Opsporing Ontploffbare Oorlogsresten (CS-000). According to the CS-000 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.

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

## 15 CONCLUSIONS

Based on the results of the historical research and UXO risk assessment the research questions are answered as follows:

- *Identify possible constraints for offshore wind farm related activities in the Nederwiek WFZ as a result of the presence of UXOs.*  
 Based upon the analysis of historical sources, it's evident that different war related events took place within and nearby the Investigation Area. Due to these events the entire Investigation Area is to be considered a UXO risk area. A large variety of UXO are likely to be present which include aerial bombs, naval mines and torpedoes. The likely presence of UXO in the area, however, is not a constraint for offshore wind farm development. With applying professional UXO risk management these risks can be reduced to a level that is considered As Low As Reasonably Practicable (ALARP).
- *Define specific requirements related to the presence of UXOs for any wind farm related activity that is to be carried out in the Nederwiek WFZ. And identify areas within the Nederwiek WFZ that should preferably not be used for the installation of offshore wind farms and/or cables or any other structure;*  
 Within the proposed area there are no UXO risk free areas identified, however since the entire Nederwiek WFZ is to be considered a UXO risk area and the risks posed by the presence of UXO can be sufficiently mitigated to ALARP, the entire Nederwiek WFZ can be surveyed and prepared for the installation of offshore wind farms and/or cables.
- *Identify possible requirements from UXO point of view that should be taken into account for:*

  - a. *Determining the different concession zones in the Wind Farm Zone.*
  - b. *Carrying out geophysical & geotechnical investigations.*
  - c. *Specific requirements (legal obligations, specific procedures) to be taken into account when finding UXOs.*
  - d. *Installation of wind turbine foundations.*
  - e. *Installation of cables and substations.*

The conducted historical research has shown that, amongst others, several calibres of aerial bombs, torpedoes and naval mines could be present within the investigation area. The possible effects of a detonation on vessels, equipment, personnel, and surroundings may form an intolerable risk. This means mitigation measures are required to reduce the risks to ALARP. It's recommended to address the source of the hazard by performing a UXO survey prior to any intrusive works. The mitigation measures consist of UXO survey, identification of potential UXO objects, re-routing or re-location of cables and structure if possible and disposal of UXO items if required.  
 Legal obligations and specific procedures that need to be followed when encountering a UXO will be specified in the Project Execution Plan that has to be composed before the execution of any field research.
- *Identify whether any further investigations should be carried out regarding the presence of UXOs and define the scope of these investigations, including their spatial extent and their timing within the overall site development programme – consideration of all relevant investigation methods shall be made for various stages of the project, from site investigation up to installation.*  
 To ensure a safe working environment additional Risk analysis is required when the intrusive activities (contractors' vessel specific) are determined. This analysis is likely to result in a UXO survey and ID & removal campaign to ensure an ALARP working situation.

16 ANNEXES

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## ANNEX 1 GLOSSARY TERMS

Term	Definition
<b>As low as reasonably practicable (ALARP)</b>	A risk tolerability principle that has particular connotations in Dutch and UK health and safety law. It requires a developer to reduce the risks from UXO until or unless the cost of implementing those measures is considered to be grossly disproportionate to the risk averted.
<b>CS-000</b>	The CS-000 is the Dutch branch specific certification plan for the system certificate "detection of conventional explosives". This includes guidelines, process requirements and expertise standards. Since January 1 <sup>st</sup> , 2021, the CS-000 has been the successor to the "Werkveldspecifieke certificatieschema voor het Systeemcertificaat Opsporen Conventionele Explosieven" (WSCS-OCE) and is legally anchored in the Working Conditions Act (Arbowet). In order to safeguard societal interests – health and safety in relation to work – the government has opted for a mandatory certification plan to guarantee the quality and safety of detecting conventional explosives.
<b>CS-VROO</b>	The "Certificatieschema voor Vooronderzoek en Risicoanalyse Ontplofbare Oorlogsresten" (CS-VROO) is a voluntary certification scheme set up by the Stichting VOMES (Veilig Omgaan Met Explosieve Stoffen). This certification scheme includes requirement that an organization and its reports (Historical Studies and Risk Assessments) must meet. This is to guarantee the quality of preliminary investigations and assessments into UXO. The CS-VROO relates solely to on-shore research, although certain parts can be used for off-shore research.
<b>Historical Desk Study - UXO</b>	<p>Preliminary desk study in which war related events in the 1940-1945 period (including post-war detection and clearance) are being analysed. The aim is to determine whether there can be a UXO risk area in the Investigation Area.</p> <p>The historical desk study UXO consists of:</p> <ul style="list-style-type: none"> <li>- Reports.</li> <li>- Affirmative or negative recommendation.</li> <li>- In case of an affirmative recommendation: <ul style="list-style-type: none"> <li>- Horizontal delimitation UXO-Risk area(s).</li> <li>- UXO risk map.</li> </ul> </li> </ul>
<b>Investigation Area</b>	Area of focus for the historical desk study. The Investigation Area is wider than the Investigation Area in order to get a full view of any war related events which could be relevant.
<b>Risk assessment</b>	The process of identifying potential threat and estimating the risks of harm and loss associated with that threat. A risk assessment also contains the evaluation of the acceptability of the assessed risk including the consequences of a materialised risk and identifies potential risk reduction and control measures.
<b>Risk mitigation</b>	Eliminating risk or reducing it from an identified unacceptable risk to an acceptable level.
<b>Unexploded ordnance (UXO)</b>	<ul style="list-style-type: none"> <li>- Unexploded ordnance (UXO) is explosive ordnance that has been primed fused, armed, or otherwise prepared for use and used in an armed conflict. It may have been fired, dropped, launched or projected, and should have exploded, but failed to do so.</li> <li>- For the purposes of this publication, the term UXO is used generically to also refer to explosive ordnance that has not been used during an armed conflict, which has been left behind or dumped by a party to an armed conflict, and is no longer under control of that party. Such UXO may or may not have been primed, fused, armed or otherwise prepared for use.</li> </ul>
<b>UXO Risk map</b>	Cartographic view of the UXO risk area(s).
<b>UXO Investigation (Five phases policy)</b>	<p>REASeuro developed a five phases policy: the integral total approach to UXO related issues comprised of five separate phases. This allows the client to make a well-considered decision for each phase and to plan follow-up actions with the aim of keeping the client in control of the project.</p> <p>Five phases policy:</p> <ol style="list-style-type: none"> <li>1. Historical research</li> </ol>

Term	Definition
	2. Project risk assessment 3. Project management plan 4. Execution 5. Clearance certificate and final report
<b>War related event</b>	Events that could possibly have led to the presence of UXO. Examples of war related events are: <ul style="list-style-type: none"> <li>- Aerial Bombardment</li> <li>- Artillery fire</li> <li>- Ammunition dumping or jettisoning</li> <li>- Ammunition related accidents</li> <li>- Aircraft crashes</li> </ul>
<b>Wind Farm Zone</b>	The area specified by the client in which regular work unrelated to UXO will be performed or in which a change of function will be implemented.
<b>“WSCS-OCE”</b>	The WSCS-OCE is the Dutch branch specific certification plan for the system certificate “detection of conventional explosives”. This includes guidelines, process requirements and expertise standards. Since July 1 <sup>st</sup> 2012, the WSCS-OCE has been the successor to the Assessment Directive on the Detection of Conventional Explosives (BRL-OCE) and is legally anchored in the Working Conditions Act (Arbowet). In order to safeguard societal interests – health and safety in relation to work – the government has opted for a mandatory certification plan to guarantee the quality and safety of detecting conventional explosives. The WSCS-OCE was succeeded by the CS-000 as of January 1 <sup>st</sup> , 2021.

## ANNEX 2 LITERATURE

For this research the following literary sources are consulted:

Abbreviation	Author	Title	Relevant
BEZ 1&2	Bezemer, K.W.L.	<i>Geschiedenis van de Nederlandse Koopvaardij in de Tweede Wereldoorlog</i> (2 dln.; Amsterdam).	Yes
BOW	Bowyer, C.,	<i>Coastal Command at War</i> (Surrey 1979).	No
CRO	Crossley, J.	<i>The Hidden Threat. The story of mines and minesweeping by the Royal Navy in World War I</i> (South Yorkshire 2011).	Yes
DIS	Distel, A. van e.a.	<i>De Nederlandse koopvaardij in oorlogstijd</i> (Amsterdam 2014).	No
KUR	Kurowski, F.	<i>Seekrieg aus der Luft. Die Deutsche Seeluftwaffe im Zweiten Weltkrieg</i> (Herford 1979).	No
KUT	Kutzleben, K. von, W. Schroeder en J. Brennecke	<i>Minenschiffe 1939-1945. Die geheimnisumwitterten Einsätze des Mitternachtsgeschwaders</i> (Hamburg 2002).	No
MVL	Ministerie voor Luchtvaart	<i>Coastal Command speurt, beschermt, valt aan</i> (London, z.j.).	No
MUN 1&2	Münching, L.L. von	<i>De Nederlandse koopvaardijvloot in de Tweede Wereldoorlog</i> (Amsterdam 1986).	No
NES	Nesbit, R.C.	<i>The Strike Wings. Special Anti-Shipping Squadrons 1924-45</i> (London 1995).	No
ROE	Roetering, B.,	<i>90 jaar Mijndienst: Feiten Verhalen En Anekdoten Uit Het Negentigjarig Bestaan Van De Mijndienst Van De Koninklijke Marine</i> (Z.P. 1997).	No
ROW	Rohwer, J., en G. Hümmelchen	<i>Chronik des Seekrieges 1939-1945</i> (Stuttgart 2007) via <a href="https://www.wlb-stuttgart.de/seekrieg/chronik.htm">https://www.wlb-stuttgart.de/seekrieg/chronik.htm</a> .	No
SCH	Schroeder, W, Kutzleben, K. von,	<i>Minnenschiffe. Marinekleinkampfmittel</i> (1974).	No
SRG	SonarReg, Cultural Heritage Agency of the Netherlands	<i>SonarReg ('Sonar Registratiesysteem') by Cultural Heritage Agency of the Netherlands</i>	Yes
SGLO	Studiegroep Luchtoorlog	<i>Crash database. Dutch Air War Studygroup.</i> <a href="http://www.verliesregister.studiegroepluchtoorlog.nl">http://www.verliesregister.studiegroepluchtoorlog.nl</a>	Yes
WRE	Wrecksite.eu,	<i>Chart 'Netherlands'</i> .	Yes
ZWA 1&2	Zwanenburg, G.J.,	<i>En Nooit was het Stil. Kroniek van een Luchtoorlog</i> (2 dln. & supplement; Oldemarkt).	No

Table 25: References to literature.

The annexes in this table contain the events that are considered relevant for the Investigation Area. To guarantee authenticity, the sources in Dutch and English have been quoted in their original language.

### First World War mobilization and interbellum, 1914-1939

The First World War forced the Dutch armed forces to mobilize. Coastal guns were installed to protect strategic positions on the coast. The Netherlands maintained a policy of neutrality. However, Dutch shipping took considerable damage from mine and U-boat warfare. Dozens of Dutch merchant vessels were sunk by the thousands of mines laid by the German and British navies. Large scale efforts to clear the minefields after the First World War did not succeed in clearing all these mines. The following literature is relevant for this period:

Date / year	Event	Source	Page
1914-1918	British, German and American mines laid during the war. The German minefields are in black, whereas the Allied fields are shaded. The underlined figures are numbers of Allied mines, and other figures are numbers of German mines. With their vastly greater resources, the Allies laid far more mines in the latter part of the war placing them strategically where they would effectively trap the	CRO	62

Date / year	Event	Source	Page
	<p>maximum numbers of U-boats. German mines were placed mainly close to headlands where ships would make landfalls and around the approach to major ports. From 1916 onwards, most of the German mines were laid by submarines, whereas the Allies were able to use surface ships, especially fast destroyer-minelayers, to operate close to enemy coasts. The chart gives an idea of how dangerous mine laying and minesweeping operations were as both enemy and friendly mines might be laid in the same areas.</p> <p>Hatched areas in the figure below indicate allied minefields, solid areas indicate German minefields. One minefield is shown within the Investigation Area. 240 mines were laid in this area. Further specification on the calibre of the mines is unknown.</p> 		
August 1914	<p>Tot de onbepaalde Duitse onderzeebootoorlog in februari 1917 begon, vormden mijnen de voornaamste oorzaak van onze koopvaardijverliezen. De Duitse regering deelde al in augustus 1914 mede, dat zij zich waarschijnlijk genoodzaakt zou zien mijnen te leggen voor de operatiebases der vijandelijke vlooten en voor havens waar troepen van de tegenstander zouden worden ingescheept of ontscheept. In oktober volgde een Britse bekendmaking dat een mijnenveld in een nader omschreven deel der Noordzee was gelegd, maar er bleef een geul over voor de scheepvaart. In de loop van de oorlog werden steeds meer geallieerde en Duitse mijnen gelegd in uitgestrekte delen van de zee, die beide partijen tot oorlogs- of gevaarlijke zones hadden gedeclareerd en verliezen onder de neutrale scheepvaart konden hierdoor moeilijk uitblijven.</p> <p>Er werden hoofdzakelijk verankerde mijnen gelegd die als ze van hun verankering lossloegen, onschadelijk werden. Zo hoorde het althans, maar de praktijk wees herhaaldelijk anders uit. Gedurende de oorlog spoelden ruim 6.000 mijnen alleen al op de Nederlandse kust aan, meest Engelse, namelijk 4.981 stuks (tegen 431 Duitse, 81 Franse en ruim 500 van onbekende oorsprong). Vele ervan kwamen echter toch tot ontploffing.</p> <p>Eind 1916 waren in totaal 29 Nederlandse schepen door mijnen gezonken. Ongeveer een derde deel daarvan was op mijnen gelopen door U-boot-mijnenleggers gelegd, zoals eerst vele jaren na de oorlog bleek. Hoewel navigatorisch geen eenvoudige operatie, met het kleine type onderzeeboot</p>	BEZ1	24-25

Date / year	Event	Source	Page
	hiervoor meestal gebruikt, wisten de Duitse onderzeebootcommandanten bijzonder nauwkeurig, in aansluitende vakken, mijnevelden te leggen.		
2 November 1914	Op 2 november 1914 had Engeland de gehele Noordzee tot oorlogsgebied verklaard. Het overschrijden van een lijn, lopend van de noordpunt der Hebriden tot IJsland, werd ontraden in termen die met een verbod gelijk stonden, met de bedoeling de neutrale scheepvaart te dwingen de weg door Het Kanaal te nemen.	BEZ1	18
6 May 1915	Shipwreck 'FV Don' Cause lost: mine Latitude: 53°16'N Longitude: 02°50'E Remarks: DON FV was a British registered fishing vessl that was sunk by a mine on the SWarte Bank when 100 miles E by S of Spurn Head.	WRE	-
25 December 1915	Shipwreck 'SS Rigi' Cause lost: mine Latitude: 53°28'N Longitude: 03°30'E Remarks: Built by Nylands Verksted, Kristiania (#217); 1912 grt, 1164 nrt, 3090 dwt. 275.3 x 42.1 x 18.3; triple expansion engine (Nyland), 263 nhp, 1200 ihp  On December 25th, 1915, the Norwegian cargo ship SS RIGI, owned at the time of her loss by Camillo Eitzen & Co., Oslo, was on a voyage from Charleston Sc to Göteborg with a cargo of oilcake, when she was lost on a mine, 47 miles northwest from Texel.	WRE	-
5 May 1917	Shipwreck 'FV Simon' Cause lost: gunfire - shelled Latitude: 53°31'N Longitude: 03°40'E Remarks: Simon, built by Edward Bros., North Shields in 1898 and owned at the time of her loss by Maatschappij Hoek van Holland, Gravenzande, was a Dutch trawler of 150 tons.  On May 5th, 1917, Simon was sunk by gunfire by the German submarine UC-71 (Hugo Thielmann), off the Terschelling Light Vessel. 11 persons were lost.	WRE	-
1918	Shipwreck 'U-97 (Mittel U-class)' Cause lost: foundered Latitude: 53°28,34'N Longitude: 03°23,72'E Remarks: German submarine U-97 sank by accident in the North Sea while on passage to surrender.	WRE	-
After 1918	Later when hostilities were over, it was possible to use drifters by themselves to sweep shallow fields near the Dutch and Belgian coasts where the water was very shallow and even mines sitting on the bottom were a danger. These all had to be painstakingly trawled up and exploded. There was also the dangerous job of exploding the many mines that became washed up on shore. This work was undertaken by a small flotilla of drifters based on Ostend.	CRO	154
1918	Mines, of course, remain deadly irrespective of peace treaties or armistices. No fewer than 240,000 mines were scattered about the seas, some in their original position, some having dragged their moorings and settled in a new location, and some drifting freely. These constituted a major danger to shipping after the end of the war. To clear them up an international committee was formed, which included most belligerent and neutral countries, and was eventually joined by the defeated powers. This was called the International Mine Clearance Committee (IMCC) and was organized principally by the Royal Navy. All members carried out	CRO	149-160

Date / year	Event	Source	Page
	<p>mine clearance activities and reported regularly to the IMCC, who issued regular charts and updates showing safe areas and known danger zones.</p> <p>The main part of the clearance work was divided between the maritime nations, Germany being responsible for sweeping Heligoland Bight, France the waters off the French and Belgian coasts, America the Northern Barrage and the UK, most of the rest, working through a new organization called the Mine Clearance Service. The service was manned mainly by Royal Navy personnel and fishermen and consisted of 14,500 men and 700 officers at its peak.</p> <p>A particular danger when clearing dense fields was what was known as 'counter mining'. This occurred when exploding one mine would set off others in the vicinity – possibly dangerously close to the sweeper involved.</p> <p>Normally, deep minefields were left until last, as they did not constitute a serious danger to shipping, but sometimes some of the mines were laid incorrectly and finished up close to the surface. It was determined to skim of any of these shallow mines first, and the sweep began in the normal way.</p> <p>The intensive mining of the eastern North Sea also affected the German Navy to such an extent that it could not even undertake exercises safely, the British offensive mining campaign contributed to the collapse of fleet discipline and hence to the popular revolt against the Kaiser's government, which resulted in the Armistice.</p>		

Table 26: Overview of events World War 1 – Interbellum.

#### Mobilisation and German invasion, 1939-1940

When the inevitability of the Second World War became clear in August 1939, the Dutch army once again mobilized to prepare for an imminent attack. While serious naval threats were not foreseen, preparations also took place on the coast and the sea. Coastal guns were once again installed, and vital waterways were mined.

In the morning of May the 10<sup>th</sup>, 1940, the German army invaded the Netherlands. One of the first steps of the German military was to mine the Dutch ports. Major clashes between naval forces did not take place however.

#### The occupation, May 1940 – June 1944 (D-Day)

Occupation followed the capitulation of the Dutch army. The North Sea became the frontline between Great-Britain and occupied mainland Europe. Fast attack craft from the Royal Navy coastal forces attacked German shipping close to the coast and laid mines to further hamper German navigation of the North Sea. Patrolling allied aircraft attacked convoys, submarines and surface vessels with all possible means, while heavy bombers dropped even more mines in the waters around The Netherlands. To make matters worse, thousands of aircraft flew over the North Sea on route to targets in Germany, jettisoning their bombs in the sea when they encountered German fighters.

Date / year	Event	Source	Page
1 September 1940	<p>Shipwreck 'HMS Ivanhoe (D16)'</p> <p>Cause lost: mine</p> <p>Latitude: 53°30'N</p> <p>Longitude: 03°30'E</p> <p>Remarks: Damaged by mine in German minefield when attempting to assist HMS Express, which had also been damaged. After an attempt to proceed to the W, stern first, was abandoned by crew about 12 hours later and left adrift with every expectation she would sink within 30 min. Vessel was sighted still afloat but listing heavily some 3 hours after being abandoned and was sunk by a torpedo fired by HMS Kelvin.</p>	WRE	-
11/12 June 1941	<p>Shipwreck 'Vickers Wellington Ic W5666'</p> <p>Cause lost: air plane crash</p> <p>Latitude: 53°06,898'N</p> <p>Longitude: 03°12,004'E</p> <p>Remarks: On 11/12 June 1941, a British Wellington Ic W5666 crashed in the North Sea, 100 km west from Texel. The bomber was on her way from SWinderby to Düsseldorf. There were no casualties among the Polish crew, all became POW.</p>	WRE	-

Date / year	Event	Source	Page
	A Vickers Wellington Ic (Serial W5666) from 300 Squadron crashed due to Flak damage on 3.20 hrs. It was ditched in the North Sea 100 km west of Texel.	SGLO	T1052
12/13 June 1941	A Handley Page Hampden I AE127 (44 Squadron) crashed in the North Sea 100 km west of Texel due to engine troubles.	SGLO	T1054A
	Shipwreck 'Handley Page Hampden I AE127' Cause lost: air plane crash Latitude: 53°05,118'N Longitude: 03°19,235'E Remarks: On 13 June 1941, the British Hampden I AE127 crashed in the North Sea, 100 km west from Texel. The aircraft had departed from Waddington and targeted Soest. 1 crew member died.	WRE	-
28/29 December 1941	A Vickers Wellington Ic T2553 (311 Squadron) was hit by flak over Wilhelmshaven and was ditched in the North Sea 100 km west of Petten.	SGLO	T1369
1942	In het vroege voorjaar van 1942 hadden de Engelsen hun achterstand op de Duitsers echter ingehaald, waarna er hevige aanvallen op de langs de kust varende konvoeien werden uitgevoerd. Omstreeks diezelfde tijd startte Bomber Command van de Royal Air Force (RAF) met het leggen van een groot aantal mijnen. Alleen al in het eerste half jaar van 1942 werden door vliegtuigen meer dan 4000 mijnen van allerlei typen (magnetische- en akoestische) in de scheepvaartroute langs de Nederlandse kust gedeponeerd. De Duitsers waren daardoor gedwongen de mijnenrijke route tussen de bekende mijnenvelden voor elk konvoi opnieuw te vegen. Ook de Duitse E-boten, die dikwijls ter bescherming van konvoeien meevoeren, werden met mijnenveegtuigen uitgerust. Bovendien werd verwacht dat de begeleidende schepen de steeds op de loer liggende Britse motortorpedoboten – die dikwijls gelijktijdig met MGB's (motorgunboats) opereerden – zouden bestrijden.	BUR	120
11 April 1942	Coastal Command: Om 20.15 uur zes Hudsons uitgestuurd voor een aanval op een konvoi van acht schepen NW van Texel en een ander, van zestien schepen (tien van 5 tot 6000 ton en 1 tot 2000 ton) 7 km noorderlijker dan het eerste. Beide konvoeien, varend op een NO-koers, waren om 16.57 uur door een Beaufighter gerapporteerd. Ze werden niet gevonden maar één Hudson deed 80 km ten westen van Texel, een aanval op een ander konvoi van vijf tot acht schepen, waarbij de bommen werden afgeworpen op één van de laatste schepen. Wegens de hevige flak kon geen resultaat worden waargenomen, maar de schutter zag een lichtflits die een bominslag op het schip kon zijn.	ZWA1	344
29 October 1942	A Vickers Wellington III (115 Squadron) crashed into the North Sea 80-120 km west of Katwijk due to being shot down by a German fighter plane.	SGLO	T1892
23-24 October 1943	Shipwreck 'S-74' Cause lost: gunfire - shelled Latitude: 53°08'N Longitude: 03°25'E Remarks: On October 23rd-24th, 1943, a torpedo operation of the 2nd, 4th, 6th and 8th Schnellboot Flotillas took place off Cromer. The British defence had strengthened itself continuously such that the employed 31 boats in the so called 'Stichansatz' only could sink the trawler WILLIAM STEPHEN (by S-74).  The Schnellboots encountered attacks from British destroyers, MTBs and motor launches and during these fights, S-63 (Lt. z. S. Howaldt) and S-88 (St. Ob. Strm. Rübiger) were sunk.  The commander of the 4th Flotilla (Korv. Kpt. Lützow), the commander of the S-88 and eight men were killed in action, 19 men were rescued by British, 24 men by German boats. The S-73 took three 40-mm-hits.	WRE	-

Date / year	Event	Source	Page
20 December 1943	A North American P-51 B (354 FG/353 FS) crashed 110 km east of Cromer due to engine trouble near Texel.	SGLO	T3240C
26/27 March 1944	A Handley Page Halifax III (192 Squadron) was ditched in the North Sea 100 km off Cromer.	SGLO	T3555

Table 27: Overview of events, German occupation to D-Day.

#### June (D-Day) – May 1945 (liberation)

One June 6<sup>th</sup> an allied invasion force landed in Normandy, rapidly advancing to Germany. German forces desperately attacked the allied convoys transporting vital resources for the advancing armies, forcing the British navy to aggressively patrol the shipping lanes. This situation continued until the capitulation of the German military in May 1945. For this period, no information has been found in relation to the investigation area.

#### Post-war period

Immediately after the war, the reconstruction of the Netherlands began. Defensive works, bunkers and remaining UXO were cleaned up. German prisoners of war were used to clear the thousands of minefields. For this period, the following information has been found in relation to the investigation area:

Date / year	Event	Source	Page
25 June 1947	<p>Shipwreck 'SS Sonata'</p> <p>Cause lost: mine</p> <p>Latitude: 53°34'N</p> <p>Longitude: 03°31'E</p> <p>Remarks: SONATA SS was sunk by a mine on the 25th June 1947.</p> <p>She was salvaged and repaired and became the Avra SS in 1951. In 1961 she was sold and became the Greek SS Thrasylvoulos which went missing and foundered on the 29th June 1965 in approx posn. 9.03N/56.25E with a cargo of iron ore.</p>	WRE	-
Post-war period	<p>Overview of SonarReg (<i>Sonar Registratiesystem</i>) data by the Cultural Heritage Agency of the Netherlands. The SonarReg data does not show specific information about the different wrecks.</p> 	SRG	-

### ANNEX 3 DUTCH ARCHIVES

Several Dutch archives have been consulted for this desk top study. These results are shown in this annex.

#### Nationaal Archief (NA)

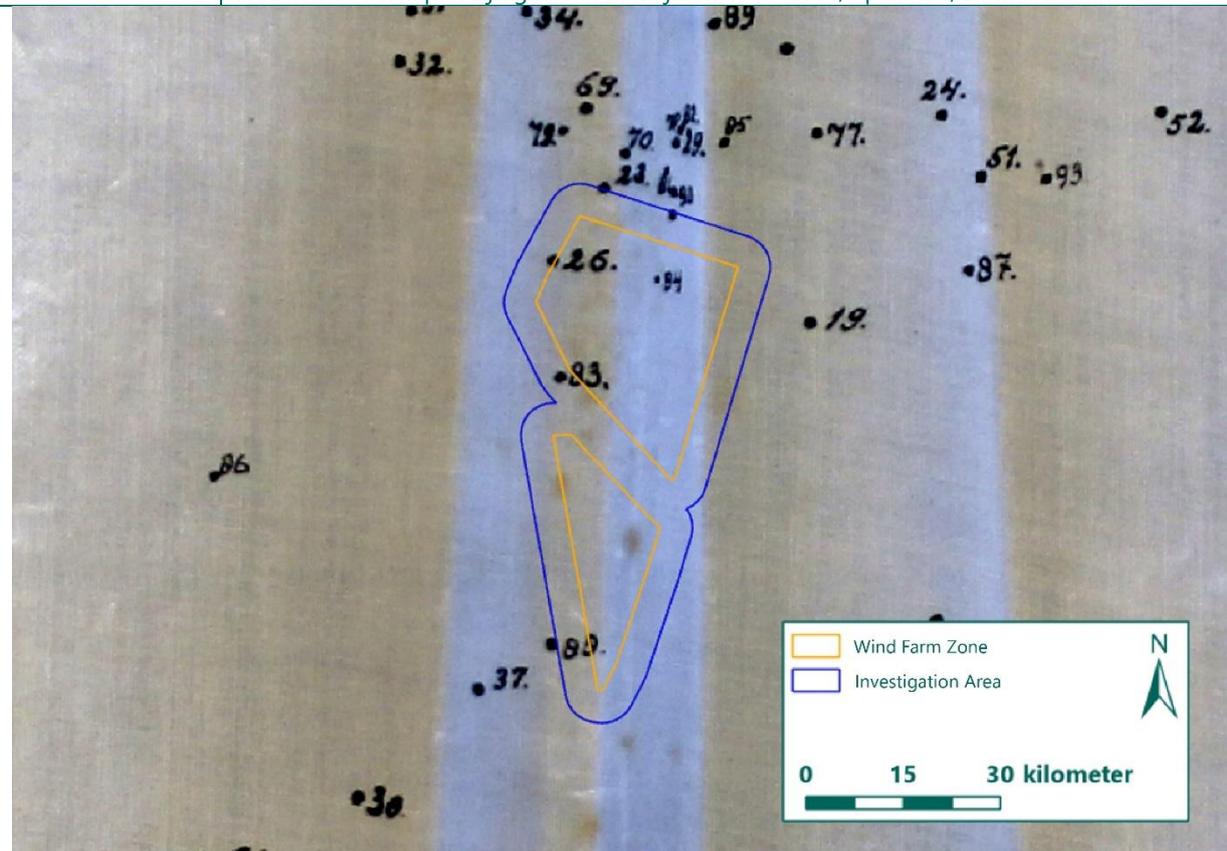
The following records have been consulted in the Nationaal Archief (National Archives):

- Toegang 2.05.32.09 BuZa/Zeeoorlogschade [*Foreign relations / naval warfare damage*]
- Toegang 2.12.18 archief van de Koninklijke Marine: Chef van de Marinestaf te 's-Gravenhage, 1886-1942 [*Chief of the Navy staff, 1886-1942*]
- Toegang 2.12.19 Marinestaf, 1945-1948 [*Navy Staff, 1945-1948*]
- Toegang 2.12.27 Marine / Tweede Wereldoorlog, 1940-1945 [*Navy during the Second World War*]
- Toegang 2.12.56 Marine na 1945 [*Navy after the Second World War*]
- Toegang 2.13.114 Marinestaf van het Ministerie van Defensie, 1948-1984 [*Navy staff of the Ministry of Defence*]

Relevant files from the record groups mentioned above are shown in the following tables:

#### Toegang 2.05.32.09 BuZa/Zeeoorlogschade

Inventaris 44	Kaart van de Noordzee met opgave van de plaatsen waar verankerde mijnen lagen, waarop Nederlandse schepen zijn gevaren in de jaren 1914-1916, op linnen, zonder datum
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Black dots indicate the locations where Dutch ships ran onto moored mines. Six black dots are visible within the and multiple near the Investigation Area. The following ships sunk due to the mines:

Number	Name of Ship	Date
19	YM 59	7-10-1915
23	YM 60	9-10-1915
26	KW 163	9-10-1915
29	KW 27	13-10-1916
37	YM 172	4-11-1915
69	KW 156	18-9-1916

70	VL 23	29-08-1916
72	YM 204	18-9-1916
81	YM 267	24-10-1916
82	YM 253	28-10-1916
83	YM 253	28-10-1916
85	MA 120	1-11-1916
88	SCH 248	7-11-1916
90	VL 155	11-11-1916
94	Trawler YN 232	25-12-1916

#### Toegang 2.12.18 archief van de Koninklijke Marine: Chef van de Marinestaf te 's-Gravenhage, 1886-1942

Inventaris 275 | Stukken betreffende het onschadelijk maken van mijnen. 1914-1940

No relevant files in this series regarding the Investigation Area.

#### Toegang 2.12.19 Marinestaf, 1945-1948

Inventaris 703 | Commandement Marine Willemsoord/Den Helder

No relevant files in this series regarding the Investigation Area.

Inventaris 723 | Hoofd Munitiedumping Sectie IX-Naval Disarmament Control Staff (NDCS)  
april - december 1946 1946, 1947.

No relevant files in this series regarding the Investigation Area.

Inventaris 823 | Stukken betreffende de mijnenrijke en niet-mijnenrijke water en voor de Nederlandse kust  
1946-1948

No relevant files in this series regarding the Investigation Area.

#### Toegang 2.12.27 Marine / Tweede Wereldoorlog, 1940-1945

Inventaris 12 | Stukken betreffende de verrichtingen van het Marine Duikbedrijf van 15 mei 1940 tot 15 mei 1942.

No relevant files in this series regarding the Investigation Area.

Inventaris 114 | Divisies hulpmijnenvegers, over 1940-1945. 1948

No relevant files in this series regarding the Investigation Area.

#### Toegang 2.12.56 Marine na 1945

Inventaris 910 | Wijziging begrenzing munitiestortplaats te IJmuiden i.v.m. herhaaldelijk opvissen van  
explosieven buiten de oorspronkelijke munitiestortplaats. 1968

No relevant files in this series regarding the Investigation Area.

Inventaris 925 | Het vergroten van de veiligheid voor de Nederlandse kust door het verbreden van de door  
mijnenvegers geveegde vaarroutes., 1948-1949.

No relevant files in this series regarding the Investigation Area.

Inventaris 946 | Onveiligheid door de aanwezigheid van mijnen voor hydrografische werkzaamheden. 1952

No relevant files in this series regarding the Investigation Area.

Inventaris 955 | Tijdig publiceren van mijnen oefeningen en het aangeven van de oefengebieden. 1957, 1960,  
1967-1972

UXO encountered in or near the Investigation Area:

Datum	Schip e.d.	Positie	Type mijn e.d. en staat waarin deze verkeerde	Juist gehandeld
3. 170167	IJmuiden 51 (Nora)	53-10 N-03-35 E	Drijvende contactmijn	Ja. ?
9. 030267	TX 2 (Willem)	52-53 N-03-05 E	vliegtuigbom 500 lbs (UK) geh. gaaf	Ja. *

Inventaris 1882 | Situatiekaarten van mijnen voor de Nederlandse kust. 1949-1950

No relevant files in this series regarding the Investigation Area.

Toegang 2.13.114: archief van de Marinestaf van het Ministerie van Defensie, 1948-1984

Inventaris 2098 | Brief van de chef van de Marinestaf aan de Secretaris Generaal betreffende explosievenonderzoek in wrakken 1950

No relevant files in this series regarding the Investigation Area.

Inventaris 5689 | Correspondentie betreffende de levensduur van magnetische grondmijnen 1959

No relevant files in this series regarding the Investigation Area.

NIMH

The following records have been consulted in the Nederlands Instituut voor Militaire Historie (Dutch Institute for Military History):

- Collectie 007. E.H. Larive (W 2426)
- Collectie 092: Marinemonografie

Files from the record groups mentioned above are shown in the following tables:

Collectie 007. E.H. Larive (W 2426)

Inventaris 20 | Nautische kaarten betreffende de locaties van de mijnevelden, lichttorens en konvoiroutes in de straat van Dover.

No relevant files in this series regarding the Investigation Area.

Collectie 092: Marinemonografie

No relevant files in this series regarding the Investigation Area.

## ANNEX 4 INTERNATIONAL ARCHIVES

Several international archives have been consulted in order to gain information on the war related events in the Investigation Area. The REASeuro database contains a large quantity of documents from the British, American and German archives. The following international archives yielded relevant documents for this desk top study:

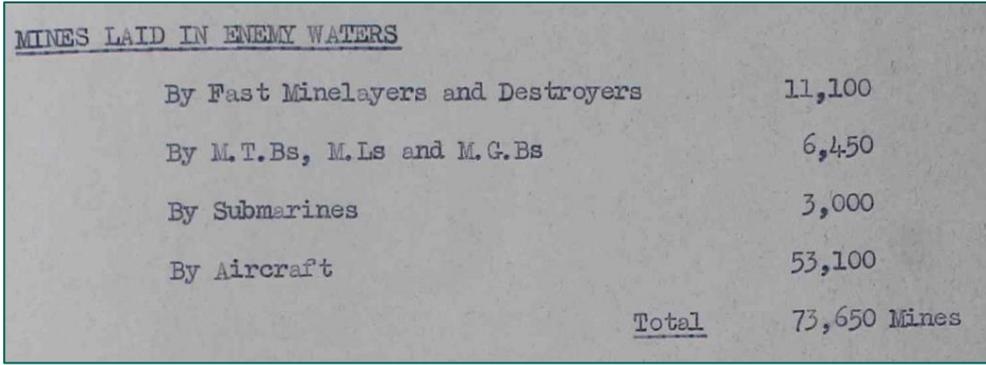
- The National Archives (TNA) in London, UK.
- National Archives and Records Administration (NARA) in College Park (MD), United States.
- Bundesarchiv-Militärarchiv (BaMa) in Freiburg, Germany.

### The National Archives

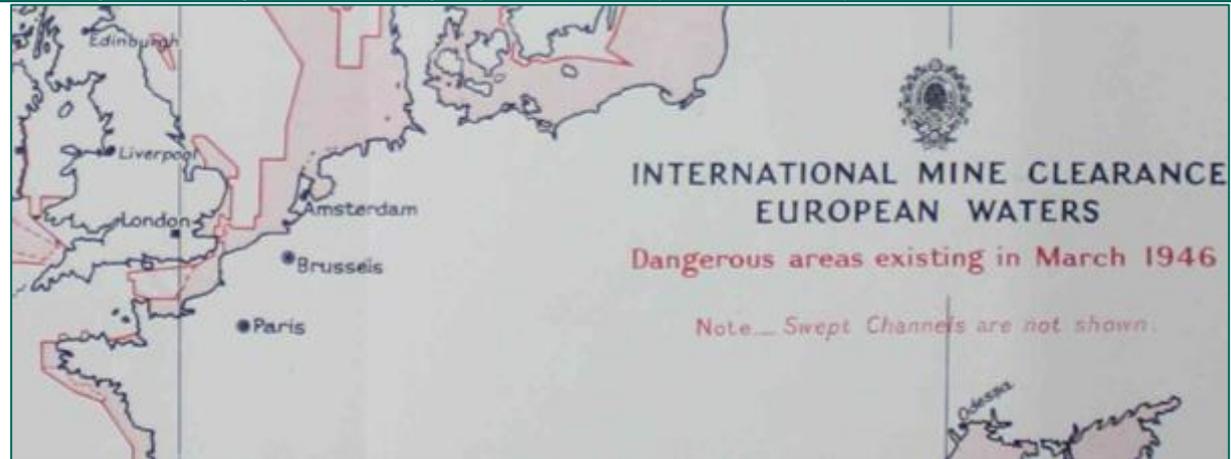
The National Archives (TNA) have been consulted for more information on maritime and aerial warfare in the Investigation Area. This annex contains relevant information from TNA. Information regarding maritime and aerial warfare is mentioned consecutively.

### Admiralty series

The admiralty series (ADM) have been consulted for information concerning wrecks, naval combat, minefields and air strikes. Consulting these series yielded several files containing relevant information. These files are shown in the tables below.

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)											
ADM 1/18996	Results of British minelaying offensive.										
General information about total amount of laid/dropped mines, 3 <sup>rd</sup> September 1939 – 5 <sup>th</sup> May 1945:											
 <table border="1"> <caption>MINES LAID IN ENEMY WATERS</caption> <tbody> <tr> <td>By Fast Minelayers and Destroyers</td> <td>11,100</td> </tr> <tr> <td>By M.T.Bs, M.Ls and M.G.Bs</td> <td>6,450</td> </tr> <tr> <td>By Submarines</td> <td>3,000</td> </tr> <tr> <td>By Aircraft</td> <td>53,100</td> </tr> <tr> <td><u>Total</u></td> <td>73,650 Mines</td> </tr> </tbody> </table>		By Fast Minelayers and Destroyers	11,100	By M.T.Bs, M.Ls and M.G.Bs	6,450	By Submarines	3,000	By Aircraft	53,100	<u>Total</u>	73,650 Mines
By Fast Minelayers and Destroyers	11,100										
By M.T.Bs, M.Ls and M.G.Bs	6,450										
By Submarines	3,000										
By Aircraft	53,100										
<u>Total</u>	73,650 Mines										
ADM 1/19745	Post-war mine clearance in European waters: first interim report of International Central Board. With charts, 1946-1947.										
Dangerous areas existing in August 1945:											
 <p>The greater part of these areas was dangerous to navigation.</p> <p><b>INTERNATIONAL MINE CLEARANCE EUROPEAN WATERS</b></p> <p>Dangerous areas existing in August 1945</p> <p>SWEPT CHANNELS ARE NOT SHOWN</p>											
Dangerous areas existing in March 1946:											

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)



ADM 1/21166	Post-war mine clearance in European waters: fourth interim report 1948-1949
No mines swept within Investigation Area.	
ADM 137/843	British Minelaying Operations, Home Waters, 1914-1915
No attacks within Investigation Area.	
ADM 137/844	British Minelaying Operations, Home Waters, 1916
No attacks within Investigation Area.	
ADM 137/845	British Minelaying Operations, Home Waters, December 1916 - September 1917
No attacks within Investigation Area.	
ADM 137/846	British and American Minelaying Operations, Home Waters, October 1917 - November 1918.
No attacks within Investigation Area.	
ADM 137/997	North Sea Operations, I 1914
No attacks within Investigation Area.	
ADM 137/998	North Sea Operations, II 1915
No attacks within Investigation Area.	
ADM 137/999	North Sea Operations, III (Commodore T.). 1914
No attacks within Investigation Area.	
ADM 137/1066	North Sea I, German Mines, 1915. 01 January 1915 - 30 June 1915
3 May 1915:	

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)

On 3<sup>rd</sup> inst.  
 British Trawler "Uxbridge" was blown up by a mine caught in her trawl in approximately 53° 43' N., 2° 59' E. This position may be several miles wrong.

8 May 1915:

British Trawler "HELLENIC" was sunk by a mine caught in her trawl in 53° 38' N., 3° 01' E. on 8th instant. The mine is believed to have been towed about 3 miles in a Westerly direction before exploding.

ADM 137/1067

North Sea II, Minesweeping, 1915. Includes 6 photographs depicting: Photographs taken from HMS Sagitta of drifting German mines. Damage to ship by exploding mine; decks and mine being hoisted on board after being rendered safe. Dated 1915.

9 – 12 May 1915:

Five mines apparently moored were sighted in 52° 48' N., 3° 21' E. on 11th inst. They are described as being freshly painted, and are of a type hitherto unknown. It is proposed to investigate the vicinity immediately vessels are available.

There have been reports from three separate trawlers of suspicious trawlers in the neighbourhood. These reports may refer to one suspicious vessel, and the suspicious vessel may turn out to be one of the Lowestoft Patrol trawlers.

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)

Lat. 53° 26' N., Long. 2° 25' E. Most of the mines in this line for the first 17 miles have been destroyed, and an attempt is now to be made to sweep straight along the whole length of it, which is thought to be about 30 miles.

The area East of G. Channel, between 53° 20' N. and 53° 43' N., and between 2° E. and 3° 10' E. has been proclaimed dangerous.

The<sup>latter</sup> were set to sweep the Northern and the Eastern sides of a triangle containing the known mine positions. The result was, mines were found very nearly in line with one another. The mean line between these mines was E.  $\frac{3}{4}$  N. from a position Lat. 53° 26' N., Long. 2° 25' E. The trawlers had swept to the West of this point and found clear for two miles.

ADM 137/1068	North Sea III, Submarines Reported, January - June 1915.
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No attacks within Investigation Area.

ADM 137/1068	North Sea IV, Attacks, January - April 1915.
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	01 January 1915 - 30 April 1915
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No attacks within Investigation Area.

ADM 137/1069	North Sea IV, Attacks, January - April 1915.
--------------	--

	01 January 1915 - 30 April 1915
--	---------------------------------

No attacks within Investigation Area.

ADM 137/1070	North Sea V, Attacks, May - June 1915.
--------------	--

	01 May 1915 - 30 June 1915
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No attacks within Investigation Area.

ADM 137/1123	North Sea: Ships Missing, Mines, etc. July - December 1915.
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	01 July 1915 - 31 December 1915
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No mines or attacks within Investigation Area.

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)

ADM 137/1551 | North Sea: Harwich Force; January-June 1918.

1 June 1918:

H.M.S. "Canterbury"		Return of Mines Sunk or Sighted.	
2nd June 1918.			
Date	Position	Description	Remarks.
June 1st.	53.28 N. 3. 7 E.	Red Spherical, cross bar on top.	Not sunk.

5 June 1918:

SHIP.	DATE.	POSITION.	DESCRIPTION ETC.	REMARKS.
HARPSHOOTER".	5/6/18.	52° 32' N. 3° 28' E.	German Naval Mine, Type IV. Four horns and centre plug. Drifting.	Sunk by machine-gun fire. One horn was observed to have been hit, but mine did not detonate.

11 June 1918:

3. At 0130, 11th June, port P.V. cut a mine in Latitude 53° 37' North, Longitude 3° 37' East. This mine was seen by "CONQUEST". No details of its appearance can be given. Nothing else was seen during the operation.

ADM 137/1552 | North Sea: Harwich Force; July-November 1918.

No mines or attacks within Investigation Area.

ADM 137/2696 | Mine Clearance reports. 1919

No specified mines encountered within Investigation Area.

ADM 137/2809 | Trade Division Records: Mines. Notices to merchant ships, fishing trawlers, etc, regarding mines, mined areas, measures to be taken in the case of floating objects, destruction of mines,

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)

forwarding fragments of mines, torpedoes, etc to the Admiralty, and other matters relating to mines, principally in the North Sea.

Mined areas in the North Sea. Chart, C.I.O., etc.

Danger from mines after declaration of peace. Arrangements for clearing the seas of mines after the war.

Special orders in force regarding dangerous areas.

German raid on East Coast, December 1914. Mines laid. Clearance of field.

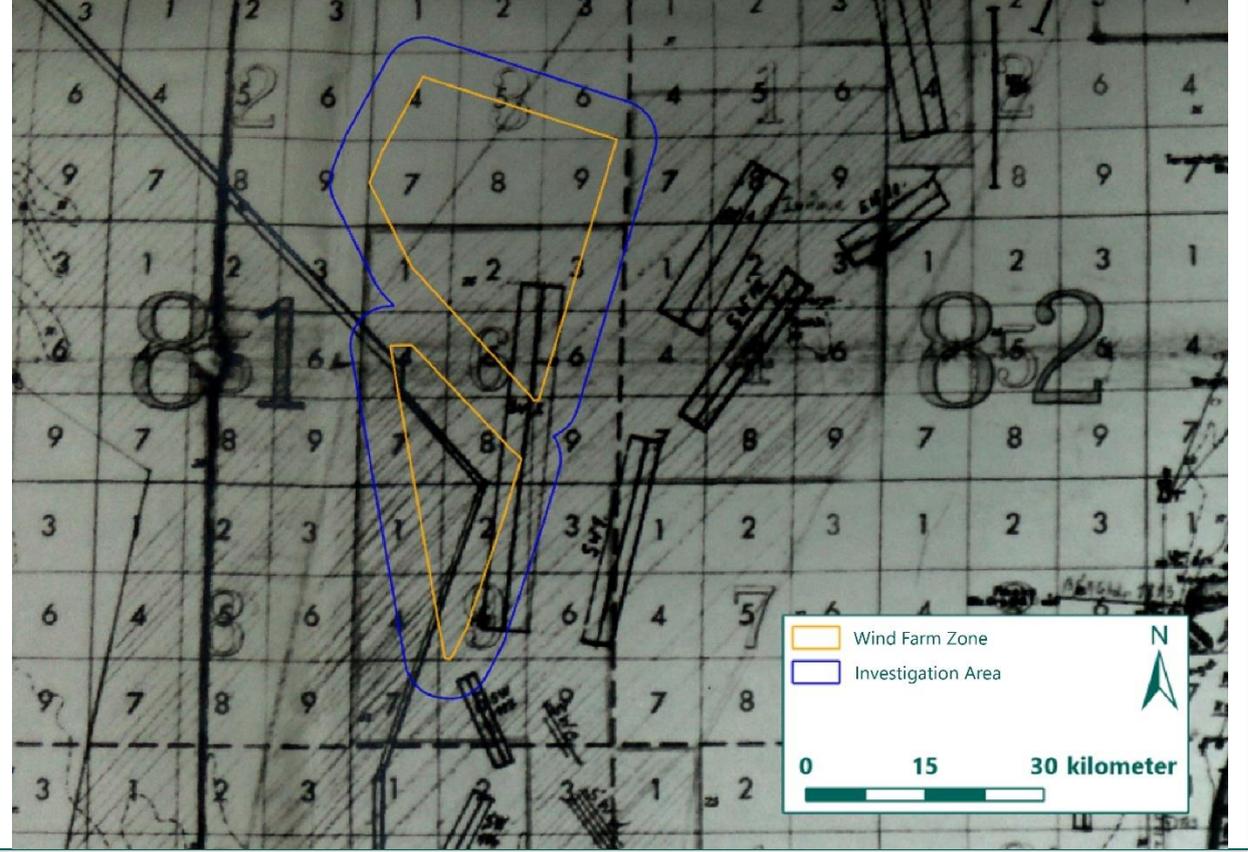
No specified mines encountered within Investigation Area.

ADM 199/153	Minelaying and minesweeping: reports 1939-1945
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No attacks within Investigation Area.

ADM 199/154	Minelaying and minesweeping: reports 1939-1945
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Map showing British Minefields, two minefields withing Investigation Area:



ADM 199/169	Enemy air attacks on HM Ships: reports 1944-1945
-------------	--

No attacks within Investigation Area.

ADM 199/253	British and Allied ships mined and ships sunk or damaged by mines: reports. 1939-1945
-------------	---

No mines within Investigation Area.

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)	
ADM 199/261	Admiralty: War History Cases and Papers, Second World War. Coastal forces actions and encounters with E-boats: reports. 1943 - 1944
No attacks within Investigation Area, mainly in French waters.	
ADM 199/262	Admiralty: War History Cases and Papers, Second World War. Coastal forces actions: reports. 1944
No attacks within Investigation Area.	
ADM 199/263	Coastal actions against destroyers and E-boats: reports 1944
No attacks within Investigation Area, mainly in French waters.	
ADM 199/264	Admiralty: War History Cases and Papers, Second World War. Coastal forces actions: reports. 1943 - 1944
No attacks within Investigation Area, mainly in French waters.	
ADM 199/265	Admiralty: War History Cases and Papers, Second World War. Coastal forces actions: reports. 1944 - 1945
No attacks within Investigation Area, mainly in French waters.	
ADM 199/266	Admiralty: War History Cases and Papers, Second World War. Coastal forces actions: reports. 1944
No attacks within Investigation Area, mainly in French waters.	
ADM 199/267	Admiralty: War History Cases and Papers, Second World War. Coastal forces actions: reports. 1944 - 1945
No attacks within Investigation Area, mainly in French waters.	
ADM 199/271	Minesweeping and minefield clearance; reports 1943-1944
No mines swept within Investigation Area.	
ADM 199/272	Minesweeping and minefield clearance; reports 1944
No mines swept within Investigation Area.	
ADM 199/273	Minesweeping and minefield clearance; reports 1943-1944
No mines swept within Investigation Area.	
ADM 199/274	Minesweeping and minefield clearance; reports 1943-1944
No mines swept within Investigation Area.	
ADM 199/542	Admiralty: War History Cases and Papers, Second World War. Laying of controlled and observation minefields: reports. 1939 - 1941
No mines laid within Investigation Area.	
ADM 199/1033	Minesweeping in home waters: reports, 1940-1943
No mines laid within Investigation Area.	
ADM 199/1034	Minesweeping in home waters: reports, 1942-1943
No mines laid within Investigation Area.	

Operation "LD" (Dummy mines in Areas 1 and 3). 6th to 13th February 1940

In order to "deter the enemy from entering the area for as long as possible" and to convince merchant traffic that the whole area had been mined, plans were drawn up by the Naval Staff, in December, for the laying of a few dummy mines along the whole length of the East Coast Barrier. The mines were to be laid irregularly in groups of 2 or 3 and visible at half tide, and the operation was planned to be carried out in three phases, by night. The first phase entailed the laying of 90 mines along the eastern edge of the northerly half of Area 1 down to the latitude of Fife Ness; in phase two 60 mines were to be laid ten miles inside the western edge of Area 1 between St Abbs Head and Newcastle; phase three was to be carried out in Area 3 with 90 mines laid along the eastern edge of the area between the latitude of Cromer Knoll and Orfordness.<sup>1</sup> In order to ensure that the mines would show at half tide, only a period of about 1½ hours either side of high water was available for laying and phases 1 and 2 were therefore split into two parts. A restriction was placed upon the laying of mines in the temporary channels established through the area for the use of fishing craft, which ran three miles either side of lines drawn:

- a. 030° from Cromer Knoll Light Vessel
- b. 080° from Bell Rock Lighthouse
- c. 090° from Girdleness Lighthouse

The PRINCESS VICTORIA, having loaded with 240 H2/VIII dummy units, sailed from Immingham at 0200 on 1st February and joined Convoy FN 83 for passage north, leaving it at the Tyne: she continued to Rosyth, escorted by the sloops FLAMINGO and WESTON, arriving a.m. on 2nd February. Bad weather delayed departure from Rosyth, but the PRINCESS VICTORIA eventually left for Aberdeen at 2130 on 5th February, escorted by the destroyers ECHO and ECLIPSE, and arrived a.m. the following day.

Operation "LD" was commenced on the night of 6th February and completed in the face of bad weather, fog and snow squalls as follows:

Night 6th/7th February	"LD1" (1st part). 48 mines laid. Escorted by the ECHO and ECLIPSE. Returned to Aberdeen on completion.
Night 9th/10th February	"LD1" (2nd part). 42 mines laid. Escorted by the EXPRESS and ESK. Returned to Rosyth on completion.
Night 10th/11th February	"LD2". 60 mines. Escorted by the EXPRESS and ESK. On completion proceeded south along swept channel.

<sup>1</sup> Area 2 was omitted as dummy mines were not laid there.

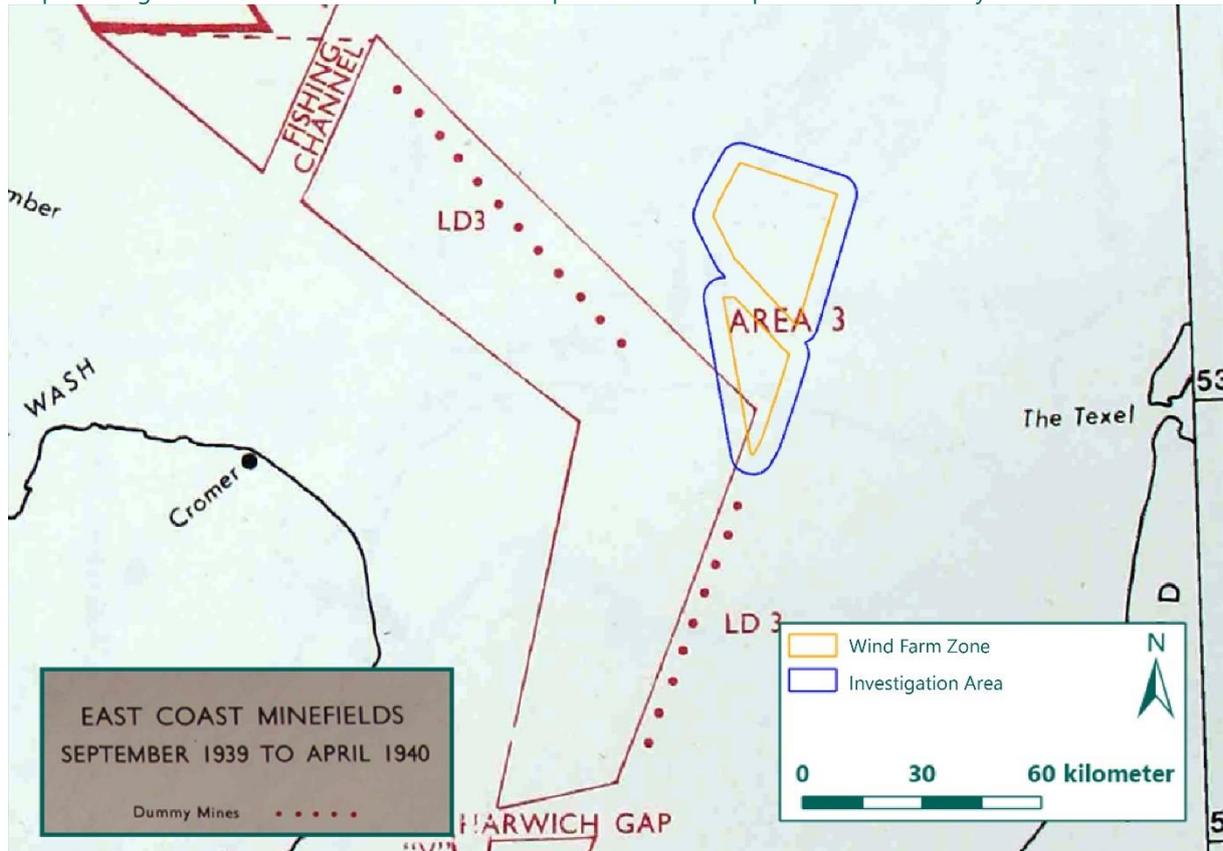
Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)

Night 11th/12th February "LD3" (1st part). 52 mines. Escorted by the EXPRESS and ESK. Anchored in Yarmouth Roads.

Night 12th/13th February "LD3" (2nd part). 38 mines. Escorted by the EXPRESS and ESK. On completion the PRINCESS VICTORIA proceeded to the Thames for docking.

ADM 234/561 | British mining operations 1939-1945: Vol 2.

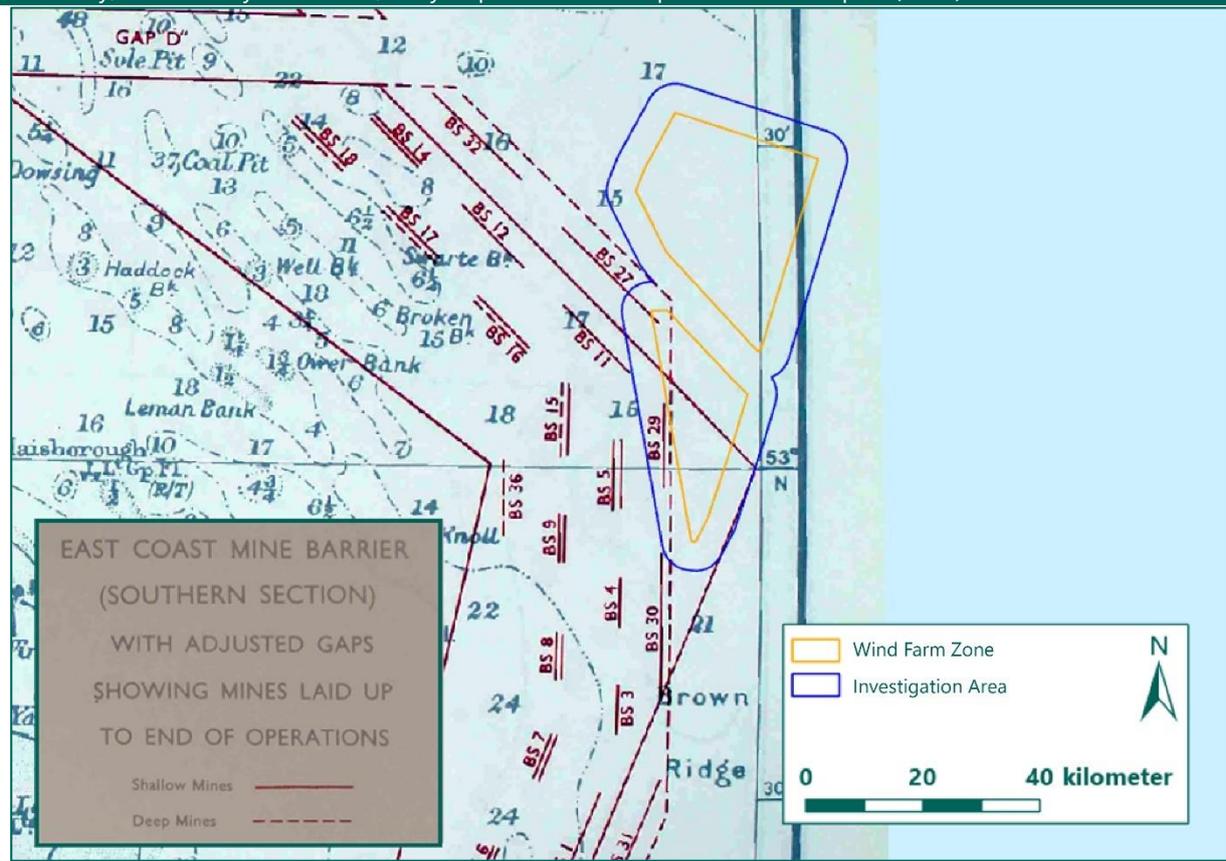
Map showing: British East Coast Minefields from September 1939 to April 1940 with Dummy Mines.



- LD 3: 90 Dummy-mines – 11/13 February 1940

Map showing: British East Coast Minefields 1940 with names of minefields.

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)



Minefields in or near Investigation Area:

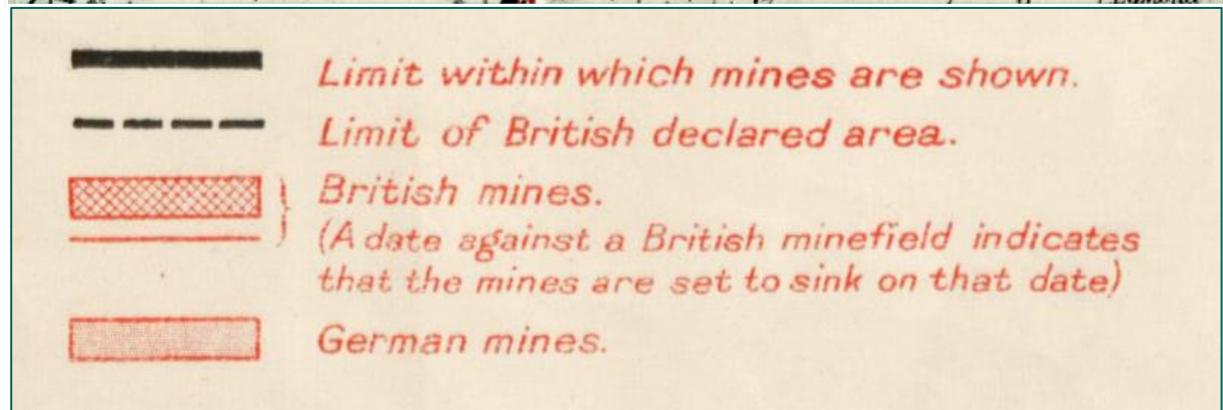
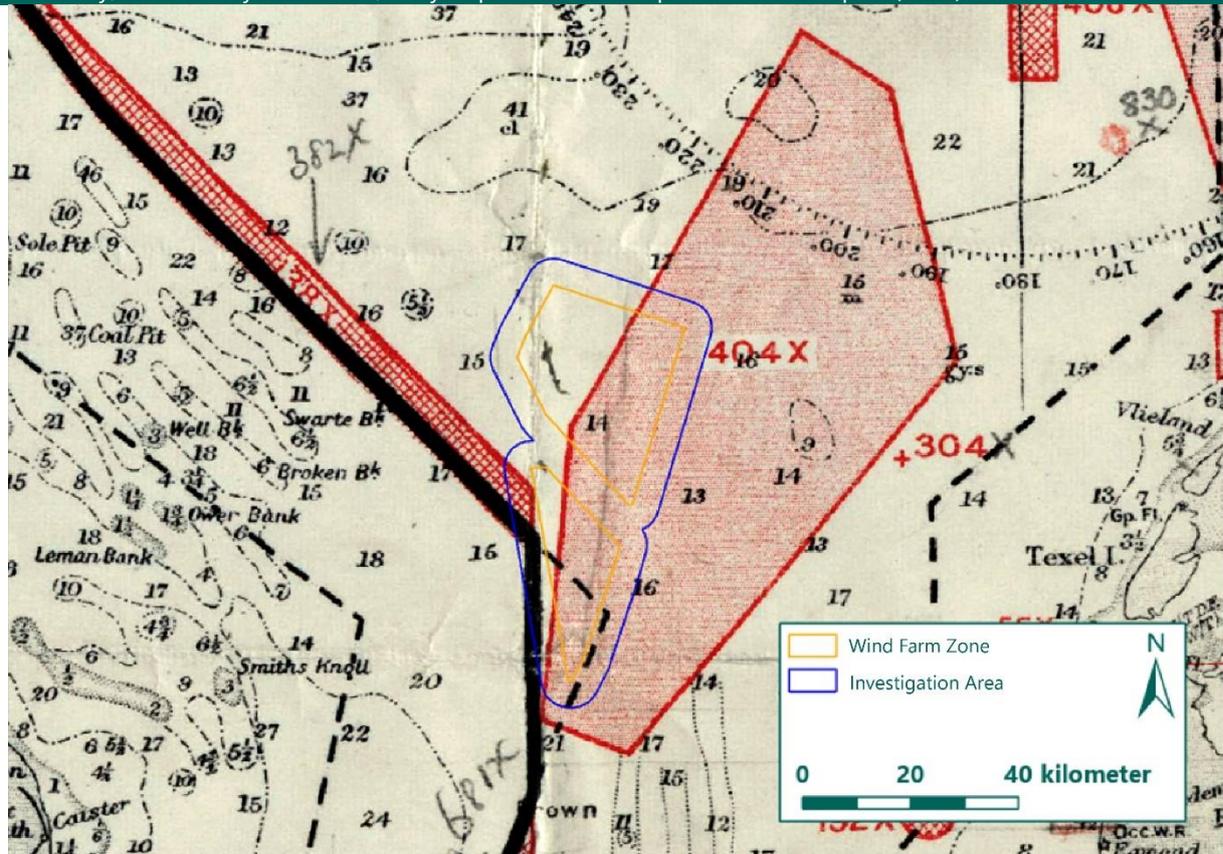
- BS 5: 540 Mk XIV/XVII mines – 18 May 1940
- BS 11: 340 Mk XIV/XVII – 6 June 1940
- BS 27: 250 Mk XX/XVII – 24 July 1940
- BS 29: 164 Mk XX/XVII – 30 July 1940
- BS 30: 300 Mk XX/XVII – 2 August 1940

ADM 239/304 | North Sea: chart 736 showing position of British and German minefields. 1941

Relevant information:

- British map showing German and British minefields:

Admiralty, and Ministry of Defence, Navy Department: Correspondence and Papers (ADM)



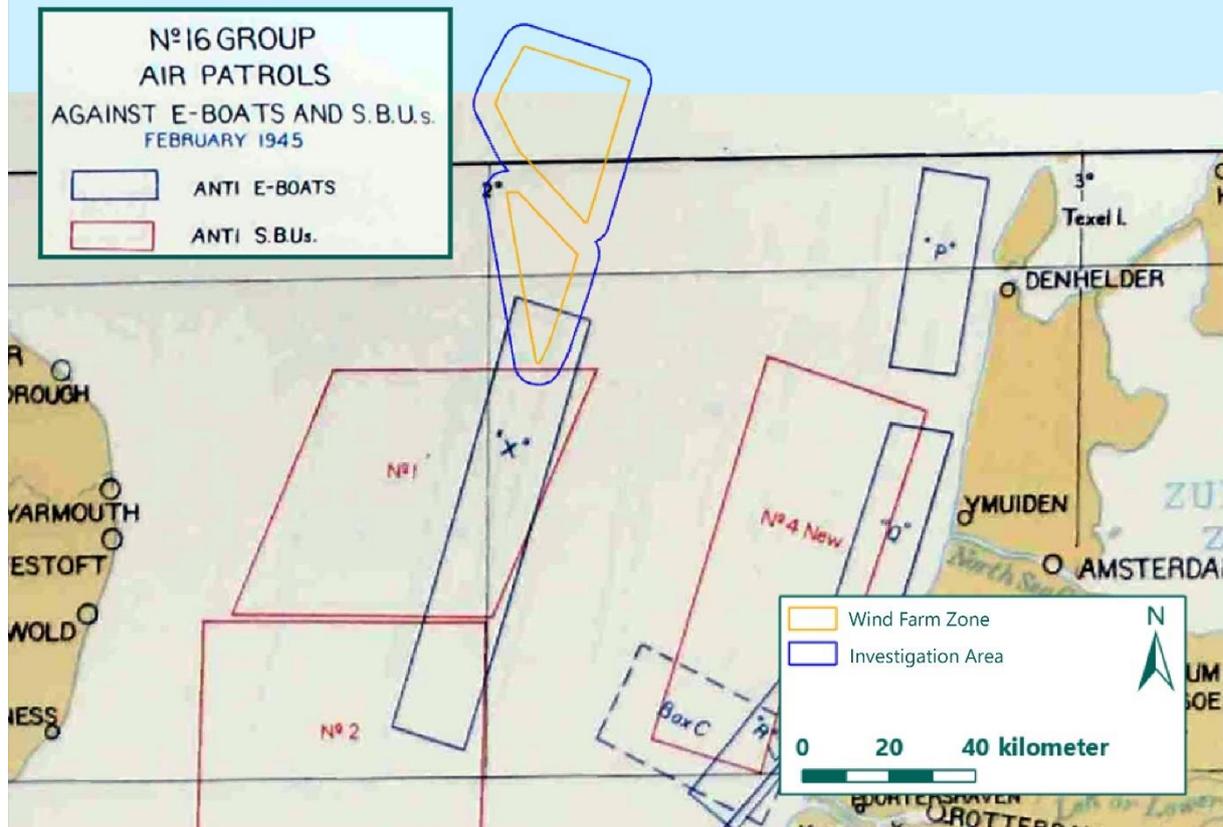
Cabinet and its committees (CAB)

CAB 101/324 | Air Offensive Against Enemy Shipping and Bomber Command Minelaying Operations, 1 September 1944 - 5 May 1945

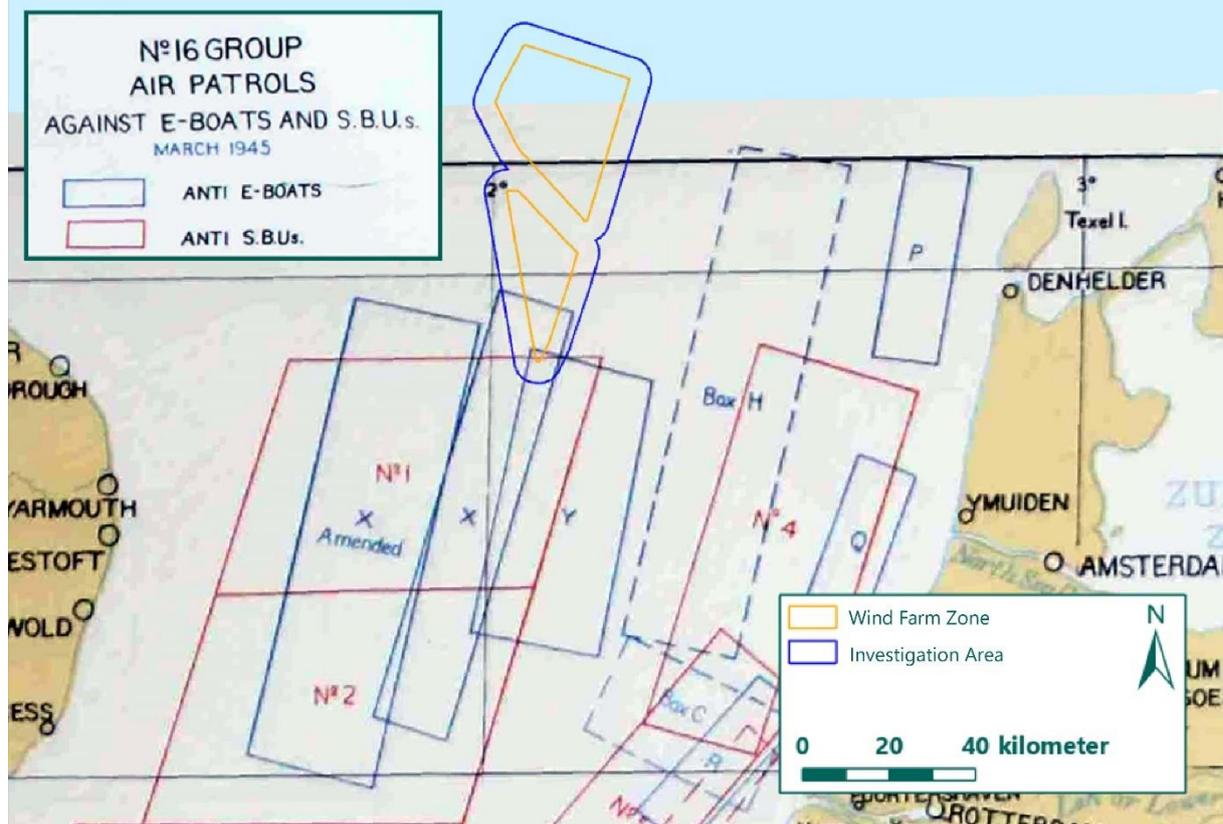
Maps showing air operations against German E-Boats and small submarines 1945:

February 1945:

Cabinet and its committees (CAB)

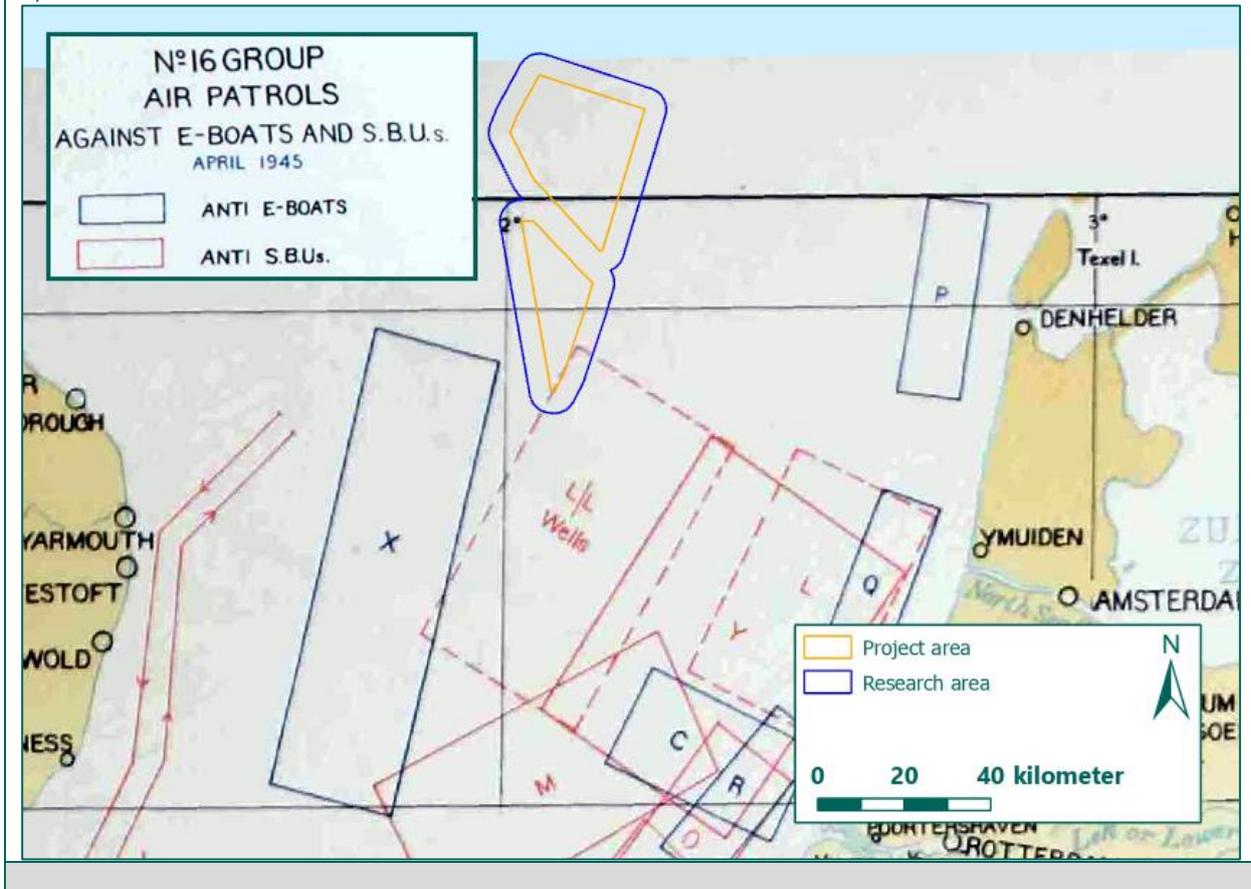


March 1945:



## Cabinet and its committees (CAB)

April 1945:



### Air Ministry series

The Air Ministry series (AIR) contain information on aerial warfare during the Second World War. The Operations Record Books (ORBs) of units that operated in or near the Investigation Area have been consulted:

- Headquarters Coastal Command, 1940-1945 (AIR 24/372 t/m AIR 24/427)
- 16 Group Coastal Command, 1940-1945 (AIR 25/313 t/m AIR 25/374)
- Headquarters Bomber Command, 1940-1945 (AIR 24/217 t/m AIR 24/319)
- Intelligence on USAAF missions (AIR 40)

16 Group Coastal Command patrolled the North Sea, attacking German shipping and conducting rescue operations. ORBs from this unit contain location of air strikes, jettisons, aircraft wreckages and Anti-Aircraft Artillery (AAA). Until halfway through 1942 the locations were noted in Coastal Command cypher which has only partially been decrypted by REASeuro. From 1942 onwards the ORBs mention locations in coordinates, based on decimal degrees. One must take into account that Coastal Command operated during the night as well, severely restraining navigational accuracy. When possible, war related events mentioned in the Coastal Command records have been coupled with records from the German point of view, resulting in more accurate positioning based on multiple sources.

Bomber Command, Coastal Command's famous land-based counterpart, was also active against German shipping during the first years of the war. Besides intentional bombing, Bomber Command aircraft also jettisoned bombs when in trouble. The jettisons preferably took place over sea, since this dramatically reduced the chance of collateral damage. Bomber Command coordinates have been digitalized and imported in GIS as well.

REASeuro digitalized all the relevant latitude/longitude coordinates from Bomber and Coastal Command ORBs and plotted these coordinates in GIS. This results in a comprehensive database of Bomber and Coastal Command activity that may have results in the presence of UXO in the Investigation Area. Bomber and Coastal Command activity in and around the Investigation Area is shown in Figure 48.

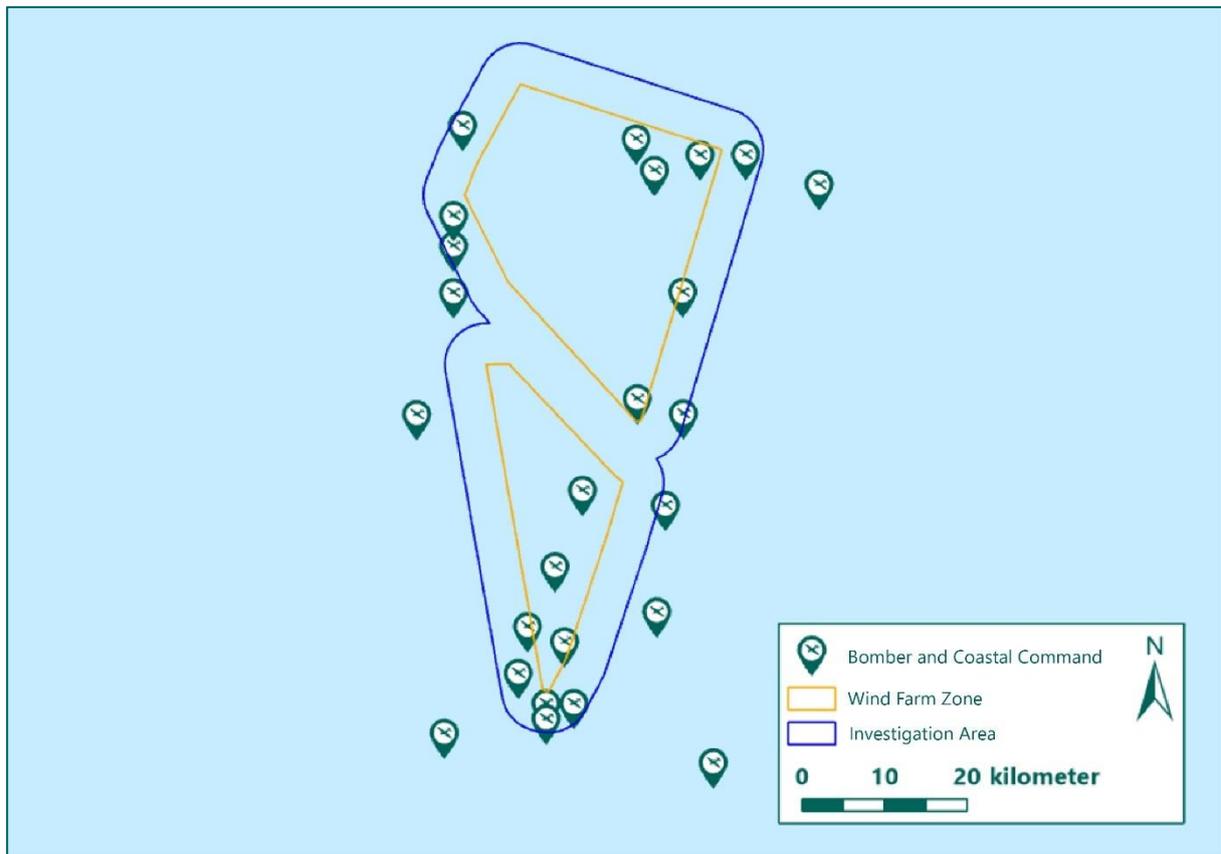


Figure 48: Locations of Bomber and Coastal Command operations, based on 16 Group logs.

Date	Event	Sources
21 June 1940	Dutch trawler MV Mercurius spotted at sea, no attack made. - <i>No attack made, not relevant</i>	AIR 28/75
16 June 1941	One Bristol Blenheim (139 Squadron) bomber crashed in the sea at 53 23' N 03 00' E after an attack made by a German Messerschmitt Me 109. It is unknown if the Blenheim dropped its four 250 lb. S.A.P. bombs before being shot down. - <i>Airplane crashed within Investigation Area, relevant</i>	AIR 24/232
3 February 1943	One Lockheed Hudson (320 Squadron) collided mid-air at 19.15 hrs in position 53 20' N 03 25' E with unsighted aircraft. The plane was badly damaged; turret and astrodome were destroyed, wireless destroyed, and tops of tail fins taken away. The plane safely landed at 20.15 hrs. - <i>No crash, not relevant</i>	AIR 25/346
5 March 1943	Photograph of British dinghy smoke floats and unnamed dinghy. No attack made. - <i>No attack made, not relevant</i>	AIR 28/595
21 May 1943	Five Avro Anson planes (280 Squadron) were dispatched for a search on the North Sea. At 19.18 hrs one mine was sighted in position 53 12' N 02 56' E. - <i>Mine sighted near the Investigation Area, relevant</i>	AIR 25/349
6 July 1943	Two British launches (military vessel) and one British Supermarine Walrus aircraft (amphibious plane) spotted at 52 53' N 03 12' E.	AIR 25/351

Date	Event	Sources
	- <i>No attack made, not relevant</i>	
29 September 1943	During a search, the mainplane of a British aircraft was spotted at 52 53' N 03 10' E. No other wreckage was seen in the vicinity. - <i>Wreck within Investigation Area, relevant</i>	AIR 25/353
5 November 1943	Airborne in formation. Onsighting tracer altered course and joined up with A/C O/X/254. At 7:32 hrs in position 52 55' N 03 40' E saw four "E" boats. "S" (Beaufighter) then attacked leading boat in starboard line making strikes amidships with two long bursts from all guns. Vessel was seen by pilot of A/C "Q" on fire amidships. Pilot states that there was intense but inaccurate flak on run in but ceased afterwards A/C "Q" (Beaufighter) attacked second vessel in port line. Hits were scored amidships and stern. Did not meet with any flak from target, but there was firing from leading vessel in port section. - <i>Attack on U-boats, relevant</i>	AIR 25/355
5 November 1943	Three Lockheed Hudson bombers (279 Squadron) were to perform a search on the North Sea. At 12.07 in position 53 06' N 03 23' E an empty dinghy (H type) was seen, partly submerged, but no signs of life were observed. Attempts were made to sink the dinghy by gunfire; hits were made but the dinghy did not sink. 2 smoke floats were then dropped but both failed to function. - <i>Dinghy fired upon and smoke floats dropped near the Investigation Area, relevant</i>	AIR 25/355
24 November 1943	Four Lockheed Hudson (279 Squadron) bombers carried out searches at sea. On take-off, aircraft was to proceed to East Kirkby and from there flew in line abreast on magnetic bearing of 067 degrees for 80 miles, and thence to search the area. The object of the search was an aircraft which was seen on fire to go into the sea in a shallow dive in position 53 12' N 03 25' E. - <i>Aircraft crashed in Investigation Area, relevant</i>	AIR 25/355
20 December 1943	One Lockheed Hudson (279 Squadron) was to carry out search for a ditched aircraft and dinghy in position 53 29' N 03 27' E and 53 29' N 03 55. 90 % of area was searched, nothing sighted. - <i>Aircraft ditched in Project Area, relevant</i>	AIR 25/356
11 January 1944	Three Lockheed Hudson (279 Squadron) bombers were to fly a patrol. At 13.50 hrs a large pall of smoke was sighted. At 14.06 hrs the position of 52 51' N 02 59' E was reached, and a large oil patch and much unidentifiable wreckage was observed: probably a dinghy. - <i>Wreckage near Investigation Area, relevant</i>	AIR 25/357
27 March 1944	Four Lockheed Hudson (279 Squadron) bombers were to carry out a search at sea. At 16:29 hrs they received the message "Home on Rooster to Position". At 16:38 hrs three Hudsons at 52 55' N 03 07' E were sighted circling aircraft wheels and seven dead bodies. A Lindholme sea rescue dinghy was dropped by one Hudson. A high-speed launch (HSL) sea-rescue boat picked up all visible bodies by 18:10 hrs. - <i>Aircraft crashed in or near Investigation Area, relevant</i>	AIR 25/359
8 April 1944	Two Vickers Wellington (415 Squadron) bombers carried out patrols between 21.10 and 4.15 hrs. At 3.32 hrs eight bombs (unknown calibre) were dropped 'safe', but one exploded. - <i>Aircraft jettisoned bombs within Investigation Area, relevant</i>	AIR 25/360

Date	Event	Sources
30 July 1944	<p>During a sea search, at 7:32 hrs in position 53 29' N 03 32' E the wreckage of an aircraft and an oil patch was spotted.</p> <p>- <i>Aircraft crashed in or near Investigation Area, relevant</i></p>	AIR 25/363
	<p>Seven Grumman Avenger bombers (848 Squadron) were to carry out a patrol. At 11.42 hrs in position 53 27' N 03 40' E two aircrafts met over a wreckage consisting of parts of mainplane of an aircraft.</p> <p>- <i>Wreckage near Investigation Area, relevant</i></p>	AIR 25/363
13 August 1944	<p>Two Lockheed Hudson bombers (279) spotted in position 52 59' N 03 22' E scattered wreckage. In the southern half of the area no aircraft wreckage was seen.</p> <p>- <i>Wreckage near Investigation Area, relevant</i></p>	AIR 25/365
3 February 1945	<p>Flame float spotted at 53 28' N 03 22' E.</p> <p>- <i>No attack, not relevant</i></p>	AIR 25/371
7 February 1945	<p>Three Vickers Wellington (612 and 524 Squadron) bombers carried out patrols between 22.05 and 2.20 hrs. At 2.22 hrs, one plane jettisoned all bombs 'live' at 53 31' N 03 01' E. At 3.36 hrs, another plane jettisoned all bombs safe at 53 25' N 03 00' E.</p> <p>- <i>Bombs jettisoned in Investigation Area, relevant</i></p>	AIR 25/371
21 February 1945	<p>Multiple Vickers Wellington (524 and 612 Squadron) bombers were to carry out a patrol on the North Sea. At 23.13 hrs some light flak was experienced, and attack instructions were requested by aircraft. At 23.28 hrs in position 53 20' N 03 00' E a visual was obtained of 9 E-boats on course 270 dgs at 30 knots. They were in two lines astern 300 ft apart with 450 ft between columns. These vessels were attacked at 23.40 hrs from 1.000 ft, some light flak was experienced. Bom burst straddled both columns. The first two bombs were seen to burst in area of 3<sup>rd</sup> E-boat in starboard column. The last four bombs burst in area of 3<sup>rd</sup> boat of port column and one boat dropped 6 miles astern. Captain bombed before receiving attack instructions as target had been established as enemy. The aircraft was armed with G.P. bombs fused 44 Pistol Tail .025 secs delay.</p> <p>- <i>Bombing near Investigation Area, relevant</i></p>	AIR 25/371
1 March 1945	<p>One Vickers Wellington (524 Squadron) with the name Yamak 47 was to attack E-boats on the North Sea. At 01.47 hrs a radar contact was obtained, and the plane homed to the position 52 49' N 03 28' E at 01.48 hrs. It attacked with six 250 lb. bombs from a height of 1500 feet. The bombs were seen to fall well short of the target. Intense accurate light flak was encountered.</p> <p>- <i>Attack on E-boats near Project Area, relevant</i></p>	AIR 25/372
17 March 1945	<p>At 3.40 hrs in position 53 02' N 03 11' E an attack was made by radar bombing graph from 1.500 feet with six 250 lb. bombs. The rear gunner saw the bombs burst 200 ft short of water of wakes [probably 'waves' caused by E-boats].</p> <p>- <i>Attack on E-boats within Project Area, relevant</i></p>	AIR 25/372
18 March 1945	<p>Multiple Vickers Wellington (524 Squadron) and Bristol Beaufighter (254 and 296 Squadron) bombers were to carry out operation 'Percolate'. At 3.22 hrs six Target Identification bombs were dropped and at 3.34 hrs four flares were dropped in position 53 07' N 03 14' E. The Yamak 38 [name of one of</p>	AIR 25/372

Date	Event	Sources
	the planes] was seen to attack five E-boats in line astern but bombs undershot about 35 yards astern of last. - <i>Attack on E-boats within Project Area, relevant</i>	
18 April 1945	At 7.23 hours in position 52 27' N 03 12' E sighted a cigar shaped object. This was attacked with cannon fire, and it proved to be a drop tank. - <i>Cannon fire in Project Area, relevant</i>	AIR 25/373

Table 28: Coastal Command operations, based on 16 Group ORBs.

The North Sea theatre of war saw also action of fighter planes of Fighter Command and 2nd Tactical Air Force (2TAF). Fighter Command patrolled the sea in order to intercept German planes heading for Britain and escorted bombers. From 1944 onward Fighter Command was involved in the war against the German V1 and V2 weapons. 2TAF mainly supported the ground forces by carrying out attacks on tactical ground targets, but also enemy shipping near the shores was attacked. No locations have been found of Fighter Command's and 2TAF's attacks within the Investigation Area.

*Remark on jettisons and flight paths*

Related to the air war are jettisons of bombs and the numerous flight paths of incoming and outgoing bombers above the North Sea. During bombing raids, allied bombers followed certain routes towards their target and backwards to base. In case of emergency or to avoid landing with the bomb load, the bombs were often released above the North Sea. The figure underneath is a document from The National Archives (AIR 14/110 Disposal of bombs not dropped on allotted targets) that describes what to with the remaining bomb load.

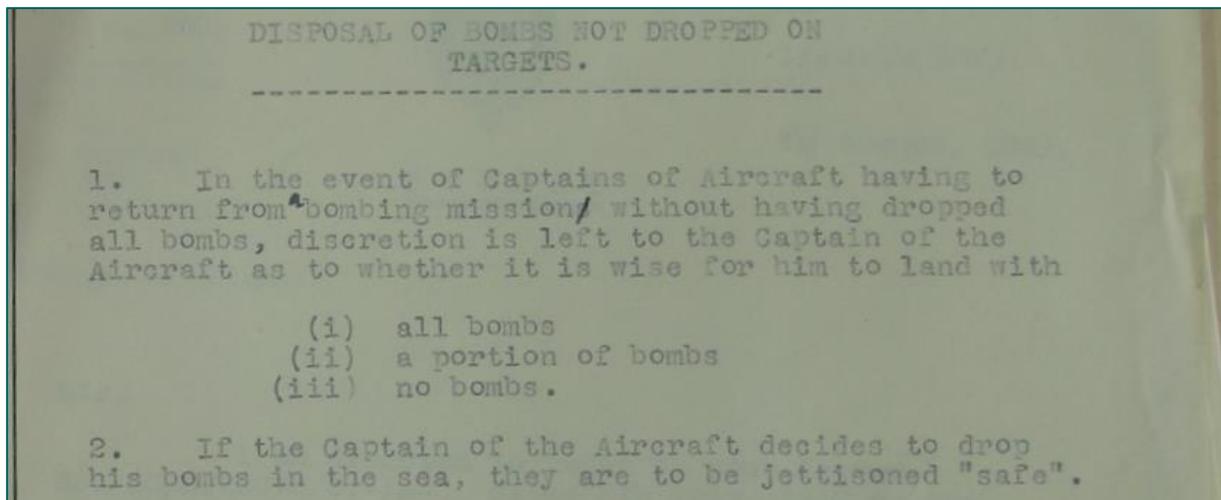


Figure 49: Extract from Bomber Command logs on the jettisoning of bombs within the North Sea (Source: TNA, AIR 24/375).

It is stated that a captain could decide wherever the bombs are dropped, as long as they are dropped in 'safe' condition. Despite this document, the logs of Bomber Command prove that bombs were also jettisoned in 'live' condition.

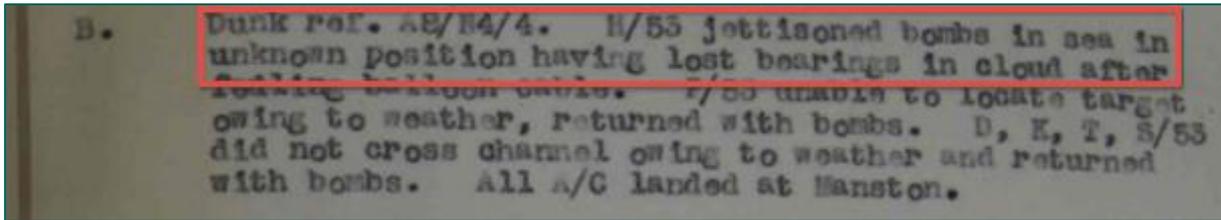


Figure 50: Extract from Bomber Command logs on the jettisoning of bombs within the North Sea (Source: TNA, AIR 24/375).

Example of flight path of returning bombers, 14 January 1944. The route passed Den Helder and the sea between Den Helder and Yarmouth.

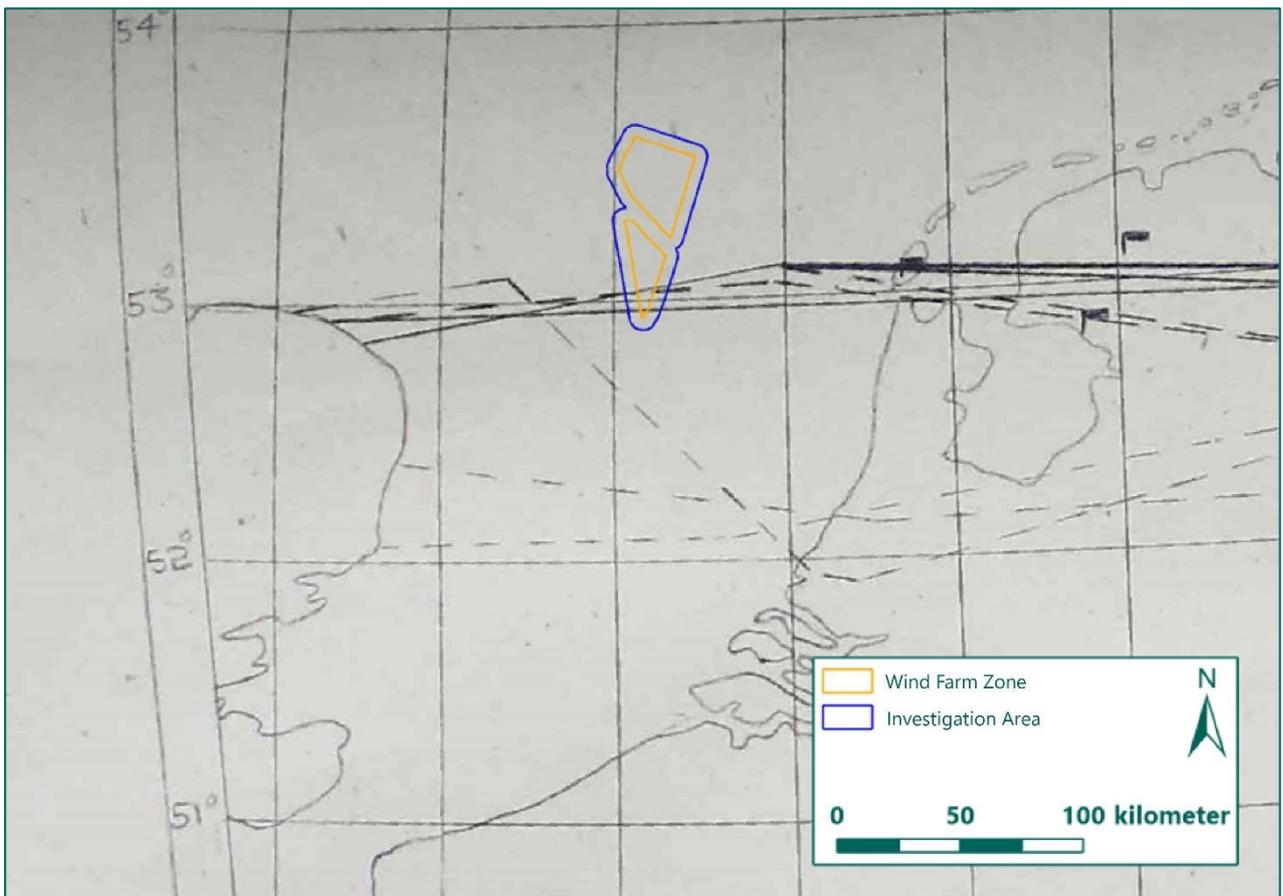


Figure 51: Example of a flight path over the Investigation Area of bombers from Bomber Command, 14/15 January 1944 (Source: TNA, AIR 24/264)

#### National Archives and Records Administration

The following Record Groups have been consulted in the NARA:

- Record Group 18: Mission Reports.  
The mission reports contain detailed information on allied bombing raids, including height, air speed and the deployed munitions.
- Record Group 242: Captured German Records  
The Captured German Records are microfilmed German army records captured after the German capitulation. In several instances the captured records are more complete than the records maintained by the Bundesarchiv.
- Record Group 342: Records of U.S. Air Force Commands, Activities, and Organizations  
Record Group 342 contains additional details not mentioned in Record Group 18.

The following documents have been found relevant for the Investigation Area:

Record Group 242: Captured German Records	
The Investigation Area falls under the responsibility of the 1. Sicherungsdivision of the German Kriegsmarine. Vessels of the Sicherungsdivision escorted convoys passing through the area that they controlled to protect these from attacks by enemy ships and aircrafts. Furthermore, enemy sea mines were cleared by the Sicherungsdivision and Minesuch-Flottillen.	
T1022, R 3150	9. S-Boot-Flottille – 31. Minensuch-Flottille
No relevant information in the Investigation Area.	
T1022, R 3194	9. S-Boot-Flottille – 7. Minensuch-Flottille
No relevant information in the Investigation Area.	
T1022, R 3533	KTB and Anlagen 1. Sicherungsdivision 1 Sep. 1943-31 Dec. 1943
No relevant information in the Investigation Area.	
T1022, R 3533	KTB and Anlagen 1. Sicherungsdivision 1 Sep. 1943-31 Dec. 1943
No relevant information in the Investigation Area.	

No further relevant files regarding the Investigation Area have been found in the consulted documents in the NARA.

#### Bundesarchiv-Militärarchiv (BAMA)

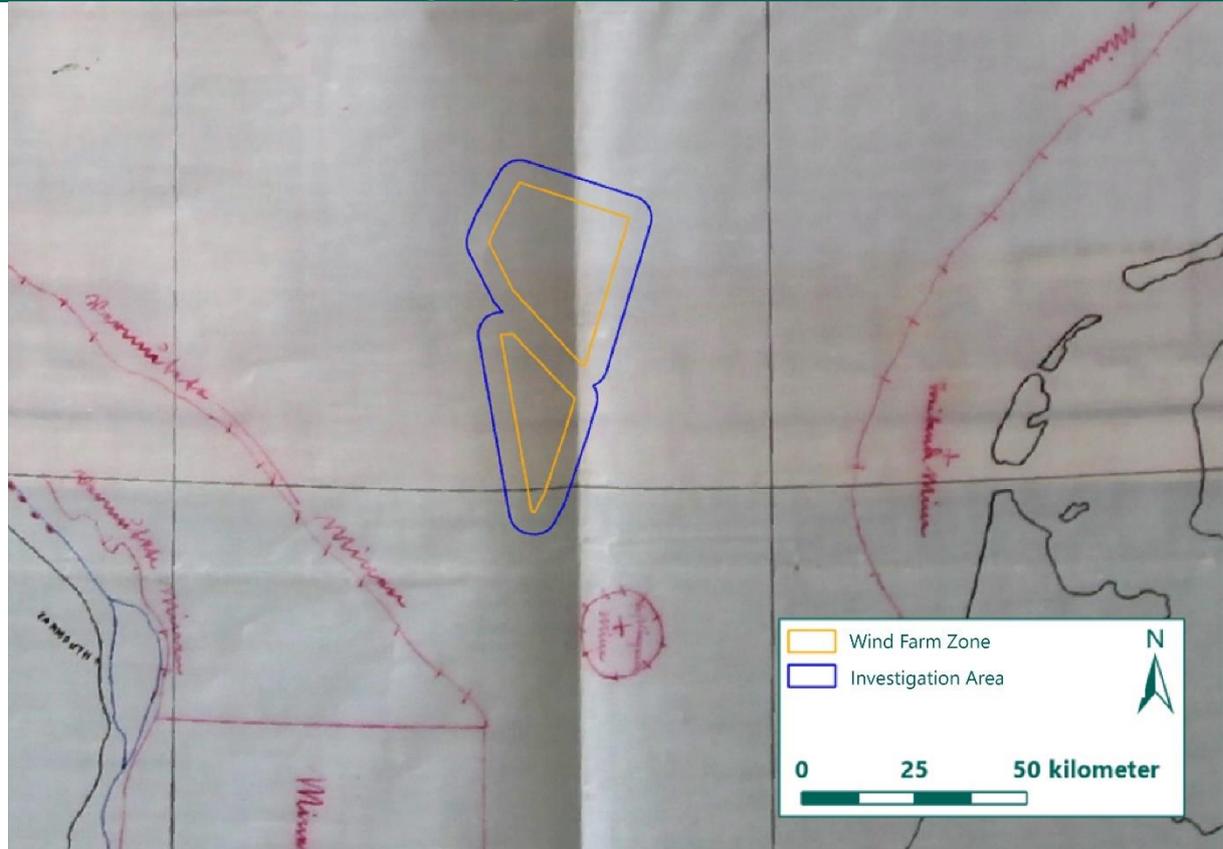
The German military archives have been consulted in the BAMA in Freiburg. This archive contains the documents from the German military in the Second World War. The following record groups have been consulted by REASeuro to gain more information about the German perspective of naval warfare in the Investigation Area:

- RM 2: Kaiserliches Marinekabinett.
- RM 5: Admiralstab der Marine / Seekriegsleitung der Kaiserlichen Marine.
- RM 7: Seekriegsleitung der Kriegsmarine.
- RM 8: Kriegswissenschaftliche Abteilung der Marine (Marinearchiv).
- RM 35-I: Marinegruppenkommando Ost – Nord der Kriegsmarine.
- RM 45-II: Dienststellen und Kommandostellen der Kriegsmarine im Bereich Deutsche Bucht und Niederlande.
- RM 67: Sicherungsdivisionen der Kriegsmarine.
- ZA 5: Deutscher Minenräumdienst (German Minesweeping Administration).

The following documents have been found relevant for the Investigation Area:

RM 5: Admiralstab der Marine / Seekriegsleitung der Kaiserlichen Marine.	
The Admiralty of the Imperial Navy was the highest level of command of the German Navy during the First World War. Record Group RM5 contains documents from the admiralty. The following documents are considered relevant for the Investigation Area.	
RM 5/4721K	Kommando der Hochseestreitkräfte: "Zusammenstellung der bisher bekannten Minensperren und minenverdächtigen Gebiete". Druck, 3.3.1915
Map showing known and suspected allied minefields, situation March 1915. The Investigation Area has no overlap with an area which was suspected to be mined.	

## RM 5: Admiralstab der Marine / Seekriegsleitung der Kaiserlichen Marine.



## RM 35-I Marinegruppenkommando Ost / Nord der Kriegsmarine

The *Marinegruppenkommando Ost – Nord* was the commander of naval troops that operated in the North- and Baltic Sea.

RM 35-I/267	Minen, Allgemein Minensperren Nordsee 10. Aug. 1940 - 1. Okt. 1943
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Information on German minefields. No additional information in comparison to ZA 5, see below.

## RM 35-II Marinegruppenkommando West der Kriegsmarine

RM 35-II/148	Hafenverseuchungen (Sperrpläne): Minensperren für die Hafenverseuchung, Kanalküste, französische Südküste, Atlantikküste
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No relevant information in the Investigation Area.

RM 35-II/213	Minensicherung Deutsche Bucht 22. Mai 1937 - 21. Jan. 1940
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Enthält:  
Minensicherung der Deutschen Bucht: Kriegsspiele;  
Minensperren;  
Übersicht Sperren;  
Überlegung der Erweiterung

No relevant information in the Investigation Area.

RM 35-II/313	Luftminen 20. Nov. 1939 - 19. Febr. 1941
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Enthält:

Einsatz von Luftminen England und Frankreich	
No relevant information in the Investigation Area.	
RM 35-II/316	Zielpausen Enthält: Zielpausen Luftmineneinsatz England und Frankreich; Zielübersicht (Luftminen) Frankreich
No relevant information in the Investigation Area.	

<b>RM 45-II: Dienststellen und Kommandostellen der Kriegsmarine im Bereich Deutsche Bucht und Niederlande.</b>	
The Investigation Area lies in front of the Dutch coast. Different commanders were responsible for the defence. The following command levels, from high to low, are potentially relevant: Harbour commander IJmuiden ( <i>Hafenkommandant IJmuiden</i> ), Commander of the Sea Defence North Holland ( <i>Kommandant Seeverteidigung Nordholland</i> ), and the Marine Commander in the Netherlands ( <i>Marinebefehlshaber in den Niederlanden</i> ).	
<b>Marinebefehlshaber in den Niederlanden</b>	
RM 45-II/218	Kriegstagebuch Kommandant im Verteidigungsabschnitt Holland bzw. (ab 18. Juni 1940) Marinebefehlshaber in den Niederlanden bzw. (ab Febr. 1943) Kommandierender Admiral in den Niederlanden (Mai 1940 - Kriegsende) 10. Mai 1940 - 31. Dez. 1941
No relevant files in this series regarding the Investigation Area.	
RM 45-II/219	Kommandant im Verteidigungsabschnitt Holland bzw. (ab 18. Juni 1940) Marinebefehlshaber in den Niederlanden bzw. (ab Febr. 1943) Kommandierender Admiral in den Niederlanden (Mai 1940 - Kriegsende) Kriegstagebücher Bd. 2 1. Jan. 1942 - 30. Juni 1943
11 September 1942. 7.00 Uhr. IJmuiden. Ein feindl. Schnellboot wurde im Qu AN 8198 von eigenen Schnellbooten gekapert und in Schlepp genommen. Zur Hilfeleistung Seerettungsboot aus Den Helder und Schlepper BS-11 aus IJmuiden entgegengesandt. Feindl. S-Boot Den Helder eingeschleppt. Zwei englische Gefangene Hafen-überwachungsstelle IJmuiden übergeben.	
RM 45-II/220	Kommandant im Verteidigungsabschnitt Holland bzw. (ab 18. Juni 1940) Marinebefehlshaber in den Niederlanden bzw. (ab Febr. 1943) Kommandierender Admiral in den Niederlanden (Mai 1940 - Kriegsende) Kriegstagebücher Bd. 3 1. Juli - 31. Dez. 1943
No relevant files in this series regarding the Investigation Area.	
RM 45-II/221	Kriegstagebuch Kommandant im Verteidigungsabschnitt Holland bzw. (ab 18. Juni 1940) Marinebefehlshaber in den Niederlanden bzw. (ab Febr. 1943) Kommandierender Admiral in den Niederlanden (Mai 1940 - Kriegsende) 1944
No relevant files in this series regarding the Investigation Area.	
RM 45-II/222	Kriegstagebuch Kommandant im Verteidigungsabschnitt Holland bzw. (ab 18. Juni 1940) Marinebefehlshaber in den Niederlanden bzw. (ab Febr. 1943) Kommandierender Admiral in den Niederlanden (Mai 1940 - Kriegsende) 1944
No relevant files in this series regarding the Investigation Area.	
RM 45-II/223	Kriegstagebuch Kommandant im Verteidigungsabschnitt Holland bzw. (ab 18. Juni 1940) Marinebefehlshaber in den Niederlanden bzw. (ab Febr. 1943) Kommandierender Admiral in den Niederlanden (Mai 1940 - Kriegsende)

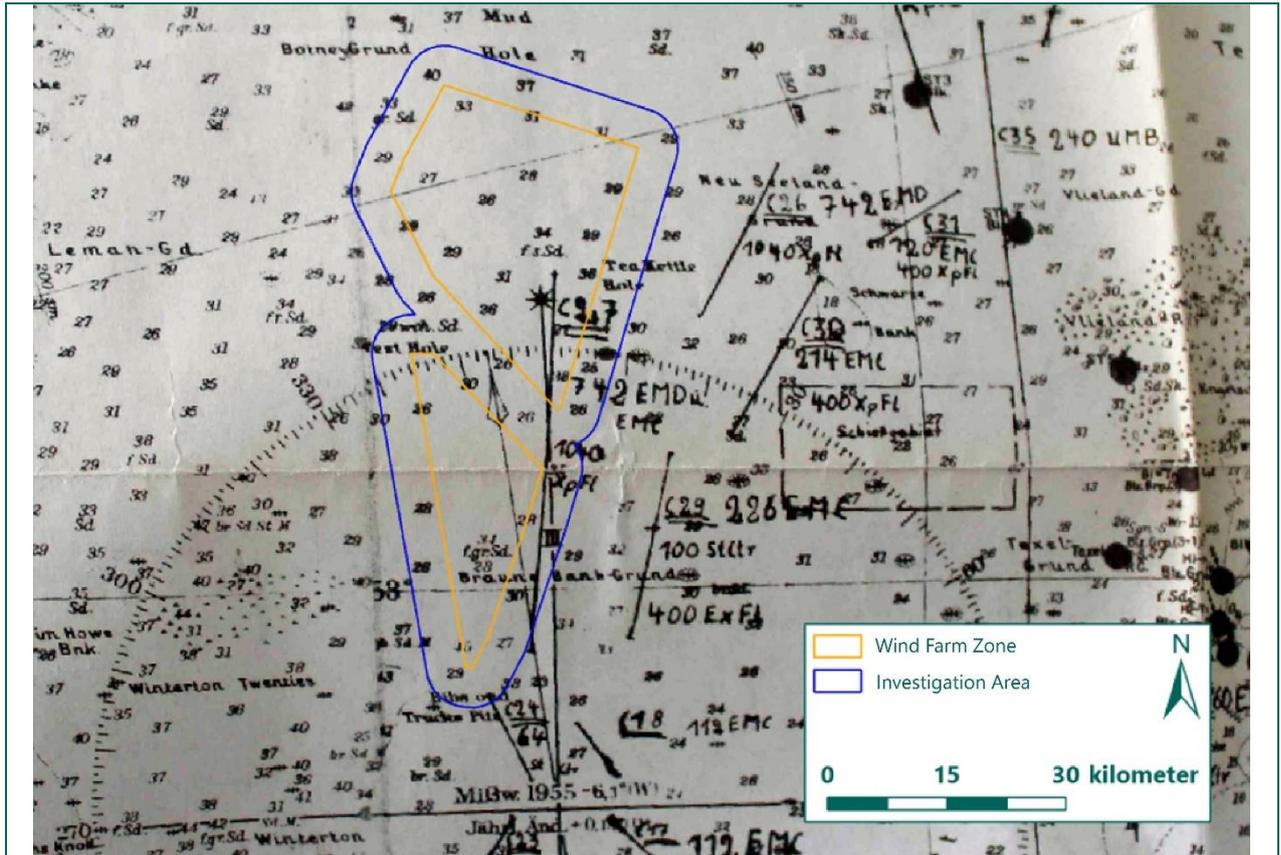
RM 45-II: Dienststellen und Kommandostellen der Kriegsmarine im Bereich Deutsche Bucht und Niederlande.	
	1944
No relevant files in this series regarding the Investigation Area.	
RM 45-II/224	Kriegstagebuch Kommandant im Verteidigungsabschnitt Holland bzw. (ab 18. Juni 1940) Marinebefehlshaber in den Niederlanden bzw. (ab Febr. 1943) Kommandierender Admiral in den Niederlanden (Mai 1940 - Kriegsende) 1945
No relevant files in this series regarding the Investigation Area.	
<b>Kommandant Seeverteidigung Nordholland</b>	
No relevant files in this series regarding the Investigation Area.	
<b>Hafenkommendant IJmuiden</b>	
No relevant files in this series regarding the Investigation Area.	

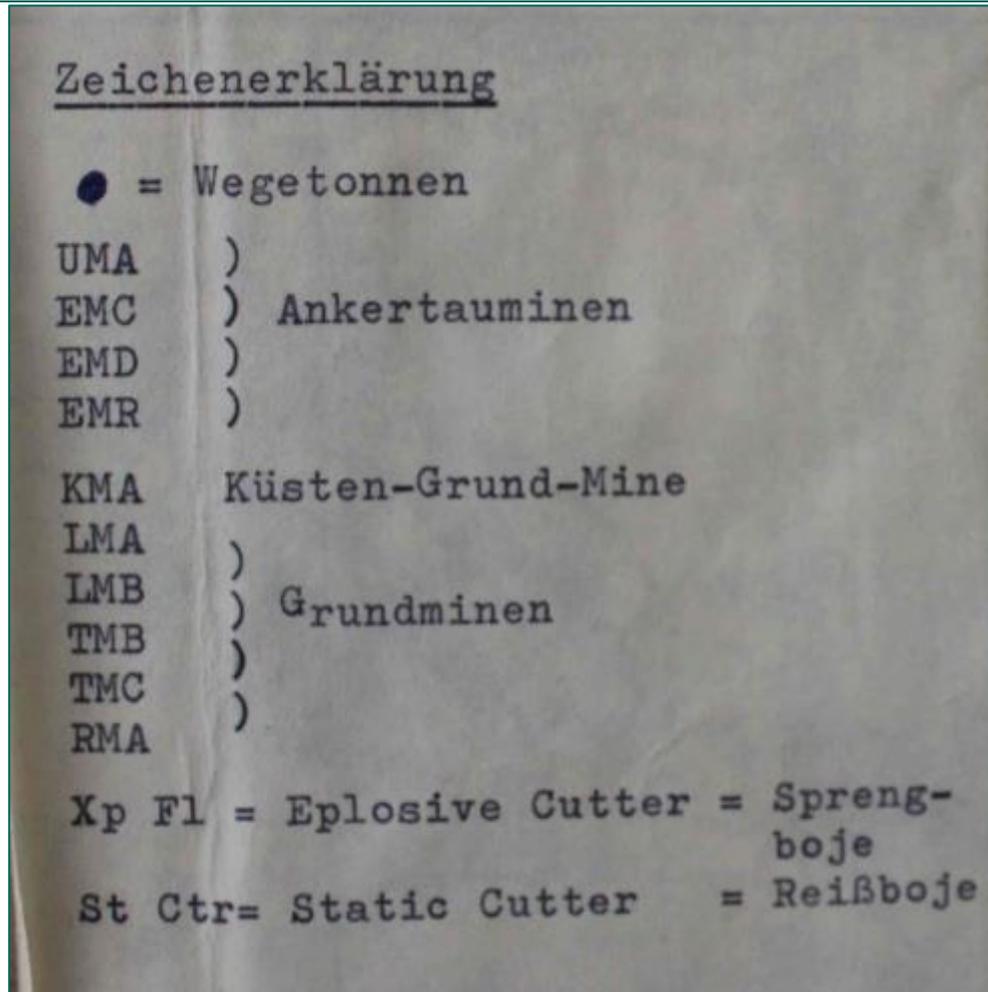
RM 67 Sicherungsdivisionen der Kriegsmarine	
RM 67/5	Kriegstagebuch 1941 – 1945 16. - 28. Feb. 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/6	Kriegstagebuch 1941 – 1945 1. - 31. März 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/7	Kriegstagebuch 1941 – 1945 1. - 30. Apr. 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/8	Kriegstagebuch 1941 – 1945 1. - 15. Mai 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/9	Kriegstagebuch 1941 – 1945 15. - 31. Mai 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/10	Kriegstagebuch 1941 – 1945 1. - 30. Juni 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/11	Kriegstagebuch 1941 – 1945 1. - 31. Juli 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/12	Kriegstagebuch 1941 – 1945 1. - 31. Aug. 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/13	Kriegstagebuch 1941 – 1945 1. - 30. Sept. 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/14	Kriegstagebuch 1941 – 1945 1. - 31. Okt. 1941
No relevant files in this series regarding the Investigation Area.	

RM 67 Sicherungsdivisionen der Kriegsmarine	
RM 67/15	Kriegstagebuch 1941 – 1945 1. - 30. Nov. 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/16	Kriegstagebuch 1941 – 1945 1. - 31. Dez. 1941
No relevant files in this series regarding the Investigation Area.	
RM 67/17	Kriegstagebuch 1941 – 1945 1. - 31. Jan. 1942
No relevant files in this series regarding the Investigation Area.	
RM 67/18	Kriegstagebuch 1941 – 1945 1. - 28. Feb. 1942
No relevant files in this series regarding the Investigation Area.	
RM 67/19	Kriegstagebuch 1941 – 1945 1. März - 30. Apr. 1942
No relevant files in this series regarding the Investigation Area.	
RM 67/20	Kriegstagebuch 1941 – 1945 1. Mai - 30. Juni 1942
No relevant files in this series regarding the Investigation Area.	
RM 67/21	Kriegstagebuch 1941 – 1945 1. - 31. Juli 1942
No relevant files in this series regarding the Investigation Area.	
RM 67/22	Kriegstagebuch 1941 – 1945 1. Aug. - 30. Sept. 1942
No relevant files in this series regarding the Investigation Area.	
RM 67/23	Kriegstagebuch 1941 – 1945 1. - 31. Okt. 1942
No relevant files in this series regarding the Investigation Area.	
RM 67/24	Kriegstagebuch 1941 – 1945 1. - 30. Nov. 1942
No relevant files in this series regarding the Investigation Area.	
RM 67/25	Kriegstagebuch 1941 – 1945 1. - 31. Dez. 1942
No relevant files in this series regarding the Investigation Area.	
RM 67/26	Kriegstagebuch 1941 – 1945 1. Jan. - 28. Feb. 1943
No relevant files in this series regarding the Investigation Area.	
RM 67/27	Kriegstagebuch 1941 – 1945 1. März - 30. Apr. 1943
No relevant files in this series regarding the Investigation Area.	
RM 67/28	Kriegstagebuch 1941 – 1945

RM 67 Sicherungsdivisionen der Kriegsmarine	
	1. Mai - 31. Juli 1943
No relevant files in this series regarding the Investigation Area.	
RM 67/29	Kriegstagebuch 1941 – 1945 1. Aug. - 31. Dez. 1943
No relevant files in this series regarding the Investigation Area.	
RM 67/30	Kriegstagebuch 1941 – 1945 1. Jan. - 31. März 1944
No relevant files in this series regarding the Investigation Area.	
RM 67/31	Kriegstagebuch 1941 – 1945 1. Apr. - 31. Mai 1944
No relevant files in this series regarding the Investigation Area.	
RM 67/32	Kriegstagebuch 1941 – 1945 1. Juni - 31. Juli 1944
No relevant files in this series regarding the Investigation Area.	
RM 67/33	Kriegstagebuch 1941 – 1945 1. Aug. - 30. Sept. 1944
<p>15 September 1944: Um 0153 Uhr in Qu.8217 2. Angriff von S-Booten u. Flugzeugen. 7 Torpedolafbahnen ausmanövriert, 3 anscheinend akustische Torpedos zwischen Geleitbooten detoniert. Gleichzeitig Leuchtbomben u. Splitterbombeneinsatz von Flugzeugen. 1 S-Boot explodiert, die S-Boote nebeln sich daraufhin ein. Hinter der Nebelwand wurden dichte Rauchwolken beobachtet, die auf weitere schwere Schäden schließen lassen.</p>	
RM 67/34	Kriegstagebuch 1941 – 1945 1944 - 1945
No relevant files in this series regarding the Investigation Area.	

ZA 5 Deutscher Minenräumdienst (German Minesweeping Administration)	
The German Minesweeping Administration was responsible for post-war mine clearance of German waters. This administration also summarized and mapped all German minefields laid during the Second World War.	
ZA 5/27	Im Kriege geworfene Minensperren in der Ost- und Nordsee etc.
Information on German minefields and sweep obstructors within the Investigation Area.	
<ul style="list-style-type: none"> <li>○ C24: 64 sweep obstructors.</li> <li>○ C27: 742 EMC, 1040 xp-floats</li> </ul>	





ZA 5/44 Summary of Enemy Minelaying, The Admiralty, United Kingdom (Großformat)

Detailed information concerning German minefields. This summary contains all relevant information that forms the basis for chart ZA 5/48, including mine types, rows, accuracy and coordinates.

The following minefields intersect with the Investigation Area:

- C.24  
The minefield was laid in July 1942 and contained 64 sweep obstructors.
- C.27  
The minefield was laid in August 1940 and contained 742 EMD and EMC mines and 1040 explosive floats. The AE Switch was "OFF" and thus considered 'safe'.

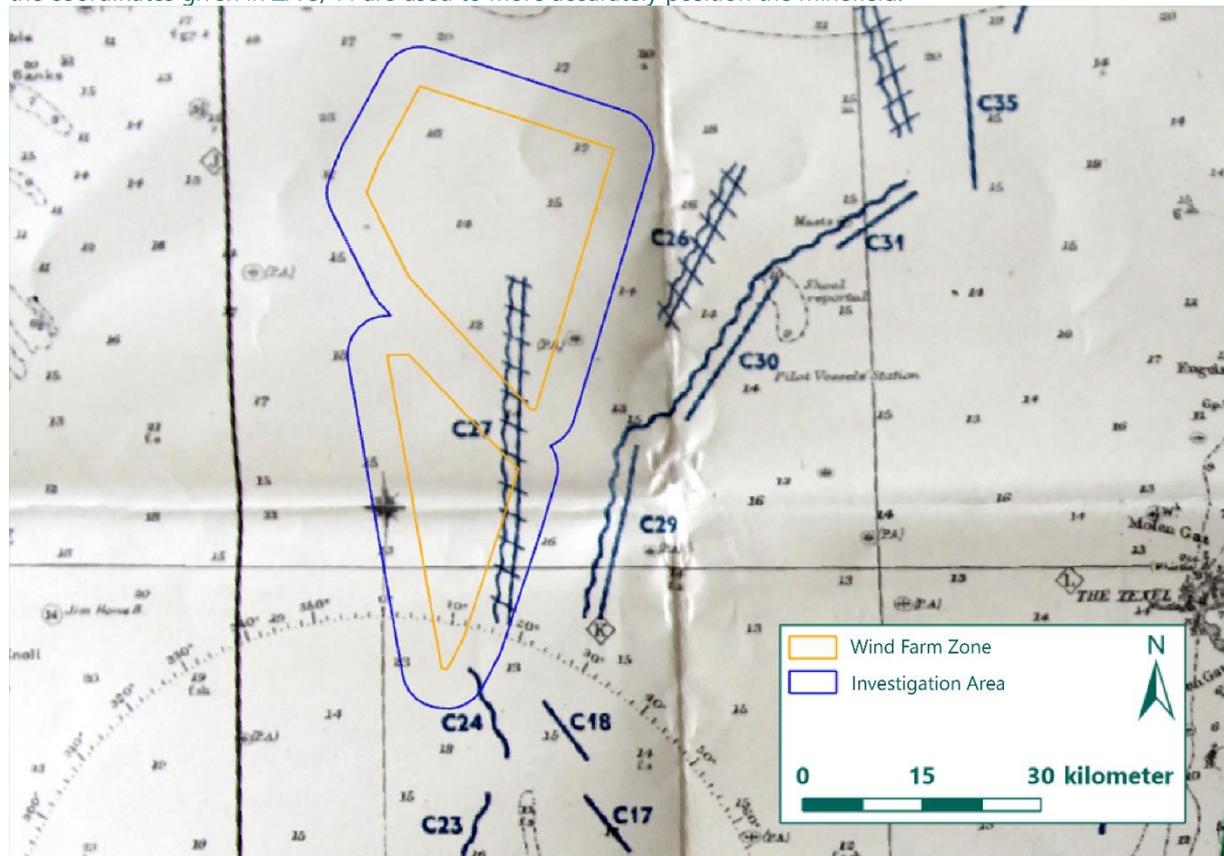
Minefields close to the Investigation Area:

- C.17  
The minefield was laid in January 1942 and contained 112 EMC mines. Remarks: 110 Fathoms mooring wire. With tombac sheathing.
- C.18  
The minefield was laid in January 1942 and contained 112 EMC mines. Remarks: 110 Fathoms mooring wire. With tombac sheathing.
- C.26  
The minefield was laid in August 1940 and contained 742 EMD Mines and 1040 explosive floats. The AE Switch was "OFF" and thus considered 'safe'.

- C.23  
The minefield was laid in July 1943 and contained 64 sweep obstructors.
- C.29  
The minefield was laid in July 1942 and contained 226 EMC mines, 100 sweep obstructors and 400 ex-floats. Remarks: the EMC mines were laid with 50 feet lower antenna. The 400 Ex-floats are for lines C29, C30 and C31. They are in the space between the mine lines.
- C.30  
The minefield was laid in July 1942 and contained 214 EMC mines and 400 explosive floats. Remarks: the EMC mines were laid with 50 feet lower antenna. The 400 Ex-floats are for lines C29, C30 and C31. They are in the space between the mine lines.
- C.31  
The minefield was laid in July 1942 and contained 120 EMC mines and 400 explosive floats. Remarks: the EMC mines were laid with 50 feet lower antenna. The 400 Ex-floats are for lines C29, C30 and C31. They are in the space between the mine lines.

ZA 5/48 | Chart C The North Sea.- Southern Sheet

Naval chart showing numbered German minefields. This map has not been used for this historical research, because the coordinates given in ZA 5/44 are used to more accurately position the minefield.



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## ANNEX 5 POST-WAR UXO CLEARANCE

This annex contains information about post-war UXO encounters and clearance. The information is derived from the Dutch Coast Guard and the OSPAR Commission.

### Dutch Coast Guard and Beneficial Cooperation (The Royal Netherlands Navy and the Belgian Navy)

Since the Second World War the Dutch fishing fleet at times experienced weekly encounters with UXO in their fishing nets. To compensate fishermen for the loss of income due to UXO, a deficiency payments regulation was introduced. These payments caused some fishermen to deliberately fish for UXO when fishing was poor. As a consequence, large amounts of UXO were reported each year. These UXO were subsequently rendered safe by the Dutch Naval EOD (Explosive Ordnance Disposal). This situation eventually led to the abolishment of the compensation. In the period that followed, no UXO incidents were reported. However, this does not mean that UXO were not encountered. Fishermen encountering UXO simply dumped the items back overboard. This often led to some extremely dangerous situations and to an uncontrolled migration of UXO.

On April the 6th 2005 three crewmembers of the vessel OD-1 'Maarten Jacob' (a trawler) were killed after an airplane bomb detonated on the deck of the vessel. This event led to an increase of the threat awareness amongst fishermen and also led to a change in government policy regarding the handling of UXO encountered by fishermen. The Dutch Coastguard implemented the current "Bijstands- en bijdrageregeling". The aim of this regulation was to reduce the risks attached with encountering of UXO as much as possible. The regulation provides guidelines for fishermen and professional support from the Coastguard and EOD. To prevent fishermen 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 1,656 UXO were reported to the coast guard, Royal Netherlands Navy and other authorities. The figure below shows the UXO encounters in and near the Investigation Area. Few UXO has been found within the Area but can be explained due to the fact that the Investigation Area is located on the edge of the Dutch maritime boundary/Exclusive Economic Zone. Multiple UXO were recorded by the Dutch Coast Guard near the Investigation Area (in blue); these will be denoted in the table below.

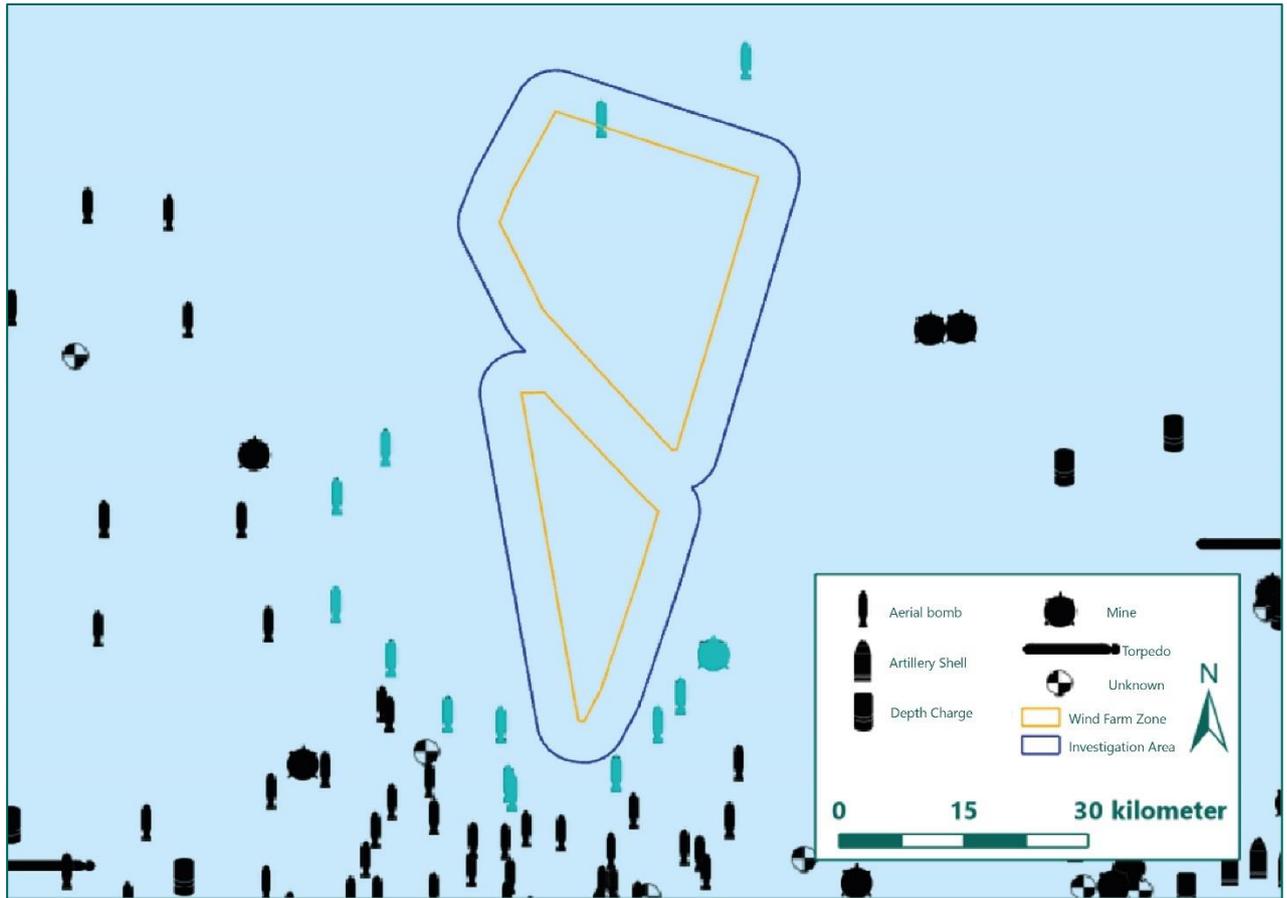


Figure 52: Overview of UXO encounters in and near the Investigation Area (indicated in blue) (Source: Dutch Coast Guard).

Nr.	UXO Type
1.	Aerial bomb nr. 29
2.	Aerial bomb [unknown number]
3.	Aerial bomb nr. 29
4.	Aerial bomb nr. 29
5.	Aerial bomb nr. 29
6.	Aerial bomb nr. 29
7.	Aerial bomb nr. 29 500 lb.
8.	Aerial bomb nr. 30
9.	Aerial bomb nr. 30
10.	Aerial bomb nr. 29
11.	Mine nr. 3
12.	Aerial bomb nr. 31
13.	Aerial bomb nr. 29
14.	Aerial bomb [unknown number]

Table 29: List of UXO cleared by the Dutch Coast Guard.

It should be noticed that some of the disposed UXO are accompanied with a number. The number refers to an explosives chart ('Explosievenkaart'), sampled by the Coast Guard. The chart gives a general overview of the most common UXO's in the North Sea and is an aid for fishermen to recognise a UXO they encountered. The purpose of the chart is to make the recognition of a UXO and the notification of it to the Coast Guard easier. Therefore, the chart gives some general pictures of the UXO. This means that the UXO encounters of the Coast Guard in many cases do not refer to the reality. This is increased by two other factors: the different of UXO on the chart are not always given in the right proportions, and the aerial bombs are pictured with their tail however the tail is seldom still attached to a bomb when encountered. To give an impression of the UXO in the Investigation Area, Table 30 shows the UXO that match the numbers on the explosives chart.

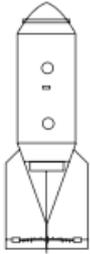
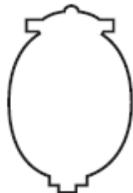
Aerial bomb nr. 29	Aerial bomb nr. 30	Aerial bomb nr. 31
		
<b>29</b>	<b>30</b>	<b>31</b>
Aerial bomb nr. 32	Aerial bomb nr. 33	Mine nr. 3
		
<b>32</b>	<b>33</b>	<b>3</b>

Table 30: Concordance between encountered UXO in the Investigation Area and the number on the explosives chart.

REASeuro has information at its disposal of the Beneficial Cooperation. The Beneficial Cooperation keeps a detailed registration on UXO encounters in the Dutch and Belgian part of the North Sea. The registration provides information

on UXO encounters since 2005. This information overlaps with the information of the Dutch Coast Guard. The Information available to REASeuro is limited to 2019. In the figure below the UXO clearances performed by the Beneficial Cooperation is shown. Specific UXO cleared by the Beneficial Cooperation will not be specified because it overlaps with the UXO mentioned in Table 29



Figure 53: Overview of UXO encounters in and near the Investigation Area (Source: Beneficial Cooperation).

#### OSPAR Commission

OSPAR is the mechanism by which 15 governments and the European Union cooperate to protect the marine environment of the North-East Atlantic. Since 1972 the OSPAR<sup>37</sup> Convention has worked to identify threats to the marine environment and has organised, across its maritime area, programmes and measures to ensure effective national action to combat them. One of the Policy Issues of the OSPAR Convention is to report encounters with conventional and chemical munitions in the OSPAR maritime area. These encounters are kept in a database<sup>38</sup>. The munition encounters from 1999 onwards within the Investigation Area are rendered in Figure 54.

<sup>37</sup> OSPAR is a abbreviation of Oslo-Paris. The 'OSPAR Convention' was open for signature at the Ministerial Meeting of the Oslo and Paris Commissions in Paris on 22 September 1992.

<sup>38</sup> This database can be consulted at <http://odims.ospar.org/layers/?limit=100&offset=0>.

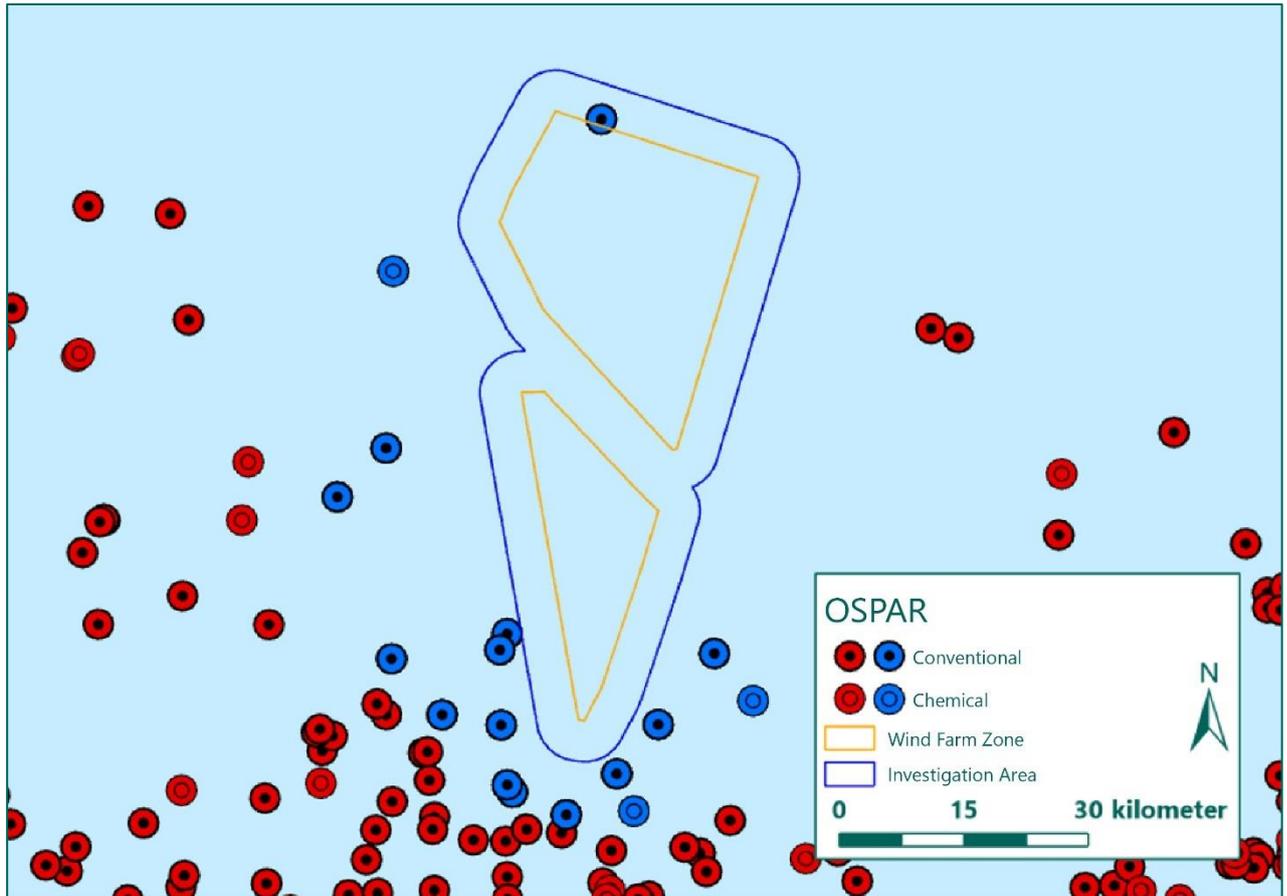


Figure 54: Overview OSPAR ammunition encounters within the Investigation Area (Source: OSPAR).

Nr.	UXO Type
1.	Conventional, released at sea.
2.	Conventional, released at sea.
3.	Conventional, destroyed.
4.	Conventional, destroyed.
5.	Conventional, released at sea.
6.	Conventional, unknown.
7.	Conventional, unknown.
8.	Conventional, unknown.
9.	Conventional, released at sea.
10.	Conventional, released at sea.
11.	Conventional, destroyed.
12.	Conventional, released at sea.
13.	Conventional, unknown.
14.	Conventional, destroyed.
15.	Unknown, destroyed.
16.	Unknown, released at sea.
17.	Conventional, destroyed.
18.	Unknown, unknown.

## ANNEX 6 CARTOGRAPHIC MATERIAL

This historical research uses extensively of cartographic materials. Relevant cartographic material includes historical coordinate systems, minefields and contemporary naval charts. Cartographic material from the following sources has been consulted:

- Latitude/longitude coordinates
- German Quadrantkarte
- Noordzeeloket
- Royal Netherlands Navy Hydrographic service
- Navy Museum Den Helder
- UK Hydrographic Office
- Library of Congress

### Latitude/longitude coordinates

Naval locations in historical sources are often noted in decimal degrees and minutes. One minute is equal to one naval mile, or 1,852 meters.

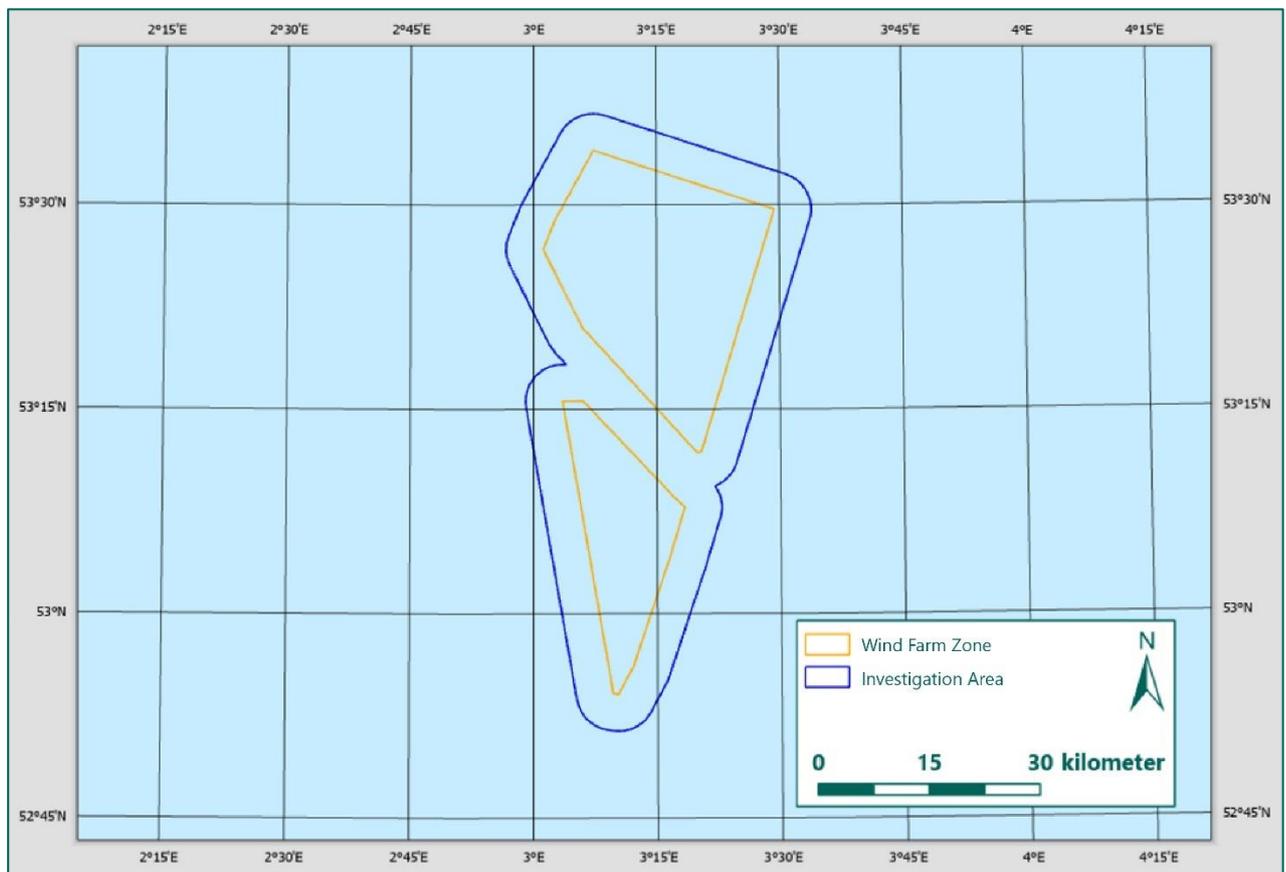


Figure 55: latitude/longitude grid (Source basemap: Esri).

### German *Quadrantkarte*

The German *Kriegsmarine* (Navy) used the so-called *Quadrantkarte* as an aid to note naval locations. The grid square (*Quadranten*) measured 6x6 naval miles and were determined with a geographic formula. REASeuro digitized the German grid in the GIS system to accurately establish the relevant grid squares for the Investigation Area.



Figure 56: German grid squares relevant for the Investigation Area (Source base map: Esri).

## Noordzeeloket

The Noordzeeloket offers governmental information about the North Sea. A map showing military exercise areas is consulted on the Noordzeeloket's website. As shown in Figure 57 the Investigation Area has no overlap with Military Exercise Areas.

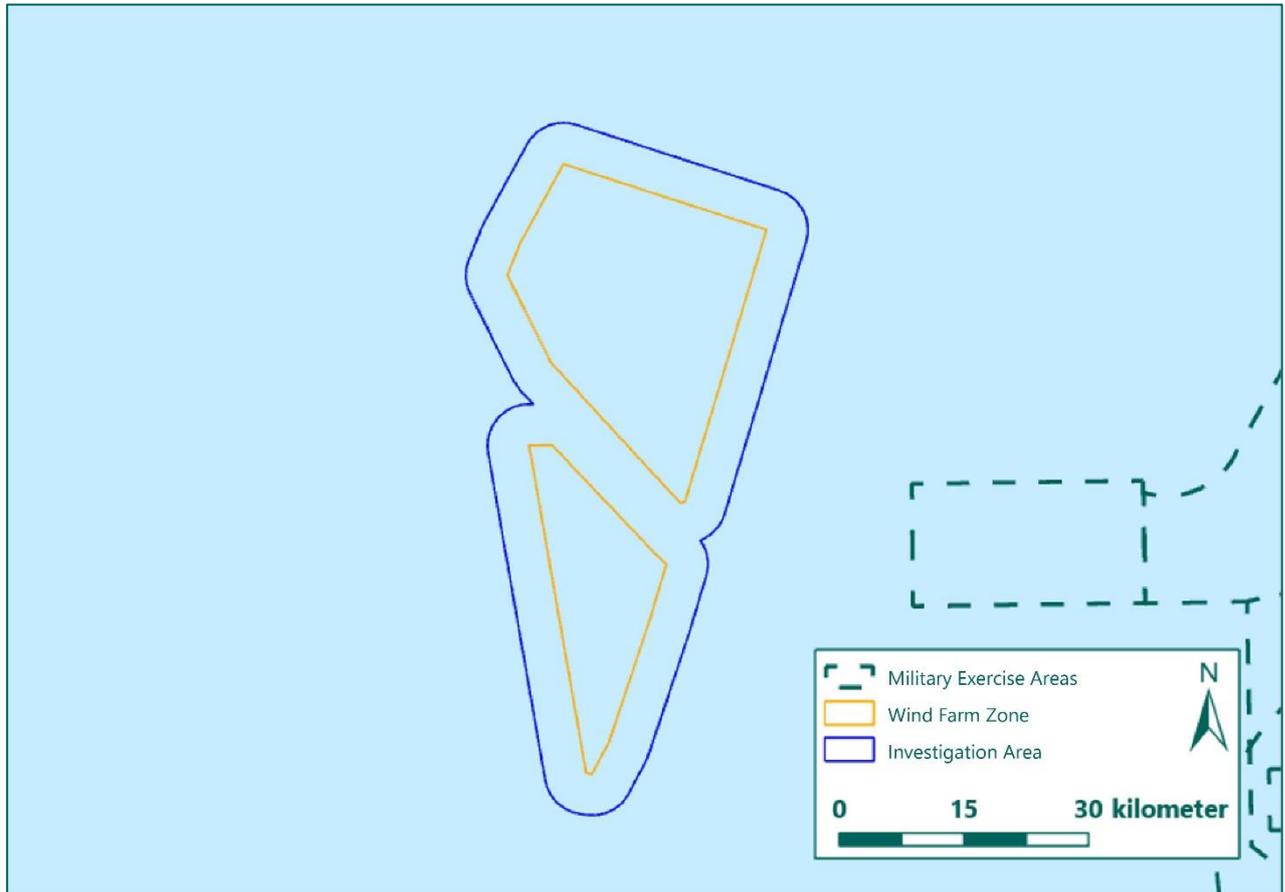


Figure 57: Extract from map Noordzeeloket (Source: Noordzeeloket).

Royal Netherlands Navy Hydrographic service

Naval charts of the Investigation Area have been acquired through the Hydrographic Service. Besides naval charts the HP39 (wreck registry) publication has been consulted to gain information on possible wrecks in the Investigation Area.

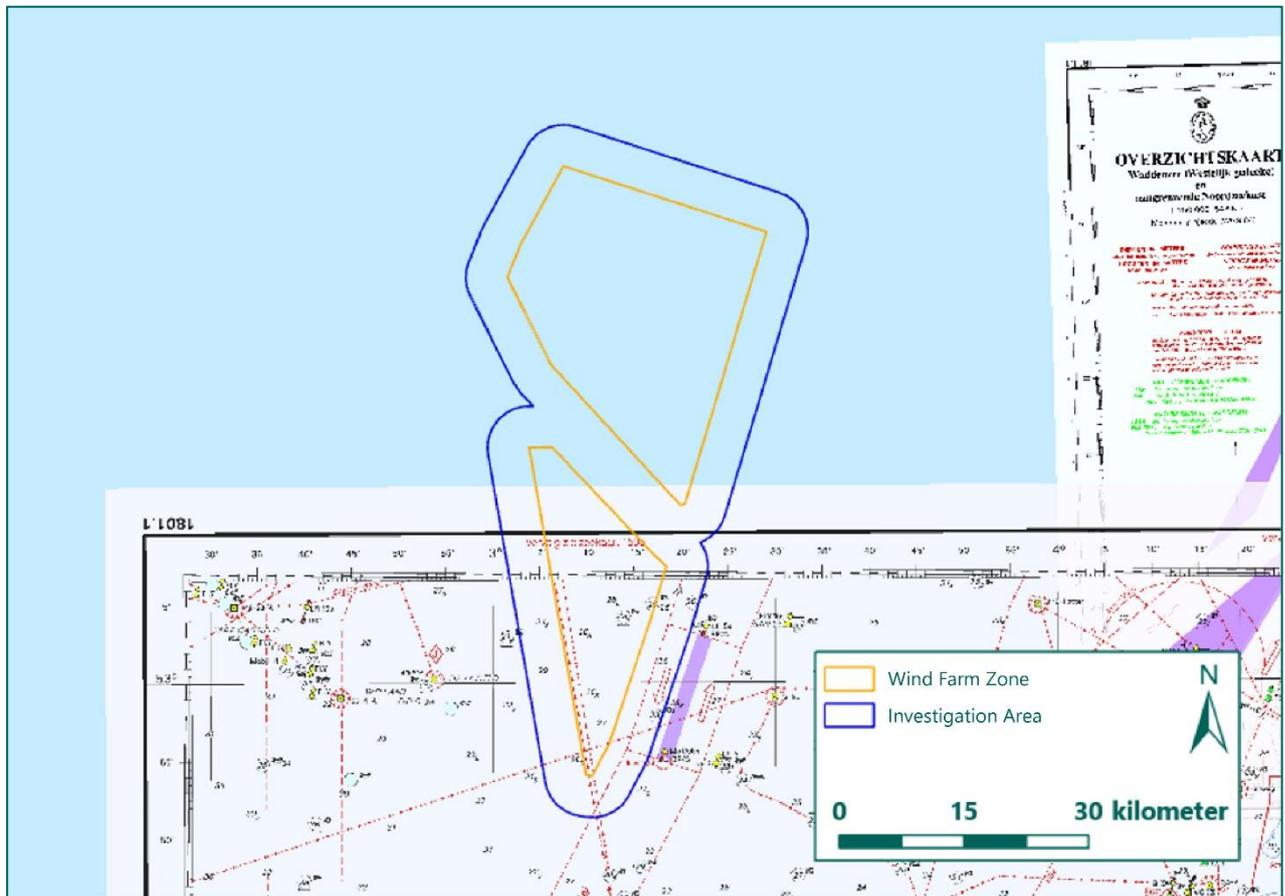


Figure 58: Naval chart.

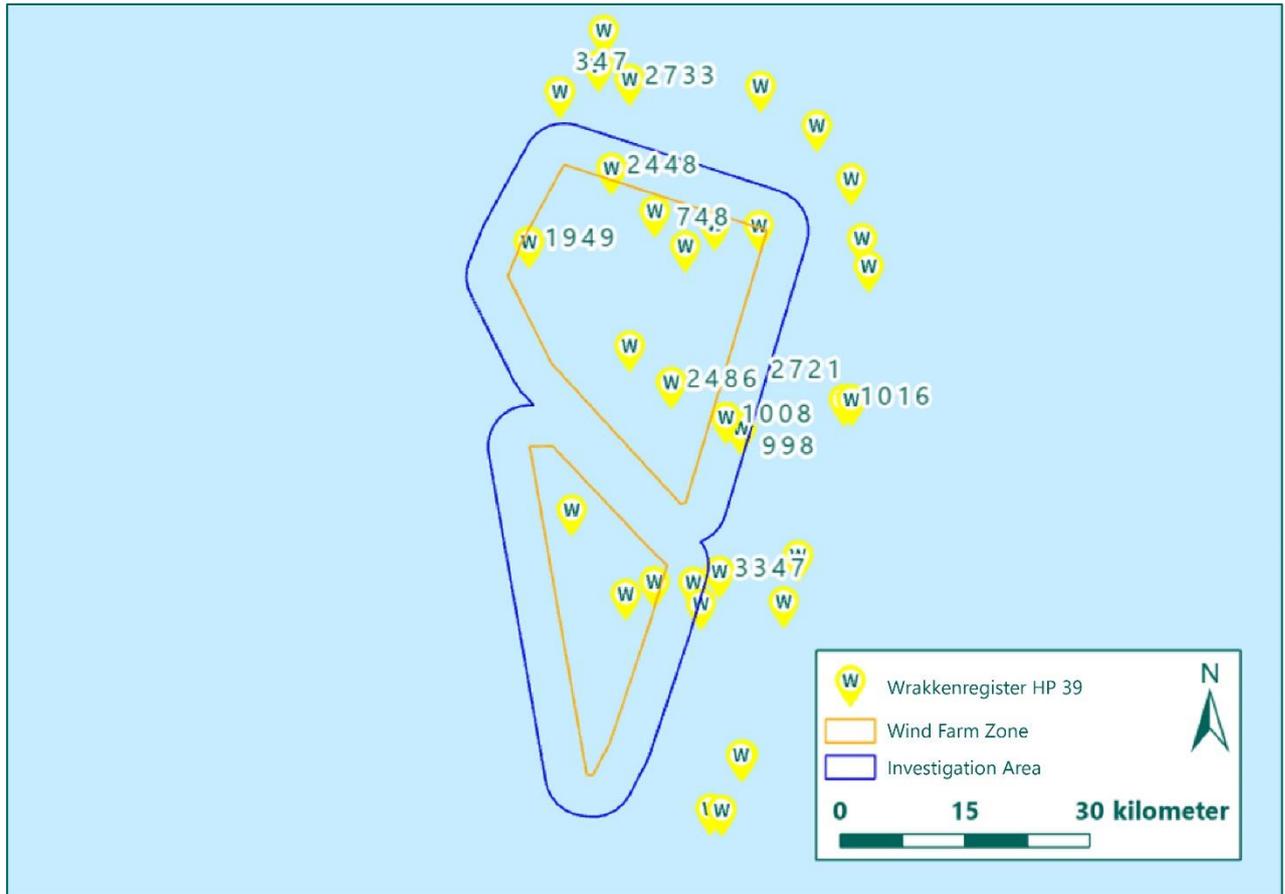


Figure 59: Shipwrecks within the Investigation Area (Source: HP39 Wrakkenregister).

Nr	Ship name	Details
347	Hellenic	No information given
748	Interocean 2	Obstructie met aangegeven minste diepte, afgedregd met dregtuig/lijn of door duiker
998	Nicolaas	No information given
1008	Jannie Jacobe (KW 4)	Wrak met aangegeven minste diepte, afgedregd met dregtuig/lijn of door duiker.
1016	Inge (VM 41)	Wrak met aangegeven minste diepte, afgedregd met dregtuig/lijn of door duiker.
1949	Alpha-H	Wrak met aangegeven minste diepte, afgedregd met dregtuig/lijn of door duiker.
2448	Janne Maria (UK 185)	No information given
2486	Spera B	No information given
2721	Arcola	Wrak met aangegeven minste diepte, afgedregd met dregtuig/lijn of door duiker.
2733	Christine-H (GY 412)	No information given
3347	Zeelandia	Wrak met minst gelode diepte.

Table 31: Wrecks within the Investigation Area of which ship names are known.

### Navy Museum Den Helder

The map collection of the Navy Museum (Marinemuseum) in Den Helder has been consulted. NEMEDRI-maps were found in this collection. These maps offer information on minesweeping and military exercise areas after the Second World War. The following figures are extracts of the NEMEDRI maps, showing the Investigation Area shortly after the war. The Investigation Area lies outside of any military exercise area for the Royal Dutch Marine.

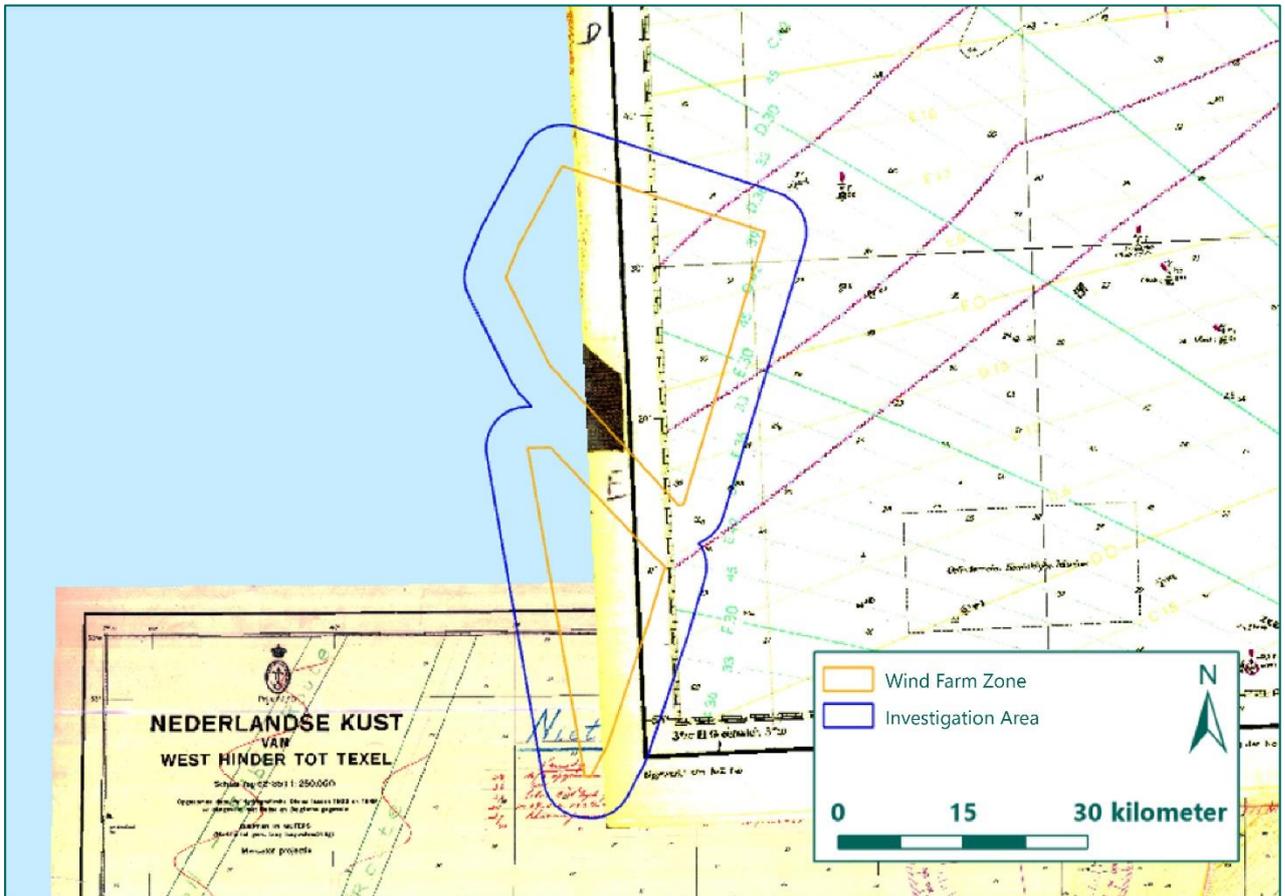


Figure 60: Extract from the NEMEDRI charts 227 (West Hinder tot Texel) and 1037 (Texel to Die Elbe) (Source: Marinemuseum Den Helder).

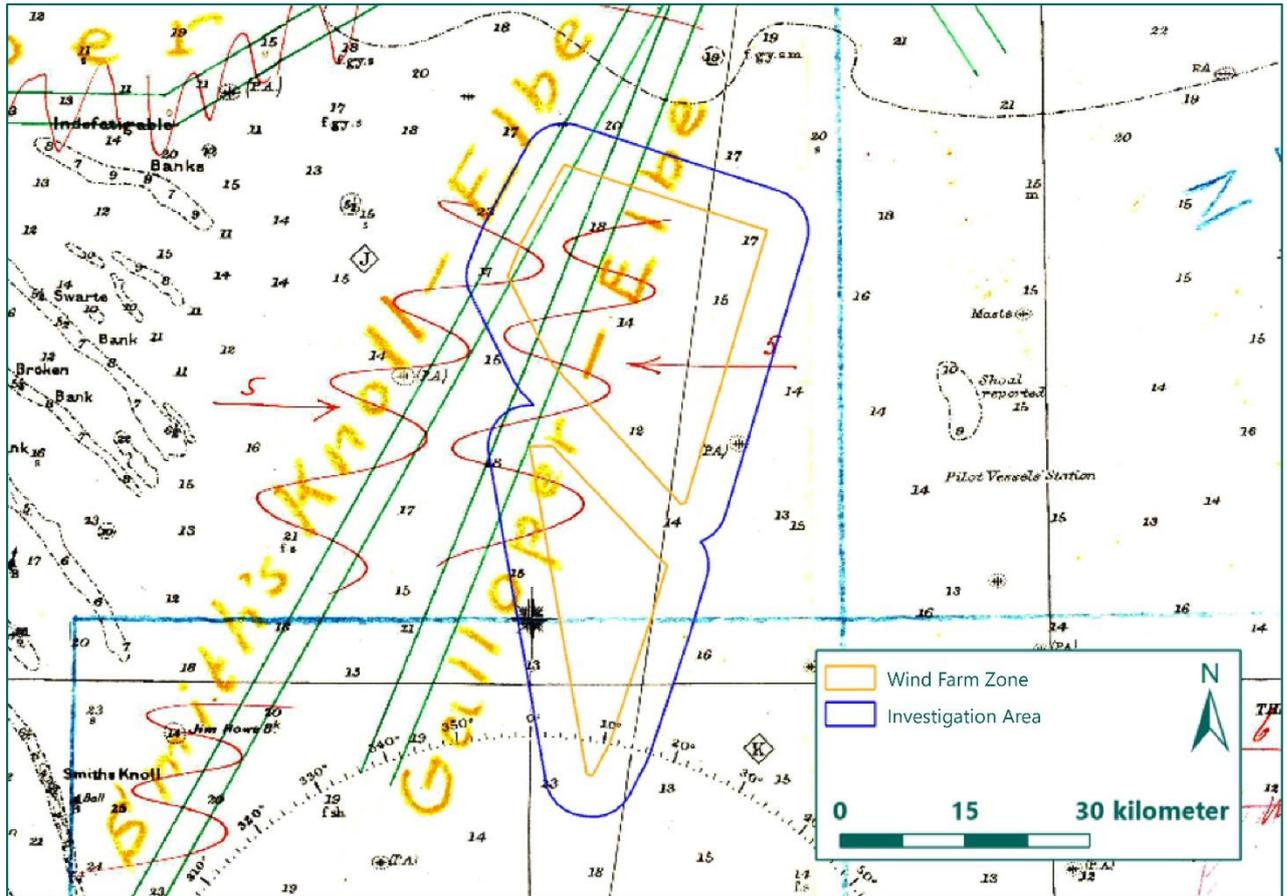


Figure 61: Extract from the NEMEDRI chart 2182 (The North Sea Southern Sheet) (Source: Marinemuseum Den Helder).

## Library of Congress

A map of known minefields on August 18, 1918 is available on the website of the Library of Congress. This map shows the area containing British minefields. No minefields are shown within the Investigation Area.

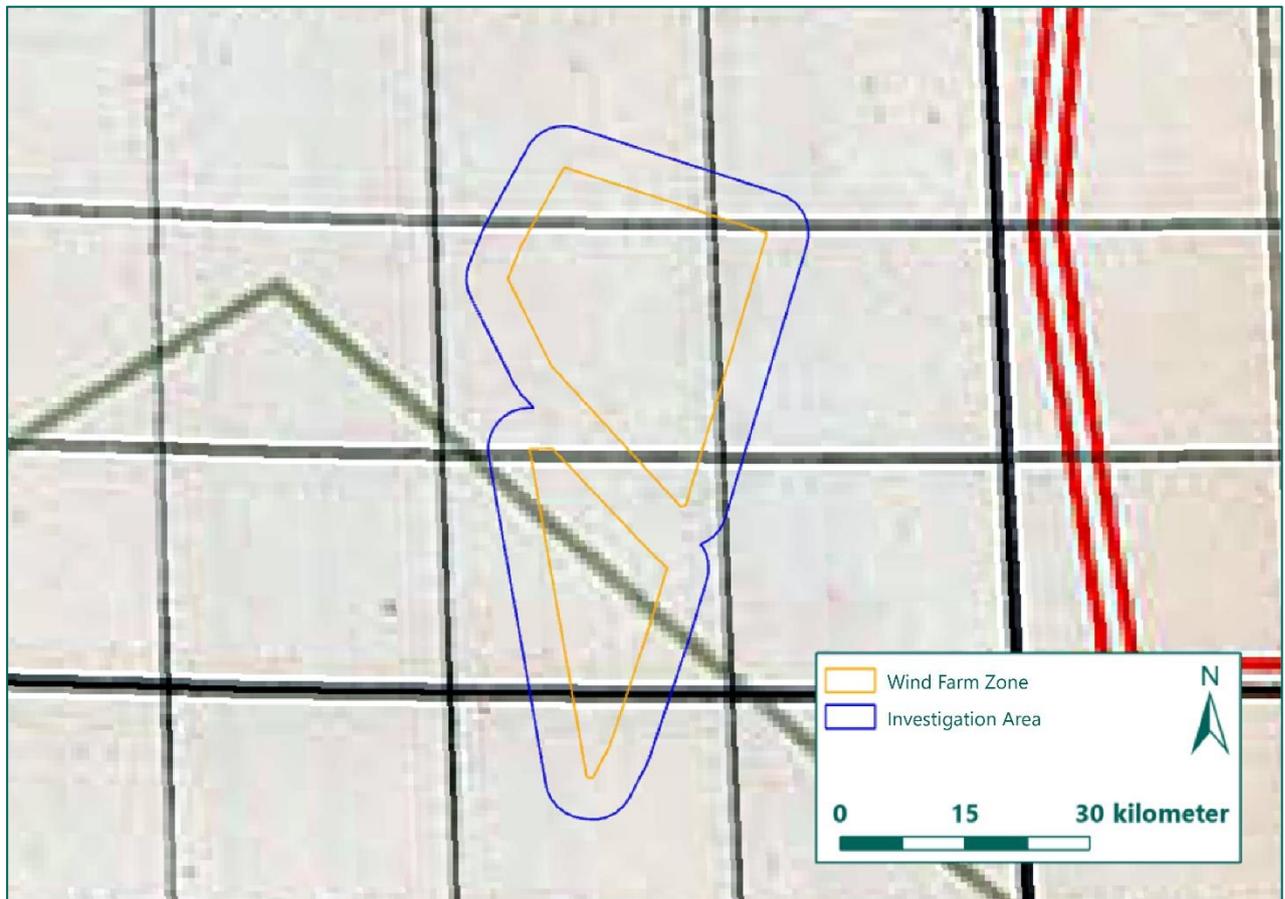


Figure 62: British Islands. Approximate position of minefields, 19th August 1918 (Source: Library of Congress).



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