Netherlands Enterprise Agency

UXO Desk Study

Unexploded Ordnance

Hollandse Kust (noord) Wind Farm Zone

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Author: REASeuro

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Unexploded Ordnance

Site Data Hollandse Kust (noord) Wind Farm Zone

20170705_SDHKNWFZ_REASeuro_UXO Desk Study_EvdBerg_V2_F
July 5, 2017

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ABN AMRO Bank N.V. • IBAN NL09ABNA0475239288 • BIC ABNANL2A • VAT NL81.50.08.387.B01

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Client	:	The Netherlands Enterprise Agency
Document Code	:	20170705_SDHKNWFZ_REASeuro_UXO Desk Study_EvdBerg_V2_F
REASeuro reference	:	72296/RO-170106 version 2.0
Place, date	:	Riel, July 5, 2017
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SUMMARY

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

Historical research

The Hollandse Kust (noord) Wind Farm Zone (HKNWFZ) and its surrounding areas were the scene of many war related activities in World War I and World War II. Due to these events the entire Hollandse Kust (noord) Wind Farm Zone 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 probable presence of generic UXO types within the site based on the evidence gathered about potential UXO sources. See table 6 for the used definitions of terminology for the likelihood of presence.

UXO type	Likelihood of presence	Remarks
Allied HE Bombs	Certain	The area of investigation is located near flight paths of allied bombers. If a plane was badly damaged or under attack, it was common for the crew to jettison their bombs in order to assist their evasion attempts or before landing at their home bases. Allied planes carried out various attacks on ships, convoys and submarines. Air-dropped high explosive (HE) bombs could be present anywhere within the area of investigation. Bombs have been found since 2005 within the vicinity of HKNWFZ.
Naval mines	Probable	The site overlaps with several WWI and WWII minefields. It concerns allied and German mine fields. Despite post-war mine clearance operations, ships still encountered mines and sunk in the post war period. Since 2005 several mines have been encountered in the vicinity of the site.
Artillery shells	Certain	After World War II, some areas in the North Sea were designated for military use by the Dutch Army. A large anti-aircraft shooting area has overlap with HKNWFZ. Since 2005 various shells were encountered within the shooting areas.
	Remote	Prior to WWI coastal guns were already present at the Dutch coast. It concerns Dutch and German coastal guns and anti-aircraft guns. Coastal guns rarely fired in this part of the North Sea. The anti-aircraft artillery however was frequently used. Because of the range of the anti-aircraft artillery, it is less likely that unexploded shells ended up in the area of investigation.
Torpedoes	Remote	There is some evidence for aerial and naval attacks with torpedoes, but no specific information was found for HKNWFZ.
Depth charges	Feasible	Naval and aerial attacks on submarines were carried out with depth charges. No specific information was found for HKNWFZ, but since 2005 some depth charges were encountered in and near the wind farm zone.

UXO Risk Assessment

In dynamic sediment conditions, UXO items are likely to become buried. UXO burial is predominantly due to one or a combination of three mechanisms: burial on impact, scour and bedform migration. The Maximum Burial Depth (MBD) in Hollandse Kust (noord) Wind Farm Zone is assessed to be 3.2 m below seabed. Migrating sand waves with heights up to 2.5 m are normative for the MBD.

Human activity may have a significant impact on UXO migration. Especially dredging and fishing activities have the capacity to move items of UXO. It is not possible to quantify the UXO migration due to human interaction. Therefore human interaction is not a factor in the ALARP (as low as reasonably practicable) sign off certification process. This migration factor is part of the baseline residual risk. The maximum permissible safe time interval between the conclusion of a geophysical UXO survey, UXO clearance operations and the commencement of construction works is assessed to be approximately two years.

The conducted historical research has shown that several calibres of aerial bombs, naval mines and depth charges 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 as low as reasonably practicable (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 and disposal of actual UXO objects.

The provisional magnetometer (MAG) threshold is set on 50 kg ferrous mass. This threshold is also sufficient to detect the ferrous naval mines likely to be present in the area. Also the risk posed by the possible presence of depth charges, torpedoes and large calibre artillery shells will be mitigated sufficiently by using the recommended threshold.

The time, effort and costs involved in mitigating the risk posed by the presence of LMB mines is extremely high, excessive and, within our understanding of ALARP, is not considered to be reasonably practicable. Therefore an Electro Magnetic (EM) survey is not recommended. To enhance the evaluation process it is recommended to perform a Side Scan Sonar (SSS) survey and correlate the SSS data with the magnetometer data.

For the SSS survey the following thresholds are recommended:
- Size: 1.5 x 0.5 m,
- Shape: cylindrical,
- Structure fitted with several small external features.

The required detection range for UXO is to the intended intrusion depth +0.5m (interarray cables) or the assessed MDB (turbine and platform foundations). The likely maximum burial depth (MBD) for an item of UXO can be calculated using the basic formula: MBD = 0 (burial on impact) + 0.6 x 1.2 (UXO diameter) + 2.5 (height of bedform) = 3.2 m. Therefore the maximum required detection range is assessed to be 3.2 m below seabed.

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 assessed in an additional risk assessment based on the (provisional) design of the wind farm and the relevant site data.

It is mandated by the Dutch legislation (WSCS-OCE) 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.

SAMENVATTING

Deze studie is onderdeel van de site data voor het windgebied Hollandse Kust (noord). De bureaustudie bestaat uit een historisch vooronderzoek en een risicoanalyse.

Historisch vooronderzoek
In het windgebied Hollandse Kust (noord) en de omgeving daarvan hebben zich in de Tweede Wereldoorlog diverse oorlogshandelingen voltrokken. Ten gevolge van deze oorlogshandelingen moet het gehele gebied als verdacht gebied worden beschouwd. De soorten Niet Gesprongen Explosieven (NGE) die mogelijk zijn achtergebleven zijn weergegeven in onderstaande tabel. Opgemerkt wordt dat in de tabel de waarschijnlijkheid van aanwezigheid van de verschillende soorten NGE is weergegeven. Deze waarschijnlijkheid is gebaseerd op het verzamelde historische feitenmateriaal. Zie tabel 6 voor de definities van de gebruikte categorieën "Waarschijnlijkheid van aanwezigheid".

NGE soort	Waarschijnlijkheid van aanwezigheid	Opmerkingen
Geallieerde vliegtuigbommen	Zeker	Het onderzoeksgebied bevindt zich nabij de geallierde vluchtroutes. Wanneer een vliegtuig was beschadigd of werd aangevallen, was het voor de bemanning gebruikelijk om de bommen boven zee af te werpen. Geallieerde vliegtuigen voerden veelvuldig aanvallen uit op schepen, konvooien en onderzeeërs. Overal binnen het onderzoeksgebied kunnen vliegtuigbommen zijn achtergebleven. Sinds 2005 zijn diverse bommen aangetroffen in (de omgeving van) het onderzoeksgebied.
Zeemijnen	Waarschijnlijk	Het onderzoeksgebied heeft overlap met diverse WOI and WOII-mijnenvelden. Het betreft zowel geallieerde als Duitse mijnenvelden. Ondanks naoorlogse mijnenveegoperaties liepen na de oorlog nog diverse schepen op mijnen. Sinds 2005 zijn diverse mijnen aangetroffen in (de omgeving van) het onderzoeksgebied.
Artillerie granaten	Zeker	Na WOII werden enkele gebieden in de Noordzee aangewezen als militair oefengebied. Een groot oefengebied voor luchtafweergeschut heeft overlap met het onderzoeksgebied.
	Onwaarschijnlijk	Al voor WOI en gedurende WOII bevonden zich kanonnen langs de Nederlandse kust. Het betreft Nederlandse en Duitse kanonnen. Deze kanonnen hebben echter nauwelijks gevuurd. Wel werd het luchtafweergeschut vaak gebruikt tegen vijandelijke vliegtuigen. Vanwege het bereik van luchtafweergranaten is het niet waarschijnlijk dat deze in het onderzoeksgebied zijn terechtgekomen.
Torpedo's	Onwaarschijnlijk	Er is feitenmateriaal aangetroffen dat wijst op luchtaanvallen en aanvallen met schepen, waarbij torpedo's zijn ingezet. Er is echter geen specifieke informatie aangetroffen op basis waarvan kan worden geconcludeerd dat dit soort aanvallen binnen het onderzoeksgebied hebben plaatsgevonden.
Dieptebommen	Aannemelijk	Er is feitenmateriaal aangetroffen dat wijst op op luchtaanvallen en aanvallen met schepen, waarbij dieptebommen zijn ingezet. Er is geen specifieke informatie aangetroffen op basis waarvan kan worden geconcludeerd dat dieptebommen binnen het onderzoeksgebied zijn ingezet. Wel zijn er sinds 2005 enkele dieptebommen in de omgeving aangetroffen.

NGE Risico Analyse
In dynamische morfologische omstandigheden, zoals aanwezig in de Noordzee, is het waarschijnlijk dat NGE begraven raken. Het begraven raken van NGE kan worden veroorzaakt door één of een combinatie van drie mechanismen: penetratie bij inslag, begraving door erosie en migratie van zandgolven. De verticale afbakening binnen het onderzoeksgebied is vastgesteld op 3,2 m onder de zeebodem. De aanwezigheid van zandgolven met een hoogte tot circa 2,5 m zijn bepalend voor de verticale afbakening.

Menselijke activiteiten kunnen een significant effect hebben op de migratie van NGE. Vooral baggerwerkzaamheden en visserij hebben een grote invloed. Het risico op migratie van NGE ten gevolge van menselijk handelen kan niet worden gekwantificeerd. Het resterende risico wordt gezien als restrisico. De houdbaarheid van de detectiedata wordt op basis van de beschikbare gegevens ingeschat op circa 2 jaar.

Het mogelijke effect van een detonatie op schepen, personeel en omgeving vormt een ontoelaatbaar risiso. Om dit risico tot aanvaarbare proporties terug te brengen zijn mitigerende maatregelen nodig. Aanbevolen wordt om de bron van het risico aan te pakken door het uitvoeren van een NGE-bodemonderzoek voorafgaand aan de uitvoering van grondroerende werkzaamheden.

De voorlopige drempelwaarde voor de magnetometer (MAG) detectie is vastgesteld op 50 kg ferrohoudende massa. Deze drempelwaarde is toereikend om de mogelijk achtergebleven NGE te detecteren.

De tijd, moeite en kosten die gemoeid zijn met het mitigeren van het risico op aanwezigheid van LMB mijnen is excessief en wordt valt in onze ogen daarom niet binnen de definitie van ALARP (as low as reasonably practicable). Om die reden wordt geen Electro Magnetische (EM) detectie aanbevolen. Om de interpretatie te verbeteren wordt geadviseerd om een Side Scan Sonar (SSS) detectie uit te voeren en de SSS data te correleren met de MAG data.

Voor de SSS detective worden de volgende drempelwaarden aanbevolen:
- grootte: 1,5 x 0,5 m,
- vorm: cylindrisch,
- Structuur Uitgerust met verschillende externe appendages.

Het vereiste detectiebereik is gelijk aan de diepte van de grondroerende werkzaamheden vermeerderd met 0,5m veiligheidsmarge of de vastgestelde Maximale Begraaf Diepte (MBD). De maximale begraaf diepte kan worden berekend met de volgende formule: MBD = 0 (indringing bij impact) + 0.6 x 1.2 (UXO diameter) + 2.5 (hoogte zandgolven) = 3.2 m Derhalve is het maximale detectiebereik vastgesteld op 3,2 m onder de zeebodem.

De grootte van de te detecteren gebieden is afhankelijk van het ontwerp, de gekozen installatiemethoden en de geotechnische parameters. De grootte van de te detecteren gebieden dient daarom te worden vastgesteld in een additionele risicoanalyse gebaseerd op het (voorlopige) ontwerp van het windgebied en de relevante gebiedspecifieke informatie.

Ingevolge het Werkveldspecifiek certificatieschema voor het Systeemcertificaat Opsporen Conventionele Explosieven (WSCS-OCE) dient alle in te zetten detectieapparatuur te worden gevalideerd. Het doel van de validatie is het vaststellen van het maximale detectiebereik waarop objecten met een ferrohoudende massa overeenkomstig de vastgestelde drempelwaarde kunnen worden gedetecteerd. Het vastgestelde meetbereik kan vervolgens worden gebruikt om na het verzamelen van de data de detectiediepte onder het zeebed en de dekkingsgraad te controleren.

1. General information

1 GENERAL INFORMATION

The Netherlands Ministry of Economic Affairs has requested "The Netherlands Enterprise Agency" to prepare and collect all site data required for the development of offshore wind farms in Hollandse Kust (noord) Wind Farm Zone. In this context The Netherlands Enterprise Agency (RVO.nl) has commissioned this UXO desk study. In this chapter a general introduction on offshore wind energy is given. Subsequently the area of research for this UXO desk study, the purpose, and main objectives are detailed.

1.1 MOTIVE

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

The road map sets out a schedule of tenders offering 700 MW of development each year in the period 2015 – 2019. The Dutch Government has developed a systematic framework under which offshore wind farm zones are designated. Any location outside these wind farm zones are not eligible to receive a permit. Within the designated wind farm zones the government decides the specific sites where wind farms can be constructed using a so-called Wind Farm Site Decision ('Kavelbesluit'). This contains conditions applicable for building and operating a wind farm on a specific site. The Dutch transmission system operator TenneT will be responsible for grid connection.

Winners of the site development tenders will be granted a permit to build a wind farm according to the Offshore Wind Energy Act (Wet Windenergie op Zee2), a SDE+ grant and offered a grid connection to the main land. The Ministry provides all relevant site data, which can be used for the preparation of bids for these tenders. This UXO Desk Study is part of the site data for Hollandse Kust (noord) Wind Farm Zone.

1.2 AREA OF INVESTIGATION

The Hollandse Kust (noord) Wind Farm Zone (HKNWFZ) is located 10 Nautical Miles off the west coast of the Netherlands. Princess Amalia wind farm (see paragraph 5.3) lies within the HKNWFZ. The area of investigation of this desk study is shown in Figure 1.

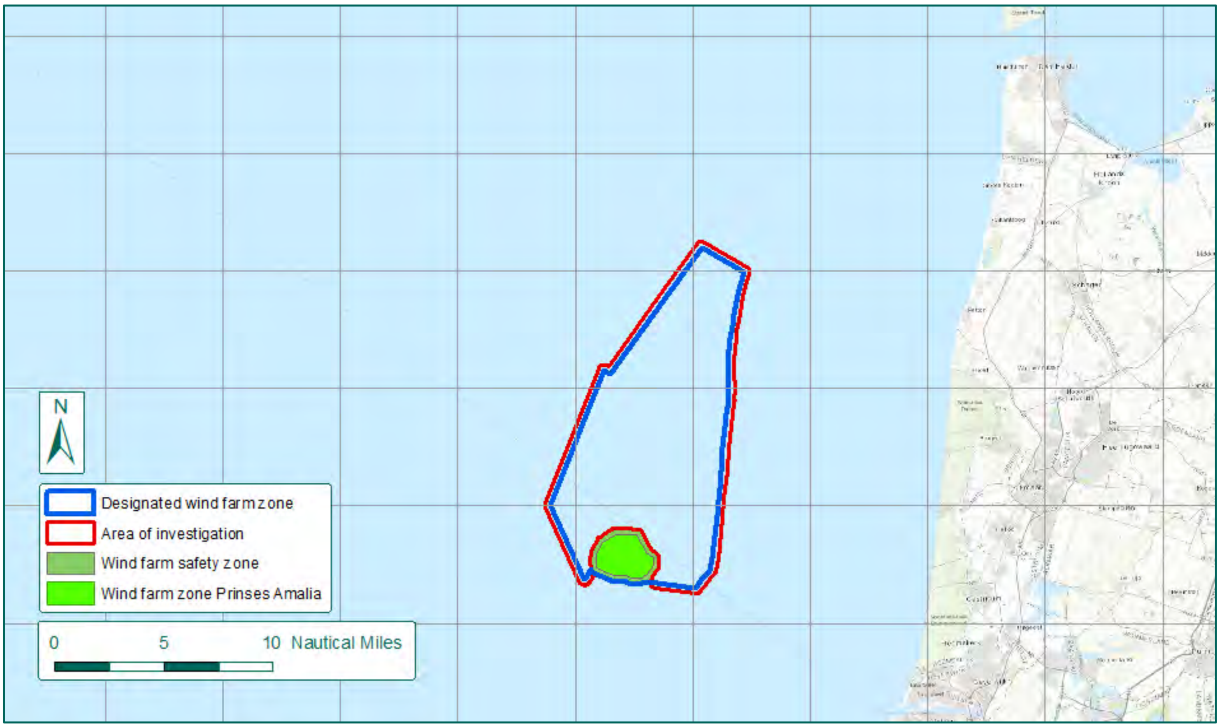

Figure 1: The HKNWFZ area of investigation.

1.3 PURPOSE AND MAIN OBJECTIVES

The purpose of the UXO desk study is to detail the areas within the HKNWFZ which present an increased risk of encountering unexploded ordnance (UXO).

The main objectives of this study are:

1. Identification of possible constraints for offshore wind farm related activities in the HKNWFZ as a result of the possible presence of items of UXO.
2. Identification of areas within the HKNWFZ that could preferably not be selected for the installation of offshore wind farms and/or cables.
3. Identifying the requirements from an UXO perspective that should be taken into account for:
   a. Determining the different concession zones in the wind farm zone.
   b. Carrying out safe geophysical & geotechnical investigations.
   c. Installation of wind turbine foundations.
   d. Installation of cables.

1.4 STRUCTURE OF THE REPORT

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

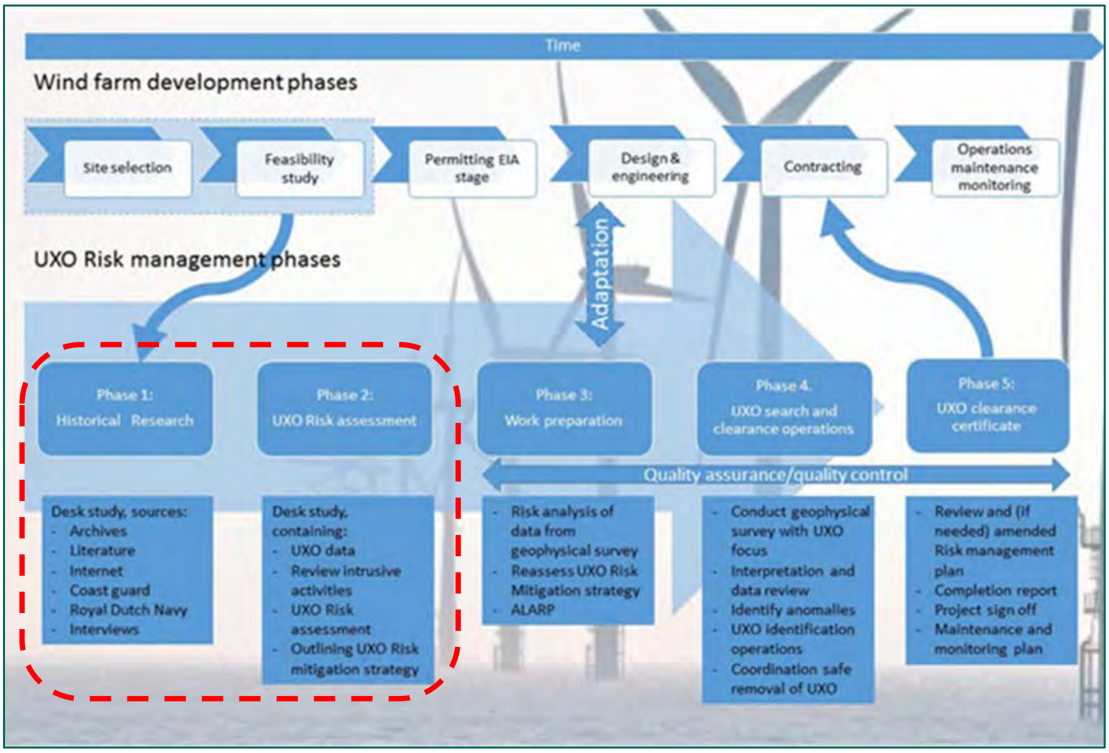

Figure 2: UXO risk management phases.

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 1. 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	- Chapter 2: Appraisal of historical sources - Chapter 3: War related events - Chapter 4: Gaps in knowledge and UXO risk area
Phase II: UXO Risk Assessment	- Chapter 5: UXO burial assessment - Chapter 6: UXO migration assessment - Chapter 7: Hazards of UXO likely to be encountered - Chapter 8: Effects of detonations - Chapter 9: intrusive activities - Chapter 10: UXO Risk Assessment - Chapter 11: Outlining the UXO mitigation strategy - Chapter 12: Geophysical survey methodologies - Chapter 13: Threshold levels to be applied

Table 1: Phases of the UXO risk management and related chapters in this report.

2. Phase I: Historical Research

2 APPRAISAL OF HISTORICAL SOURCES

This chapter describes the consulted sources. An elaboration of each source is given 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 3 of this historical research.

2.1 SOURCES

Detailed historical research is conducted for this UXO desk study. Source material from the following sources has been consulted:

Literature

An overview of used literature can be found in annex 4. 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 area of investigation. The resulting events are shown in chronological order in the tables in annex 4. The references (book and page) for each event are included in the tables.

Crashed planes

The Dutch Air War Study Group 1939-1945 (Studiegroep Luchtoorlog 1939-1945) keeps an online record of all military airplane losses in the Netherlands during WWII. This record is checked and the results are presented in Annex 4.

Ship wrecks

Information regarding the presence of ship wrecks is retrieved form the 'Archaeological Desk Study Hollandse Kust (noord) Wind Farm Zone, conducted by Periplus.

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 5.

Noordzeeloket

The North Sea Desk ('Noordzeeloket') is a cooperation between all Ministries with tasks and responsibilities on the North Sea. The website of this cooperation provides different kinds of information, including the map 'Military Use', see annex 5.

Hydrographical Service, Royal Netherlands Navy

The Sea Map of the Hydrographical Service of the Royal Netherlands Navy were consulted. This map also indicates known wreck sites, wreck remains and foul areas, see annex 5.

Bundesarchiv- Abteilung Militärarchiv (BAMA) in Freiburg, Germany

A variety of records form the Bundesarchiv- Abteilung Militärarchiv in Freiburg were consulted. This section of the German national archive preserves records of the German army from 1495 till 1990. Copies of war diaries, maps, correspondence and aerial photographs are part of the records that were used for this historical research. The results can be found in annex 6.

The National Archives (TNA), London

A variety of data from The National Archives in London were consulted, comprising of Operations Record Books of the British Royal Air Force units such as Second Tactical Air Force, Fighter Command, Coastal Command and Bomber Command.

These information sources were checked for bombardments or other aerial war events that took place within or near the area of investigation. The results are presented in annex 7.

United Kingdom Hydrographic Office (UKHO), Taunton

The UKHO has a large collection of historical maps and charts, including charts of minefields off the Dutch coast. These maps were consulted and the results presented in annex 8.

The National Archives Records Administration (NARA), Washington D.C.

The collection of records from the U.S. National Archives and Records Administration was consulted. It concerns archival materials of the American 8th Air Force, like Mission Reports, aerial photographs, strike photos, and military intelligence reports. The consultation of NARA has not provided relevant data for the area of investigation.

Post-war UXO Clearance

The area of investigation is situated in the North Sea, 12 Nautical Miles off the Dutch coast. Therefore the UXO-related interventions of the Royal Netherlands Navy[1] and the database of the OSPAR Commission[2] were consulted. The results of these consultations can be found in annex 9.

Previous UXO Research

Earlier preformed research has been conducted nearby the area of interest. These studies were checked for relevant information. Results are described in annex 10.

2.2 WAR RELATED EVENTS RELEVANT FOR THE AREA OF INVESTIGATION

Based upon the consultation of the above mentioned historical sources the following war-related events possibly relevant for the area of investigation are identified:

- German and allied minelaying operations,
- Aerial warfare,
- Naval warfare,
- Coastal guns,
- Wrecks of vessels and airplanes,
- Post-war (Second World War) ammunition dump sites,
- Post-war disposal of UXO.

The events mentioned above, happened during WWI and WWII, or in the aftermath of these conflicts. These possible relevant war events are analysed in chapter 3 in order to determine the likelihood of presence of UXO in the area of investigation due to these events.

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1 The Royal Netherlands Navy 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.

2 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.

3. War related events

3 WAR RELATED EVENTS

This chapter discusses the different war related events that possible led to the remanence of UXO in or near the area of investigation. As stated in paragraph 2.2, the war related events are mostly related to World War I and II, or the aftermath of these conflicts. The war related activities are analysed per event for both wars, followed by the analyses of post-war UXO-dumping and artillery exercises.

3.1 NAVAL MINES

Naval mines were used during both World Wars and could have been used as offensive or defensive weapon. During WWI, the North Sea was a major theatre of the war. The British Grand Fleet took position against the German High Seas Fleet. Britain's larger fleet could maintain a blockade of Germany, cutting it off from overseas trade and resources. The German fleet remained mostly in the harbours behind a screen of mines, occasionally attempting to lure the British fleet into battle.

During WWII, German and allied forces laid various defensive minefields along their shores. The German offshore minefields were part of the coastal defence. The belligerent parties also laid mines along each other's convoy routes and harbours. Initially, contact mines were employed, usually tethered at the end of a cable just below the surface of the water. By the beginning of WWII, most nations had developed mines that could be dropped from aircraft, making it possible to lay them in enemy harbours. The following two paragraphs describe the German and allied minelaying activities.

3.1.1 World War I: German Mine Fields

Although the Netherlands remained neutral during World War I, this conflict also bears consequences for the HKNWFZ. The German Navy laid defensive minefields in front of the Dutch coast during the First World War. Two German minefields lay approximately 4.6 NM (8.5 km) south of the HKNWFZ, see Figure 3. These minefields intersect with Hollandse Kust (zuid) Wind Farm Zone. Research in the Bundesarchiv (Freiburg) yielded fragmented information about German World War I minefields. However, information regarding these minefields was not found. The World War I minefields only contained moored mines. The German E-Mine, see annex 3, was most common during WWI.

Figure 3: German WWI minefields near the area of investigation.

During WWI about 430 German mines washed ashore the Dutch coast (see annex 3). Since 2005, a moored contact mine was encountered in the vicinity of the area of investigation (see annex 9). The specific type of the encountered mine is not reported. Therefore, it is not known if the encountered mine was a World War I mine.

3.1.2 World War II: German minelaying

German minelaying near the HKNWFZ started on 10 May 1940. German airplanes deployed magnetic mines (LMA mines, *Luftmine A*) in front of IJmuiden harbour. Four days later, German planes laid LMA and LMB (*Luftmine B*) mines if front of the Dutch coast. Approximately 24 mines of each type were dropped in the zones near Texel, Den Helder and IJmuiden (see annex 4).

In the Bundesarchiv – Militärarchiv (see annex 6) a selection of naval minefield charts were consulted. These charts provide a complete overview of all German laid minefields. The German minefields are indicated on a map, see Figure 4. Each minefield has its own number, which refers to an index that provides information about the quantity, type of mines, the date on which the field was laid, and the positional coordinates. An example is given in Figure 5.

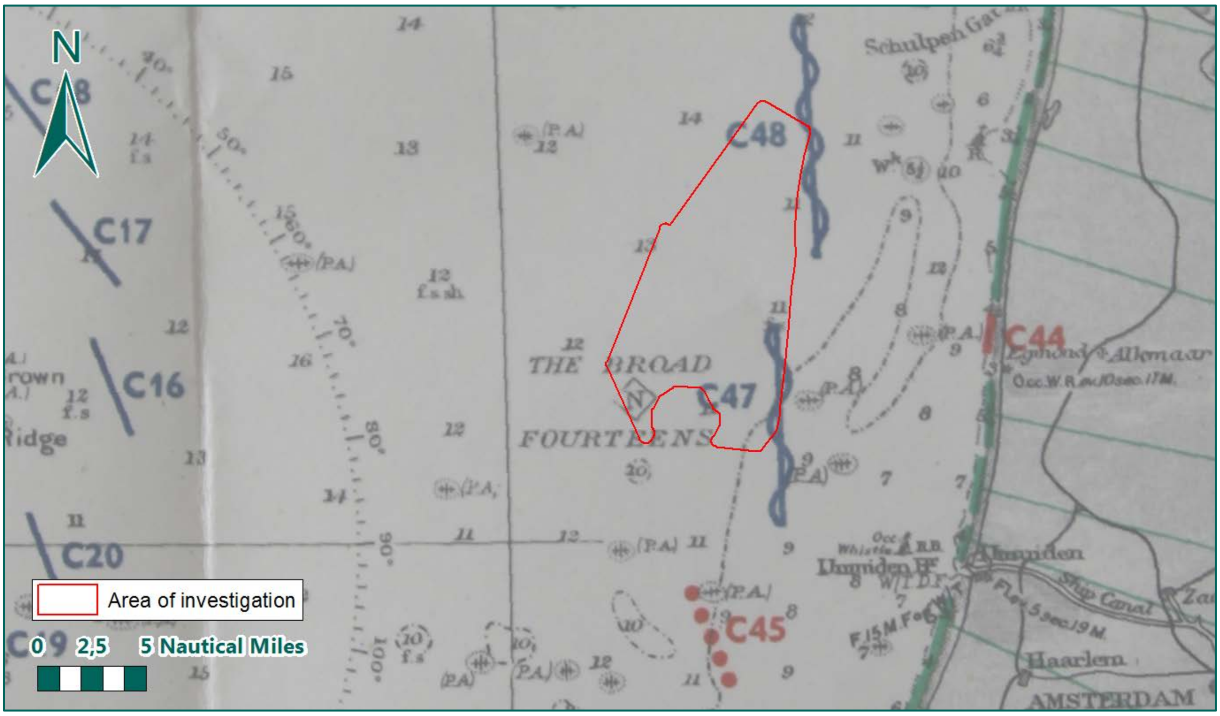


Figure 4: German Minelaying 1939-1945. (Source: annex 6, BAMA, ZA 5/50).

CHART "C" - SOUTHERN NORTH SEA (Continued)

Ref. No.	German No.	Date laid	POSITION	Degree of accuracy in miles	CONTENTS: LINES etc. (in German)	CONTENTS: UNITS (in German)	M or G	DEPTH (in feet)	SPACING (in yards)	LINES: No.	LINES: SPACING (in yards)	REMARKS
C39	6	9/39	54 23.5 N 05 37.0 E 54 32.0 N 05 25.0 E	2	174 EMC and EMD 202 XpFl		M M	4-15 35-50		{2 1}	330	Half with AE Switch at 15 feet. Half without AE Switch at 4 feet. (Comment - Not shown on German charts. Probably considered safe.)
C40	6a	7/42	54 55.0 N 05 44.0 E 54 36.2 N 05 20.5	2	400 EMCII 400 XpFl		M M M	12 23-33		2 1	330 165	With 100 ft. Tombac tubing.
C41	7	9/39	54 30.0 N 05 10.0 E 54 40.3 N 05 02.0 E	2	174 EMC and EMD 202 XpFl		M M	4-15 35-50		{2 1}	330	Half with AE Switch at 15 feet. Half without AE Switch at 4 feet. (Comment - Not shown on German charts. Probably considered safe.)
C42	8	9/39	54 43.5 N 05 00.0 E 54 54.0 N 04 53.0 E	2	174 EMC and EMD 202 XpFl		M M	4-15 35-50		{2 1}	330	Half with AE Switch at 15 feet. Half without AE Switch at 4 feet. (Comment - Not shown on German charts. Probably considered safe.)
C43) B4)	9	9/39	55 01.0 N 05 51.5 E 55 13.3 N 05 51.0 E	2	174 EMC and EMD 202 XpFl		M M	4-15 35-50		{2 1}	330	Half with AE Switch at 15 feet. Half without AE Switch at 4 feet. (Comment - Not shown on German charts. Probably considered safe.)
C44	SWK3	6/44	52 37.5 N 04 36.0 E 52 39.0 N 04 36.3 E	.25	22 LMB		G	30	250	2	165	Mean MINE spacing 125 yds.
C45	SWKA-1b	9/44	52 26.5 N 04 13.5 E 52 22.8 N 04 16.6 E	.5	72 LMB	DM-1	G		240	2	165	Mean MINE spacing 120 yds. Arming delay 24 hours (?)
C46	SWKA-2	9/44	52 20.2 N 04 12.5 E 52 13.6 N 04 05.5 E	.5	124 LMB	DM-1	G		260	2	165	Mean MINE spacing 130 yds. Arming delay 24 hours.
C47	SWKB-1	11/44	52 30.0 N 04 20.0 E 52 39.0 N 04 20.0 E	1	160 EMC 40 StCtr		M) M)	10	270	3	220	With chain 4 mines to 1 obstructor. Mean spacing 135 yards.
C48	SWKB-2	11/44	52 42.0 N 04 23.0 E) 52 53.0 N 04 23.0 E)	½-1	160 EMC) 40 StCtr)		M	10	330	3	330	Mines with chain. Four mines to one obstructor. Mean spacing 150 yards.

Figure 5: Summary of German Minelaying. (Source: annex 6, BAMA, ZA 5/44).

Based on this map and charts, it appears that the area of interest has overlap with the following two German minefields:

- C.47: 160 EMC mines (moored contact mine) and 40 static cutter sweeping obstructers
- C.48: 160 EMC mines (moored contact mine) and 40 static cutter sweeping obstructers

These minefields were laid in November 1944. The mines and obstructers in C.47 and C.48 were laid in three separate lines, with a spacing of approximately 200 meters (C.47) or 300 meters (C.48). A chain of four mines was attached to one obstructer. The sweeping obstructers were equipped with cutters to disable minesweeping gear.

Besides above mentioned minefields, two mine fields were located in the vicinity of the area of investigation. At approximately 7.6 NM (14 km) to the south of the HKNWFZ was minefield C.45. This minefield consisted of 72 LMB ground mines that were laid in two separate lines with a spacing of approximately 150 meters. This field was laid in September 1944.

Minefield C.35 is a much larger field and was laid in October 1943, see Figure 6. The information of the Bundesarchiv states that eight mines were missing from the south end of the centre line. The historical information about the exact amount and type of mines is ambiguous. According to the sources 240 or 340 mines were laid in three separate lines with a spacing of approximately 146 meters. Furthermore, a document in the Bundesarchiv mentions LMB mines (ground mines), while the map and the Summary of Enemy mine laying refer to UMB mines (moored contact mine against U-boats). Based upon these documents, the exact type of mines in C.35 cannot be specifically determined.

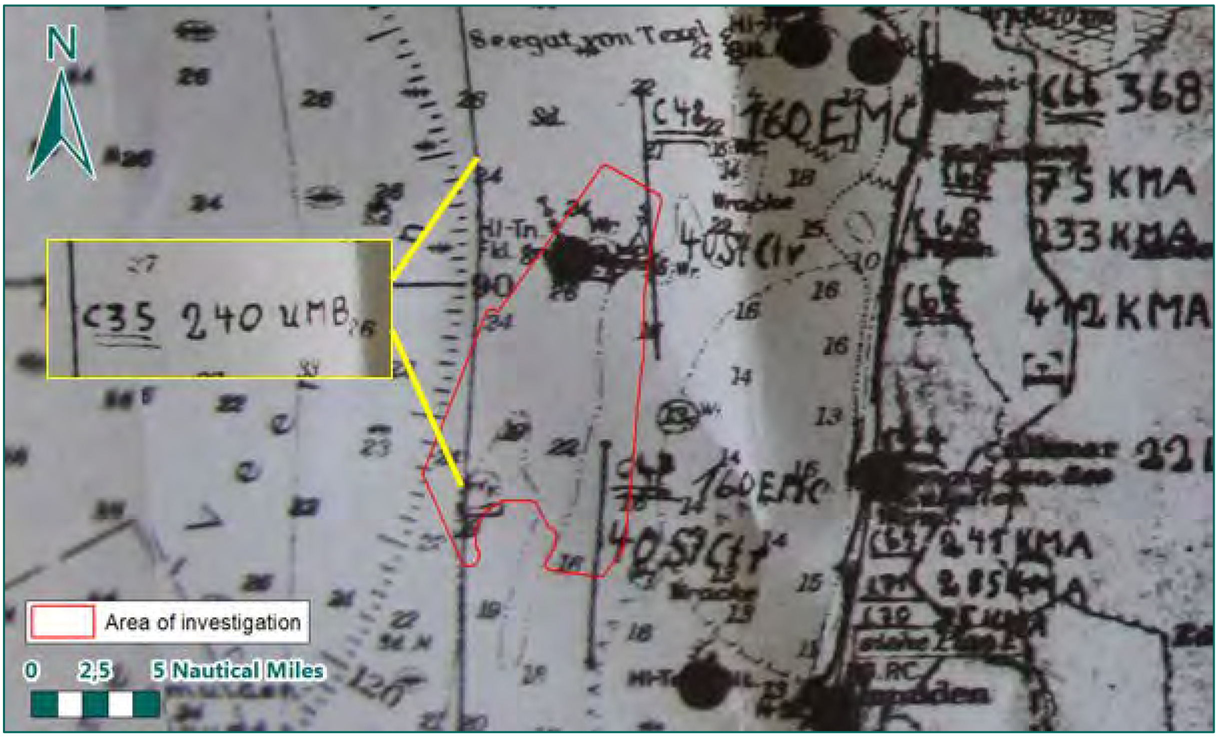


Figure 6: German minefield C.35. (Source: annex 6, BAMA, ZA 5/27).

The post-war UXO encounters show that an LMB mine was encountered at 2.7 NM (5 km) from the HKNWFZ (see annex 9). This mine may be related to the aerial laid mines in May 1940, to minefield C.45, or possibly to minefield C.35. Besides this particular LMB mine, two other mines were encountered near the area of investigation. One was a moored mine.
Specific detailed information about the second mine is lacking in the reports. It is not known if these mines were German mines. If so, the mines may be related to the German minefields in or around the vicinity of the area of investigation. The encountered mines may also be of British origin, as is discussed in the next paragraph.

3.1.3 World War II: British minelaying

British forces laid mines near the Dutch coast with surface vessels (motor torpedo boats, motor gun boats and destroyers) and aircraft.

In May 1940, during the German advance in the Netherlands, Belgium and France, British minelayers laid mines in front of the Dutch coast as a defensive measure against German vessels. These were the so called 'CBX' operations. On 10 May, 1940, the HMS Princess Victoria laid 236 Mk XIV/XVII mines in front of the Dutch coast during operation CBX. HMS Intrepid laid 60 Mk XIV/XVII mines in front of the Dutch coast during operation CBX 2. Both minefields have overlap with the area of investigation, see Figure 7.

This figure shows red shaded areas closer to the Dutch coast. British vessels also laid mines into these zones. This were the so called 'QU' operations. From November 5th 1942 to April 23rd 1944, more than 1.000 mines of various types (e.g. A Mk I-IV and Mk XVII) were laid in these areas.

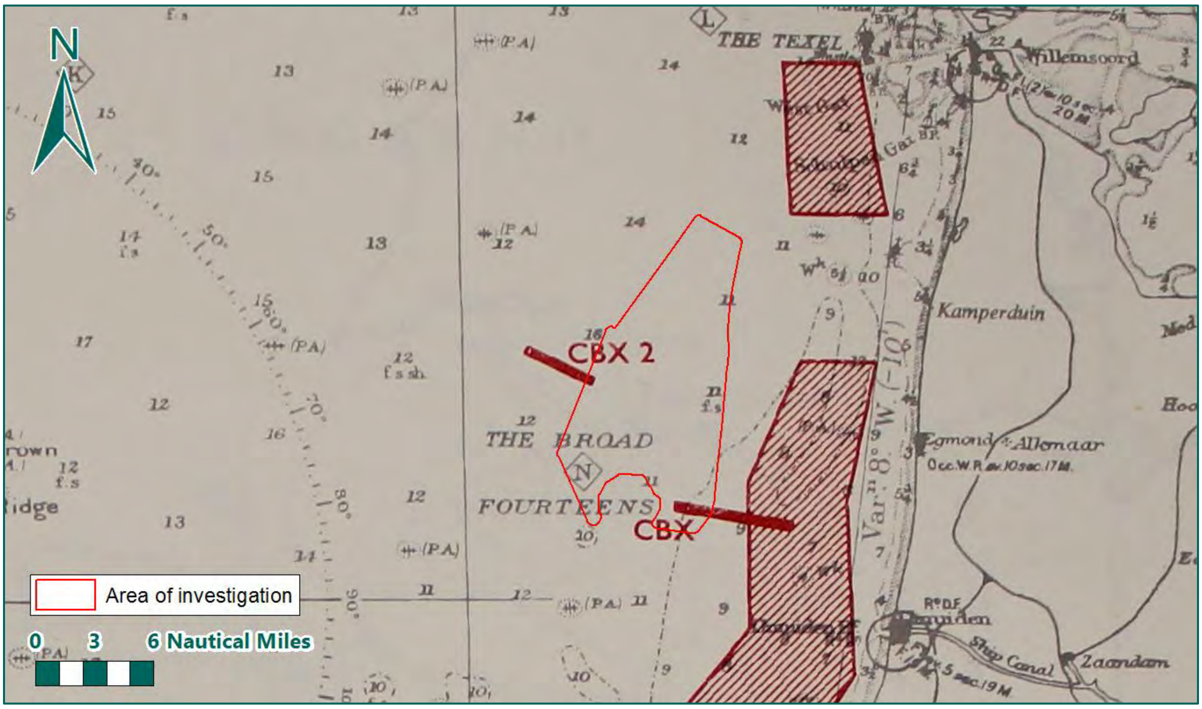


Figure 7: Minelaying by surface craft off the French, Belgian and Dutch coast between Cap Griz Nez and the Texel May 1940 to May 1944. (Source: annex 7, TNA, ADM 243/560).

The consulted literature (see annex 3) highlights various minelaying operations that were conducted by the aircraft of Bomber Command and Coastal Command. These operations are also recorded in archival documents of The National Archives.

During the war, Bomber and Coastal Command squadrons strategically placed mines in the Northwest European waters to reduce German shipping, immobilize harbours and hinder shipping traffic in rivers that feed factories and cities. These naval minefields were called ‘gardens’ and each field had a code name referring to vegetables, flowers, trees or fish.

Figure 8: Gardening fields near the HKNWFZ.

As indicated in Figure 8, two garden fields lay in the vicinity of the area of investigation. These garden fields were mined earlier in the year 1944 by the British coastal forces. Later during the year, with the lengthening of the days, the nights became too short for the Coastal Forces operations. The garden fields passed to Bomber Command for aerial mining. Both garden zones lay at least 3.2 NM (6 km) from the wind farm zone.

Because of the British minelaying operations in May 1940 it is likely that moored mines could have remained within or near the area of investigation. Because of the distance between the area of investigation and the closest garden fields, it is less likely that mines from QU operations and garden operations are present in the area of interest, but it cannot be excluded. Both QU and gardening operations consist of large areas, in the vicinity of the area of investigation, in which mines were dropped.

3.1.4 Post-war mine clearance

After World War I, 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. This 'clearing' was carried out by sweeping a cable with anchors below the water surface. The cable was dragged by two ships.

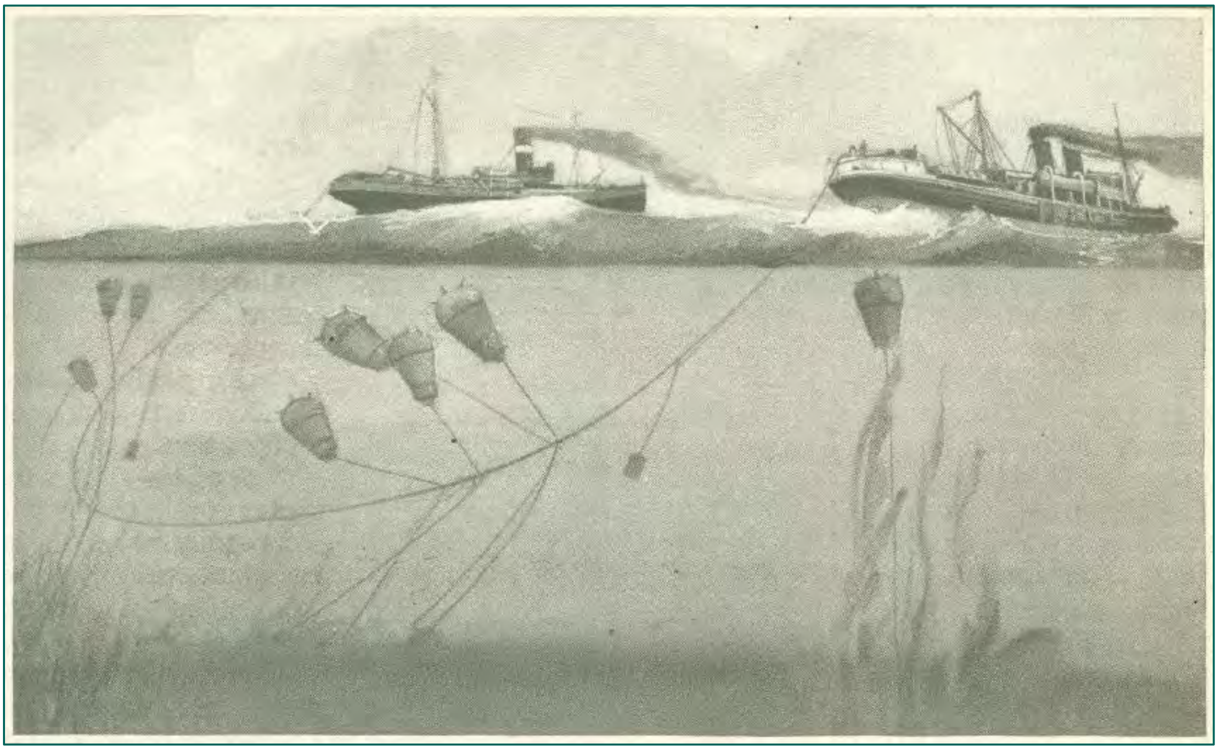


Figure 9: Post WWI mine sweeping. (Source: http://www.digitalhistoryproject.com/2012/06/submarine-mines-in-world-war-i-byleland.html).

Mines also continued to pose a danger to shipping after World War II. In order to combat this threat, a large scale minesweeping campaign was set up. The HKNWFZ was situated in the Dutch sweeping zone. Charts of the Marinemuseum (see annex 5) show that a large part of the HKNWFZ was a designated danger area. Minesweeping was conducted with a variety of methods. Moored mines were usually swept with Oropesa sweeping gear[3].

[3] 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.

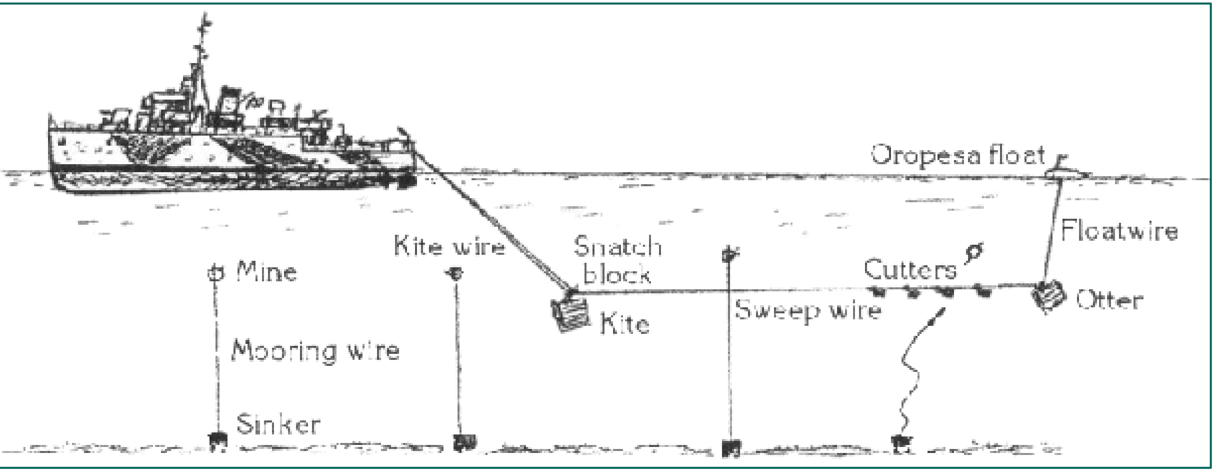


Figure 10: Oropesa sweeping (source: 'The 'Art' of Minesweeping', 27 May 2013, http://www.minesweepers.org.uk/sweeping.htm, consulted 6 December 2016).

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.

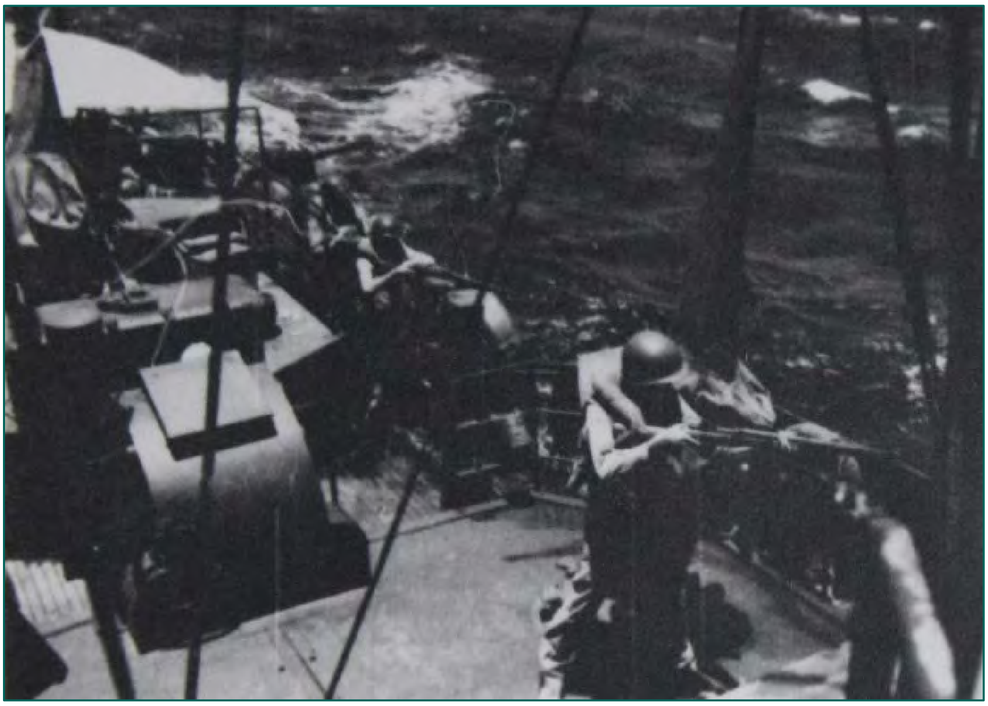


Figure 11: Mine disposal team preparing to fire on swept mines. (Source: TNA, ADM 199/154).

The efficiency of minesweeping was poor. Despite intensive post-war clearance operations, the sea bottom is still littered with unexploded mines. Nowadays, fishermen and dredging ships still encounter naval mines on a regular basis.

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.

3.1.5 Conclusion on naval mines

Minelaying events relevant for the HKNWFZ are processed in the paragraphs 3.1.1 to 3.1.4. It became clear that a variety of minelaying operations took place in or in the vicinity of the area of investigation. During World War I, two German minefields were present to the south of the area of investigation. The area of investigation has overlap with two German (C.46 and C.48) and two British WWII minefields (CBX and CBX 2). Furthermore, during World War II two German minefields (C.35 and C.45) and three British minefields (QU, Trefoil and Whelks) were present in the vicinity of the wind farm zone.

The following table shows the types of mines that may be present in the HKNWFZ, according to the consulted historical sources. The likelihood of presence is defined in paragraph 4.2. It must be highlighted that this table is based on the minefields actually present in the area of investigation. According to the consulted historical sources, the types of mines mentioned in Table 2 are considered the most plausible types of mines to be present in the area of investigation. Moored mines are most likely to have lost their buoyancy and sunk on the seabed.

Naval mines and sweeping obstructers in the HKNWFZ
World War II
German EMC moored mines
German static cutter sweep obstructers
• This types were laid in the minefields C.47 and C.48, which have overlap with the area of investigation
British Mark XIV moored contact mines
• During operation CBX and CBX 2 in May 1940, this type of mines was laid in two minefields that overlap the area of investigation.
British Mark XVII moored acoustic mines
• During operation CBX and CBX 2 in May 1940, this type of mines was laid in two minefields that overlap the area of investigation.

Table 2: Expected types of naval mines.

3.2 AERIAL WARFARE

Aerial Warfare came into existence during WWI and was further developed during WWII. Germany depended on an air force that was closely integrated with land and naval forces. Germany downplayed the advantage of fleets of strategic bombers, and was late in appreciating the need to defend against allied strategic bombing. By contrast, Britain and the United States initially took an approach that greatly emphasized strategic bombing and to a lesser degree, tactical control of the battlefield by air, and adequate air defences. They both built a strategic force of large, long-range bombers that could carry the air war to the enemy's homeland.

3.2.1 Flight paths of allied bomb raids

An around-the-clock campaign attacked German occupied territory, with British bombers at night and U.S. aircraft during the day. From 1942 onward, the intensity of the British bombing campaign against Germany and German occupied territory became less restrictive, increasingly targeting industrial sites and eventually civilian areas. By 1943, the United States had significantly reinforced these efforts. The controversial fire bombings of Hamburg (1943), Dresden (1945), and other German cities followed. Depending on the target, allied bombers flew various routes above the North Sea and the Continent. An example of a flight path is given in Figure 12.

As in WWI, navigation was not as developed as nowadays. It occurred that pilots could not locate their primary or alternative targets. To avoid the risk of a landing with bombs, bombers often jettisoned their bomb load in the North Sea on the way back to England. Besides that, bombers could also jettison their bombs in case of an emergency, e.g. due to mechanical problems or damage by enemy anti-aircraft-artillery. In that case the bombs were jettisoned in order to reduce weight and, increase the chance of reaching friendly territory. Bomb loads could be jettisoned in a safe or armed condition. Safe condition means the initiation device fitted within the bombs were not in there armed state. Specific information about the positions of these jettisons are often lacking, most logbooks simply state 'jettisoned in the North Sea'.

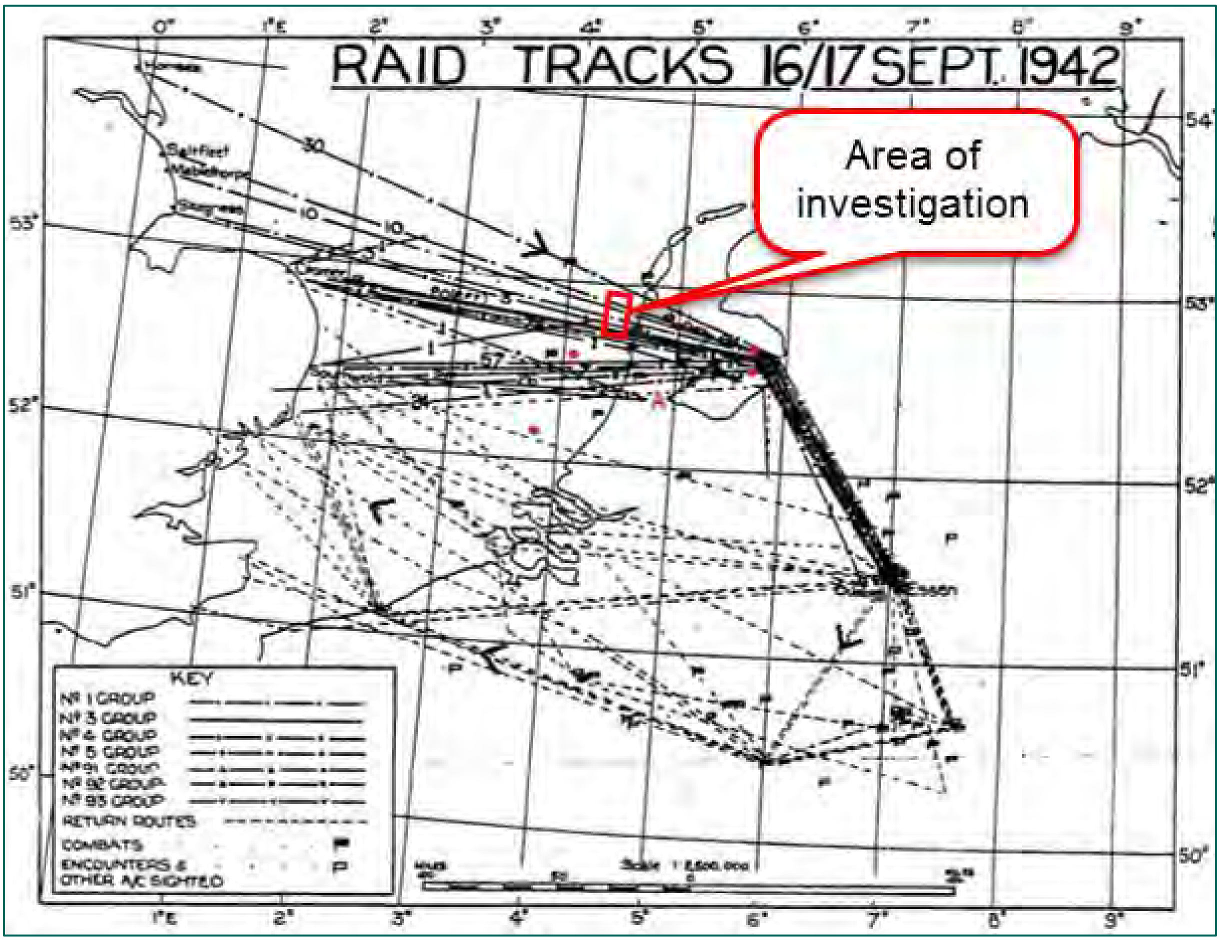


Figure 12: Example of allied flight paths used for a bomber attack on Essen, night of 16/17 September 1942. (Source: http://www.zzairwar.nl/dossiers/541.html).

Since allied bombers frequently flew over the North Sea, also near the area of investigation, it is highly likely that aerial bombs were jettisoned and still remain in the North Sea. Approximately half of the UXO encounters in the North Sea are air dropped bombs.

3.2.2 Aerial attacks on ships and convoys

Besides allied bombing raids in German occupied territory and on the coast, allied planes also attacked enemy ships and convoys. Most attacks on ships and convoys were conducted by planes of Coastal and Bomber Command and occasionally by Fighter Command. A brief selection of attacks on ships and convoys, based on literature (see annex 3) are given in Table 3.

Date	Event
28 May, 1940	Coastal Command. Swordfishes attacked three motor torpedo boats 60 km west-north-west of IJmuiden. Results from this patrols were not reported.
11 September, 1940	Bomber Command. Nine Blenheim bombers on sea sweep and ports reconnaissance. One aircraft bombed a convoy off Dutch coast.
18 March, 1941	Coastal Command. A Blenheim bomber attack a Dutch fishing trawler 70 km north west off IJmuiden with two small bombs. Near misses.
2 August, 1941	Bomber Command. One Blenheim attacked two small trawlers 5 km west off IJmuiden. However, the bombs fell wide from target.
6 January, 1942	Coastal Command. Four Hudson bomber patrolling the Dutch coast. One Hudson attacked 20 km north-north-west off IJmuiden a 1.000 ton ship. Results were not observed.

Table 3: Examples of aerial attacks on ships and convoys. See also annex 3 for additional attacks.

A ship is a relatively small moving target, hence difficult to hit with aerial bombs. For allied pilots the only certitude to strike a ship, was by flying quite low and dropping the bombs just above the ship. This means that planes had to fly a few meters above the sea and had to pull up in front of the target. The bombs hit the ship shortly after and were equipped with a time delayed fuse. This ensured the pilots would have enough time to get to a safe distance prior to detonation. This tactic made airplanes vulnerable for the ships anti-aircraft guns. Notwithstanding the pilot's courage, sinking ships was quite difficult. Furthermore, the planes could only carry bombs of smaller calibres, such as 100 lbs, 250 lbs and 500 lbs. More effective were attacks with torpedoes. Torpedoes were dropped from planes flying less than 30 meters above the sea, about 600 meters distance from the target. Figure 13 and Figure 14 give an impression of aerial attacks on convoys in front of the Dutch coast near IJmuiden. The aerial photographs below are available in the Imperial War Museum, London.

Figure 13: Oblique aerial photograph taken during an anti-shipping strike by Bristol Beaufighter on a heavily-armed northbound convoy off IJmuiden, Holland. The arrowed vessel is a 'Sperrbrecher' (magnetic-mine detonating vessel). (Source: http://www.iwm.org.uk/collections/item/object/205023235).

Figure 14: Low-level oblique aerial photograph showing a Lockheed Hudson of No. 59 Squadron dropping its torpedo during an attack by six aircraft on an enemy convoy off IJmuiden, Holland. (Source: http://www.iwm.org.uk/collections/item/object/205023107).

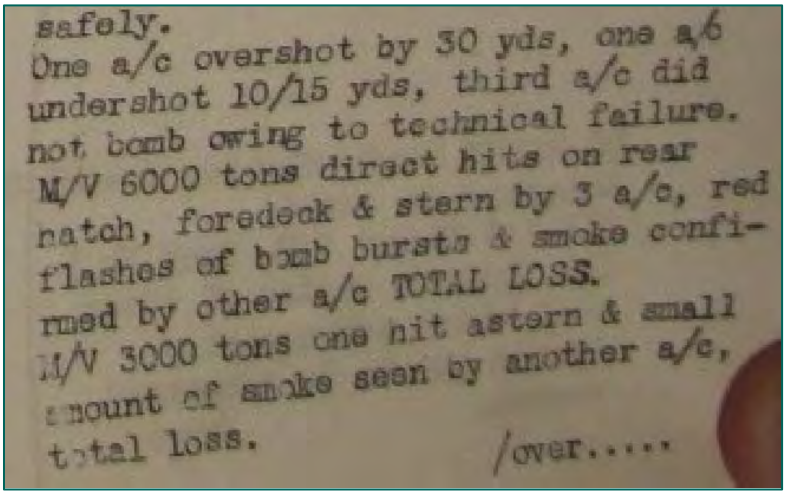
Next to surface ships and vessels, allied aircraft also targeted U-boats. An effective weapon against U-boats were depth charges. According to the post-war munition encounters, a depth charge was encountered within the area of investigation (see annex 9).

Allied attacks on ships and convoys are also documented in the Operations Record Books of Bomber Command and Coastal Command, see annex 7. The records refer to coordinates and the locations where attacks took place. Some examples are presented in Figure 15.[4]

[4] It should be noticed that this is only a momentum. For the past two years, REASeuro undertook several visits to the National Archives in London. Each visit results in thousands of copies of records of the British Admiralty and Air Ministry during WWII. These copies contain a large amount of information about Allied operations. Making this information accessible is a long and ongoing process. That no 'hits' for aerial attacks in HKNWFZ were found, does not mean that aerial attacks did not took place.

An extract of an Operations Record Book from a Bomber Command attack on 14 July, 1941 is shown in Figure 16. The terms 'overshot' and 'undershot' indicate that bombs fell too far or too short from the target. Attacks were carried out with bombs (25 lbs incendiary, 250 lbs SAP, 500 lbs SAP).
Also torpedoes and 60 lbs rockets may have be used however this study has not produced any evidence from the record books which indicate the use of torpedoes and rockets.

Figure 15: Area of investigation HKNWFZ and Bomber Command attacks (black dots) on ships and convoys.



safely.
One a/c overshot by 30 yds, one a/c
undershot 10/15 yds, third a/c did
not bomb owing to technical failure.
M/V 6000 tons direct hits on rear
hatch, foredeck & stern by 3 a/c, red
flashes of bomb bursts & smoke confi-
rmed by other a/c TOTAL LOSS.
M/V 3000 tons one hit astern & small
amount of smoke seen by another a/c,
total loss. /over.....

Figure 16: Extract from an Operations Record Book. (Source: annex 7, TNA, AIR 24/233).

By August 1944, the German Command had been forced to cease sending convoys by day along the Dutch coast. The toll taken by the allied air forces had become too heavy. The only possible tactic was to sail the convoy by night in short hops from port to port, sheltering in strong defended harbours during daylight hours. In response, the allied air forces tried to attack convoys at night using new tactics. Because of the minelaying activities, German convoys were stuck to certain sea routes. Figure 17 shows that German sea routes crossed the area of investigation. Convoys along these routes are likely to have been attacked by allied planes.

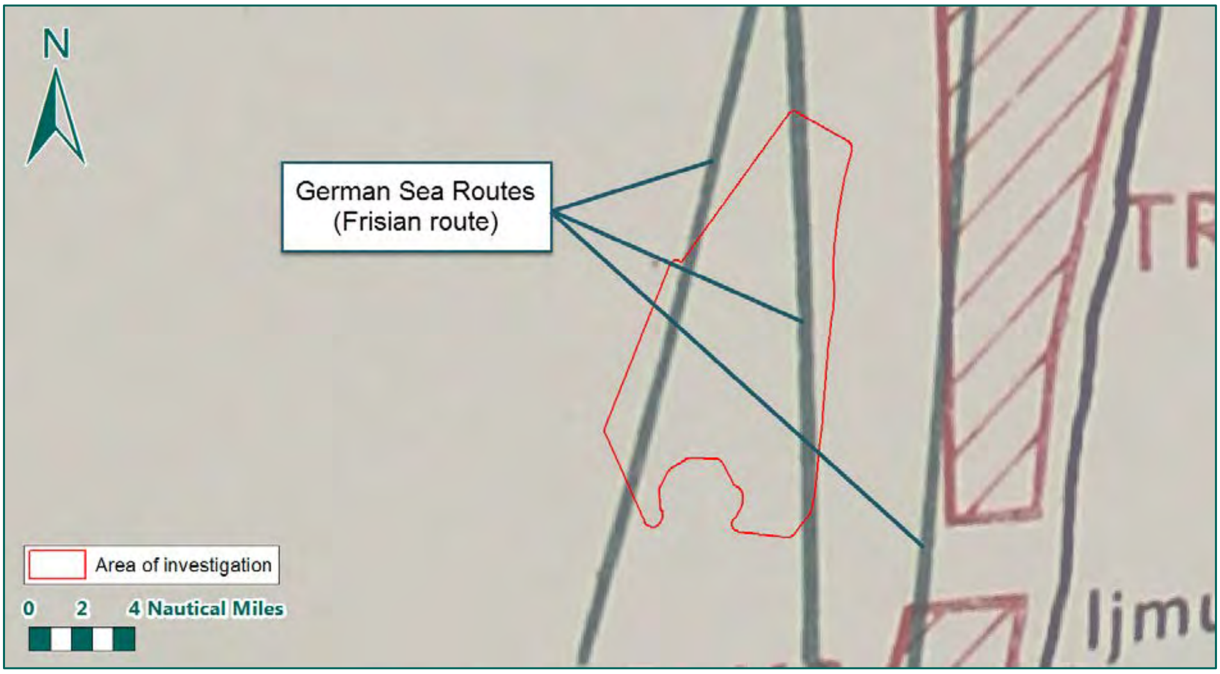


Figure 17: German sea routes. (Source: annex 7, TNA, ADM 234/561).

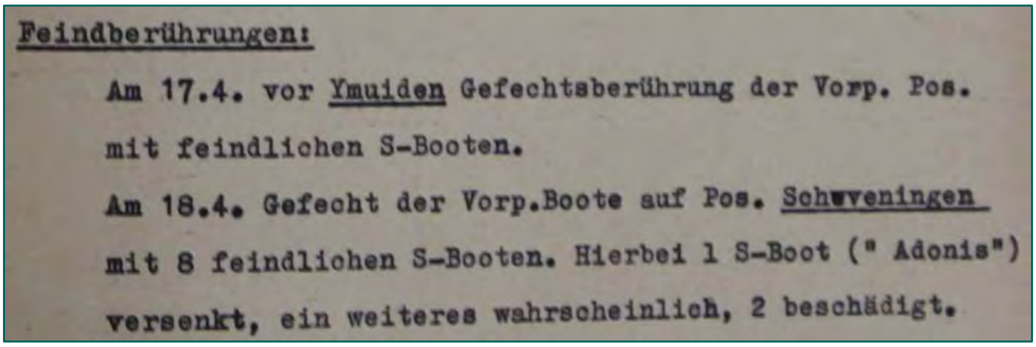
3.2.3 Conclusion on Aerial Warfare

Due to jettisons by returning and/or damaged allied bombers, aerial bombs could have remained in and near the area of investigation. Most common calibres during WWII are 250, 500 and 1.000 lbs.

Various aerial attacks on ships and convoys took place in the vicinity of the area of investigation. Aerial attacks on ships, convoys, and U-boats could have led to the presence of aerial bombs (25 lbs incendiary, 250 lbs SAP and 500 lbs SAP), torpedoes and depth charges. According to the OSPAR munition encounters and the reports of the Dutch Coastguard (see annex 9), various aerial bombs and depth charges have been encountered in the North Sea in front of the Dutch coast.

3.3 NAVAL WARFARE

Research for naval warfare, e.g. engagements between vessels or submarines, has also been conducted for this desk study. Except for some German reports (see annex 6) about attacks using torpedoes or engagement between small vessels (Motor Gun Boats or Motor Torpedo Boats), no strong evidence was found for naval warfare. Furthermore, the German records do not mention exact positions, see Figure 18 for example.


Feindberührungen:

Am 17.4. vor Ymuiden Gefechtsberührung der Vorp. Pos. mit feindlichen S-Booten.

Am 18.4. Gefecht der Vorp.Boote auf Pos. Schweveningen mit 8 feindlichen S-Booten. Hierbei 1 S-Boot (" Adonis") versenkt, ein weiteres wahrscheinlich, 2 beschädigt.

Figure 18: Extract from Heft II: Lageübersicht Westraum/Nordsee. Kriegstagebuch Teil BII. 15. Oct. 1941 – 31. Dec. 1943. (Source: annex 6, BAMA, RM 7/86).

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Conclusion

Since there is no factual evidence for naval warfare related to the location of the HKNWFZ, it is not expected that UXO would be present as a cause of these events.

3.4 WRECKS OF AIRPLANES AND VESSELS

During World War II a large number of aerial missions (e.g. bombing runs, reconnaissance flights, and attacks on ships and convoys) were carried out by the allied air forces. Allied planes had to deal with German FLAK-ships, coastal FLAK-batteries and German (night) fighters. As a consequence a large number of airplanes crashed into the North Sea. The Dutch Air War Study Group keeps an online Crash database (see annex 4) with military airplane losses in the Netherlands. According to the database about 758 aircraft crashed into the North Sea. Several aircraft crashed off the coast near IJmuiden, Egmond, Noordwijk, Alkmaar and Castricum. The crash database only provides estimated distances, e.g. 25 west off IJmuiden. Therefore it is not possible to retrieve the exact location of crashed airplanes.

Information on known objects and ship wrecks within the investigation area was obtained from the 'Archaeological Desk Study'[5]. In this study Periplus identified 244 known objects present in the investigation area, several of which are ship wrecks. Four ship wrecks have been identified and are not related to WWII. For the remaining wrecks, details like names, types and date of sinking are not known, nor are the exact locations. All ship wrecks within the investigation area are shown in table 4.

NCN	HY	Easting	Northing	Description	War related
2043	2230	590712	5824349	Wreck; unknown; BDS 1452/2004	Unknown
2051	2241	589301	5826959	Wreck Eton; Buyskes HY01129; British cargo ship built 1890 sunk 25-08-1912	No
2060	2251	588397	5827512	Wreck; unknown; HY 09223 Wreck is broken; partially covered with sand	Unknown
2065	2257	580767	5830306	Wreck; Fishing vessel, TX 24, sunk 29-05-1957 pos. acc. 20m	No
2066	2258	591639	5830773	Wreck; unknown; pos. acc. 20m; Buyskes HY01129	Unknown
2077	2270	578616	5833718	Wreck; unknown, pos. acc. 20m, 42.2x7.6m. Marhis: wreck of Salland, Dutch cargo vessel, sunk February 1953	No
2078	2271	580189	5833909	Wreck; unknown; pos. acc. 1000m; Buyskes HY00087 wreck not found	Unknown
2082	2275	581060	5835778	Wreck; unknown; pos. acc. 1000m; Buyskes HY00087 wreck not found	Unknown
2086	2279	581029	5837632	Wreck; unknown; pos. acc. 1000m; Buyskes HY00087 wreck not found	Unknown
2117	2312	589328	5847520	Wreck Sirabuen; Norwegian cargo vessel, built 1921, sunk 1956 after collision pos. acc. 20m; 43x11m;HY12322	Unknown
2118 & 16651	2313	592677	5846416	Wreck; pos. acc. 20m, 60x15m;HY12322	Unknown
2126	2321	588678	5850747	Wreck; unknown; pos. acc. 20m;HY10322	Unknown
2288	2520	588628	5837944	Obstruction; HY 09223 Hr.Ms. Luymes. Total area wreck remains ca. 300 x 100 m.	No
2545	2990	586708	5837737	Wreck; unknown; 67.9m	Unknown
25000	42	582190	5841144	Former wreck Kugelbake SH 23 sunk 19-09-1989, wreck raised, remains may be present	No

Table 4: Overview of known ship wrecks potentially related to WWII[5].

[5] Periplus, Archaeological Desk Study Hollandse Kust (noord) Wind Farm Zone, Document HKN_20170501_Periplus_Archaeology_Desk_Study_V1.0_D, revision 1.0 (draft), date may 1, 2017.

Al other contacts identified by Periplus are listed in Appendix 3 of the Archaeological desk study. These contacts have not been identified. There is a possibility remains of ships or plane wrecks are present.

Conclusion

Although exact information about aircraft crash locations is lacking, it cannot be excluded that the remains of plane wrecks and their associated payload could be present in the area of investigation.

The identified ship wrecks are not related to WWII. It remains unknown if any of the objects that are not identified are ship wreck remains that are war related.

3.5 COASTAL ARTILLERY

Different shooting areas are visible on the map 'Military Use' of the Noordzeeloket (see annex 5). Figure 19 shows that a large artillery firing range / unsafe zone has overlap with the Wind Farm Zone. This shooting area near Petten is bounded with a 14 NM (25.9 km) radius, and is further restricted to the sector between 225° to 345°. Based on experiences of former Dutch Navy personnel the used calibres vary from 20 mm to 40 mm anti-aircraft shells.

Figure 19: Extract of the map 'Military Use'. (Source: annex 5, Noordzeeloket).

Figure 20 shows the firing range areas with a projection of the post-war encounters of artillery shells. It is possible that also High Explosive shells with a heavier calibre were used during exercises before and shortly after World War II.

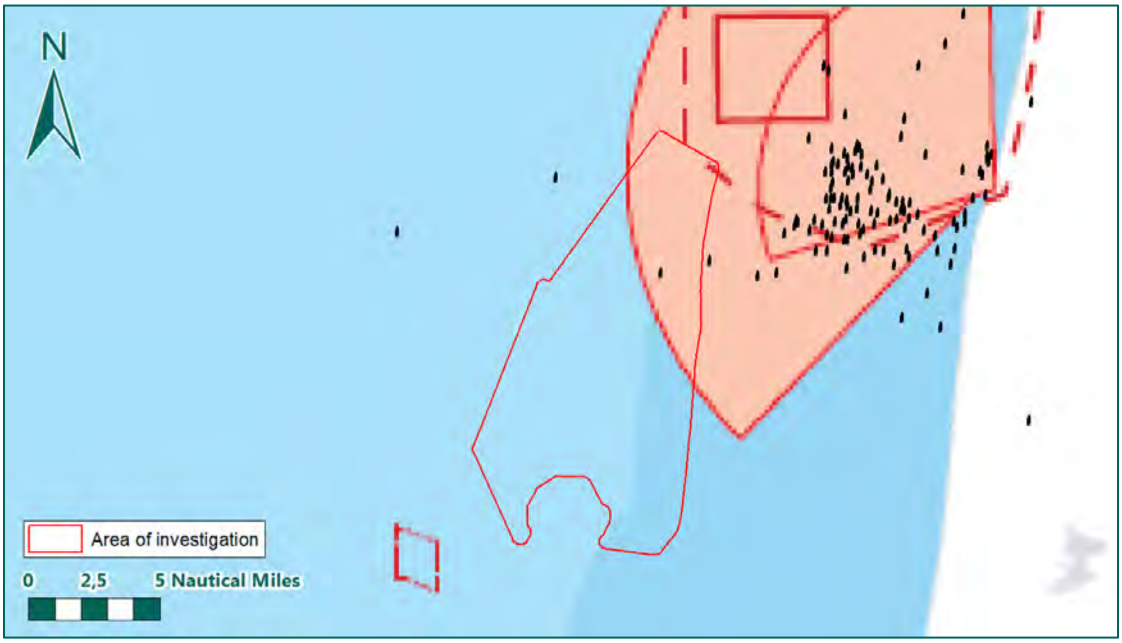

Figure 20: Extract of the map ‘Military Use’ and locations of encountered artillery shells.

Long before WWII the Dutch Government installed coastal guns as a defence from oversea attacks. These defence works were mainly concentrated near important harbours, like IJmuiden and Den Helder. The HKNWFZ is situated between these two places. Figure 21 shows the defences in 1911, a few years before the outbreak of World War I.

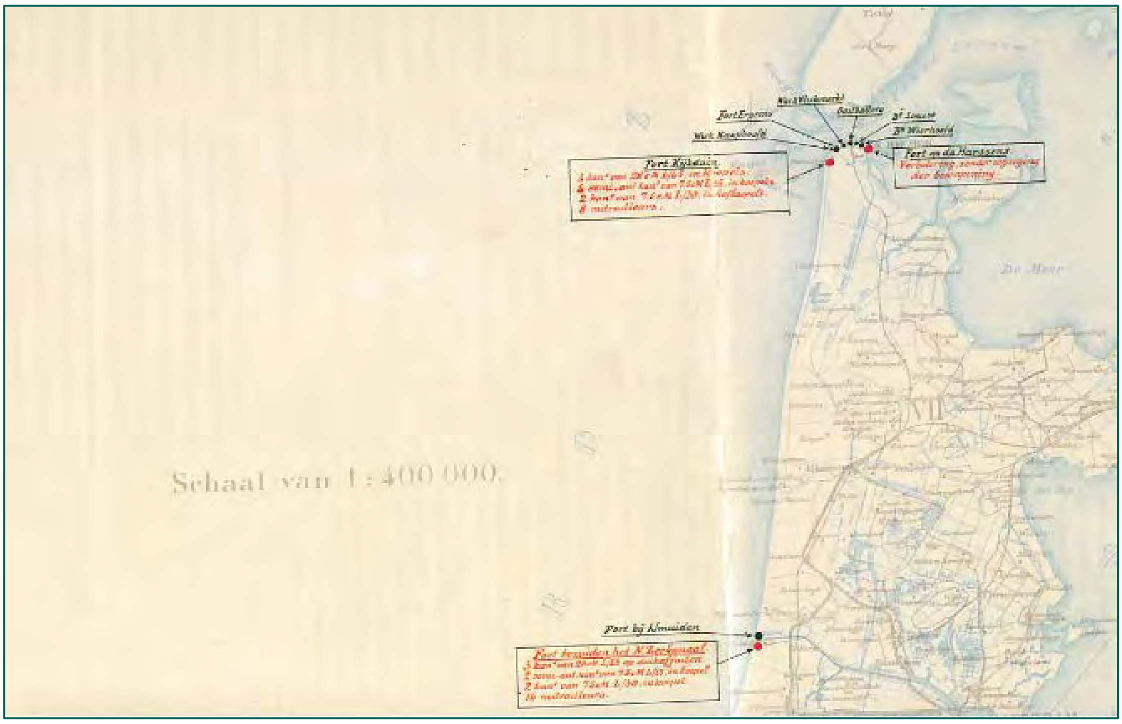

Figure 21: Dutch coastal guns, 14 December 1911. (Source: annex 4, VER, page 30-31).

Dutch coastal guns, 1911	
Den Helder	
Calibre	*Range (in km)*
7.5 cm	5.5 km
15 cm	7 km to 14 km
24 cm	6 km to 10 km
28 cm	20 km to 34 km
IJmuiden	
Calibre	*Range (in km)*
7.5 cm	5.5 km
28 cm	20 km to 34 km

Table 5: Overview Dutch coastal guns, 1911.

During World War I the coastal defences near Den Helder and IJmuiden were reinforced with 21 cm and 12 cm guns, with a range of 12 km and 12.5 km. The mentioned calibres were also present in 1940, on the eve of World War II. The area of investigation lies at least 20 km off IJmuiden and 25 km off Den Helder, which means only the calibre of 28 cm munitions would have been capable of reaching the area of investigation.

During World War II, after the capitulation of the Netherlands on 14 May 1940, the German occupier started to reinforce the Dutch coast. Since 1942, the defences were firmly reinforced and became known as the *Atlantikwall*. This was a German coastal defence line from Norway to France. Figure 22 shows the German coastal guns and their shooting range. According to this figure, the calibres of 12 cm, 15 cm and 17 cm were able to reach the area of investigation. The book *Bergen (NH) 1940-1945* (see annex 4) mentions that those coastal guns rarely fired. The anti-aircraft artillery however was frequently used.

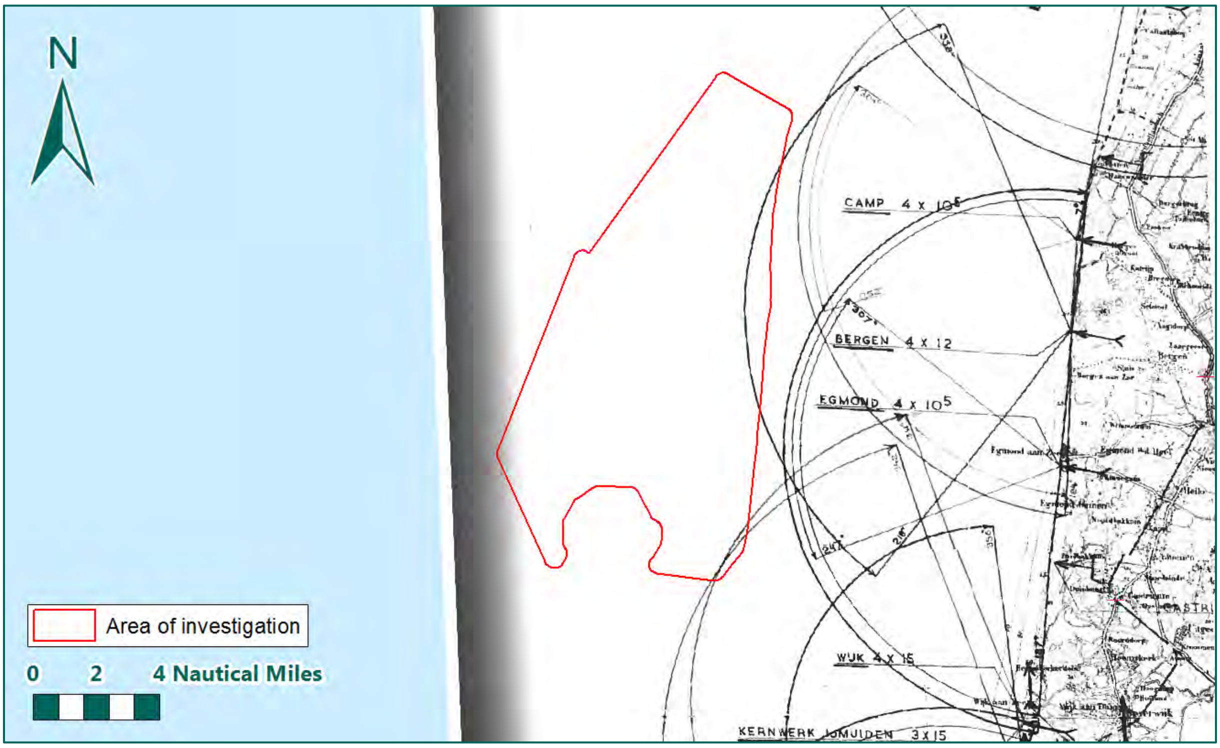

Figure 22: German coastal guns and shooting ranges, Den Helder to IJmuiden, mid 1944. (Source: annex 4, HAR, page 328).

Conclusion

According to the historical information it is very likely that artillery shells are present in the part of the investigation area which overlaps the firing range. In this area it is likely that 40 mm anti-aircraft shells are present. Since there is almost no information regarding engagements with coastal guns, it is less likely that artillery shells are present in the remaining area of investigation.

3.6 POST-WAR (SECOND WORLD WAR) AMMUNITION DUMP SITE.

The NEMEDRI 227 mine map, see Figure 23, indicates a munition dumping area that lies about 3 NM (5.6 km) from the area of investigation. The dump site is also shown on the map 'Military Use' of the North Sea Desk and the Sea chart of the Hydrographic Service of the Royal Netherlands Navy (see annex 5).

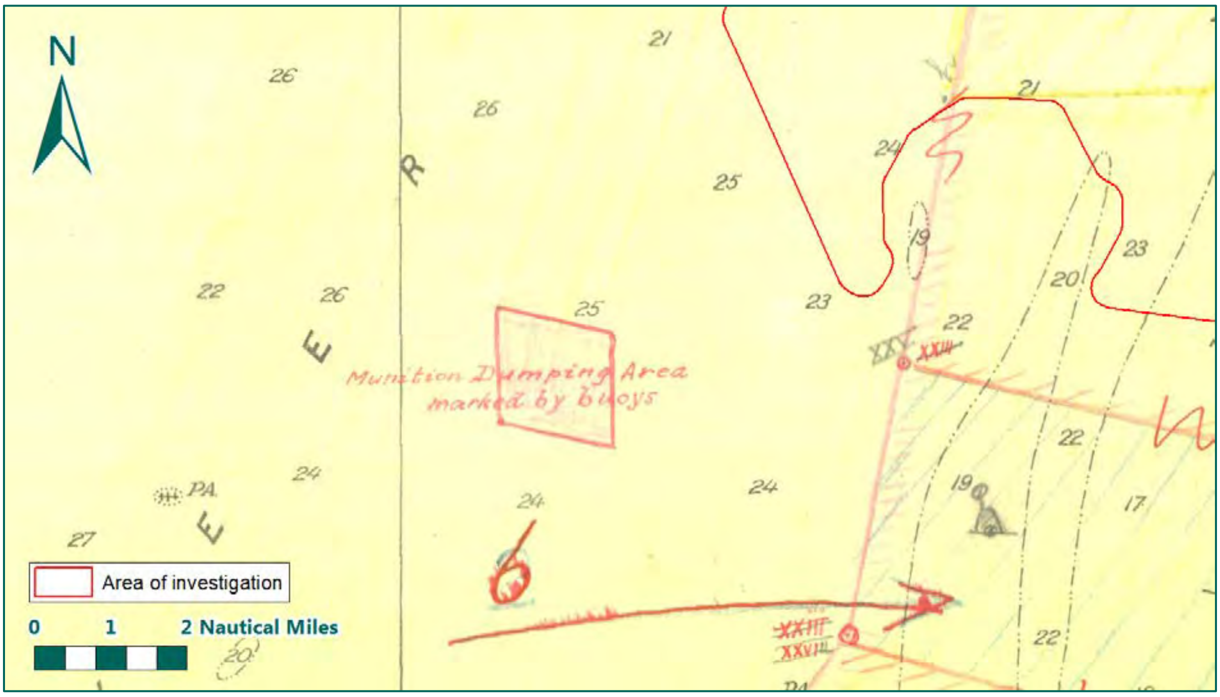

Figure 23: Munition dumping area on the NEMEDRI 227 mine map. (Source: annex 5, Marinemuseum).

No information is found about the types and amount of the dumped ammunition. According to the Dutch coast guard UXO encounters, two depth charges have been encountered within the boundaries of the dump site. Because of the distance between the dump site and the HKNWFZ, at least 3 NM, it is not expected that the dump site poses a risk towards the wind farm zone. This zone is indicated as an 'Area to be avoided', which excludes fishing activities with trawlers. This means the risk of migrating UXO on the sea bottom is relatively low.

Conclusion

Approximately 3 NM (5.6 km) from the wind farm zone lies a munition dump area. Because the sea charts marks it as an unsafe zone, it is assumed that the risk of migrating UXO is relatively low.

4. Gaps in knowledge and Risk Area

4 GAPS IN KNOWLEDGE AND UXO RISK AREA

4.1 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 1914-2016 UXO were encountered in and/or removed out of the investigation area, e.g. it is not known if UXO were encountered during installation of Amalia and Egmond windfarms.
- 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.
- There is no specific information about crashed airplanes in the vicinity of the site.
- There is no exact information about the total amount of dropped bombs during aerial attacks or jettisons above the North Sea.

4.2 UXO RISK AREA

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

The following UXO are likely to be encountered within the area of investigation:

- Artillery shells;
- Aerial bombs;
- Naval mines;
- Depth charges;
- Torpedoes.

Figure 24 on the next page presents an overview of all identified war related events near the area of investigation.

The likelihood of presence and state of the expected UXO is elaborated in paragraphs 4.2.1 and 4.2.2 of this report.

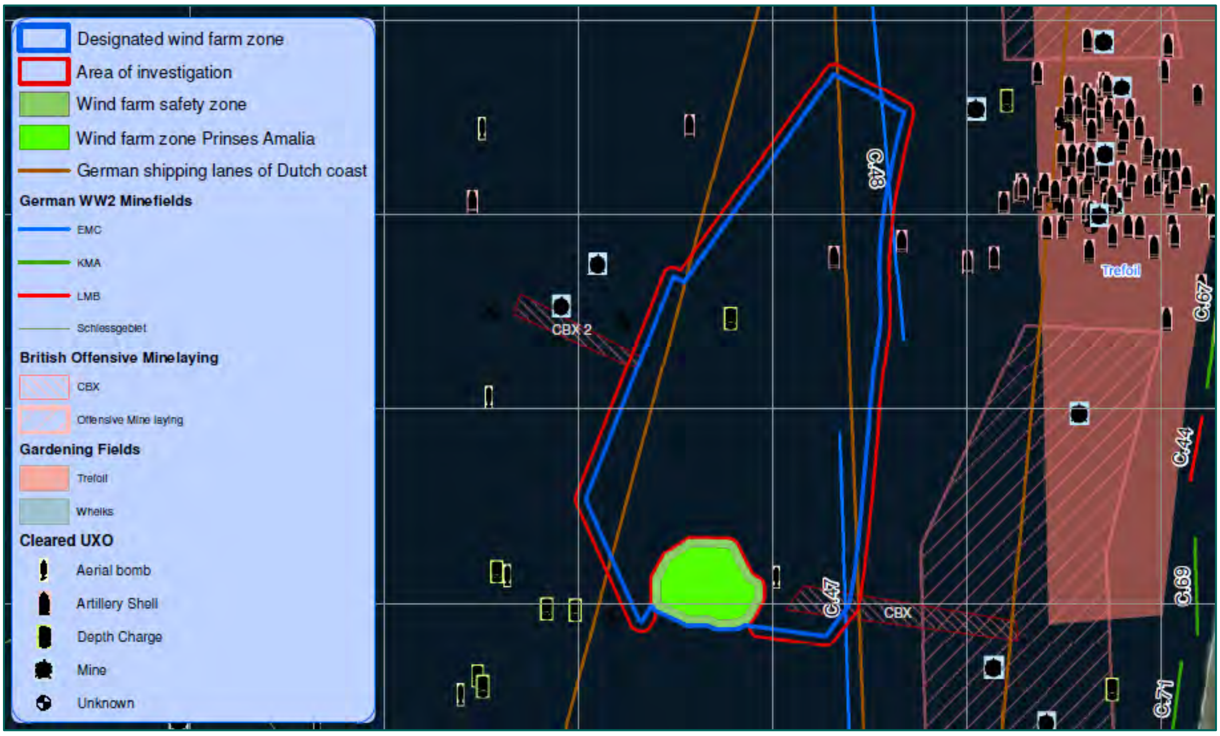

Figure 24: Overview of war related events

4.2.1 Defining the UXO Risk Area

The UXO items considered most likely to be present within the area of interest are shown in Table 7. 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 is important to recognise that the presence of a UXO type does not necessarily mean that it will be encountered. The likelihood of encounter (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 area of interest; given that the actual footprint of wind farm installation operations will be less than the total investigation area volume. In Table 6 the terminology is shown, Table 7 is used to indicate the likelihood of presence of a specific type of UXO in the investigation area.

"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 6: Definitions of terminology used for the likely presence of UXO.

UXO type	Likelihood of presence	Remarks
Allied HE Bombs	Certain	The area of investigation is located near flight paths of allied bombers. If a plane was badly damaged or under attack, it was common for the crew to jettison their bombs in order to assist their evasion attempts or before landing at their home bases. Allied planes carried out various attacks on ships, convoys and submarines. Air-dropped high explosive (HE) bombs could be present anywhere within the area of investigation. Bombs have been found since 2005 within the vicinity of HKNWFZ.
Naval mines	Probable	The site overlaps with several WWI and WWII minefields. It concerns allied and German mine fields. Despite post-war mine clearance operations, ships still encountered mines and sunk in the post war period. Since 2005 several mines have been encountered in the vicinity of the site.
Artillery shells	Certain	After World War II, some areas in the North Sea were designated for military use by the Dutch Army. A large anti-aircraft shooting area has overlap with HKNWFZ. Since 2005 various shells were encountered within the shooting areas.
	Remote	Prior to WWI coastal guns were already present at the Dutch coast. It concerns Dutch and German coastal guns and anti-aircraft guns. Coastal guns rarely fired in this part of the North Sea. The anti-aircraft artillery however was frequently used. Because of the range of the anti-aircraft artillery, it is less likely that unexploded shells ended up in the area of investigation.
Torpedoes	Remote	There is some evidence for aerial and naval attacks with torpedoes, but no specific information was found for HKNWFZ.
Depth charges	Feasible	Naval and aerial attacks on submarines were carried out with depth charges. No specific information was found for HKNWFZ, but since 2005 some depth charges were encountered in and near the wind farm zone.

Table 7: Summary of UXO likely to be present within the investigation area

4.2.2 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.

- In the 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 munition possibly 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 can be highly sensitive.
- 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 energises a battery and functions the main charge. Therefore this type of mine must be handled with extreme caution.

- Torpedoes were initiated by means of a pistol/exploder which sometimes had a tendency to be unreliable. As these can contain a mechanical detonator striker, they must be handled with extreme caution.

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

5 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 explored below. In the offshore marine environment, UXO burial is predominantly due to one or a combination of three mechanisms:

- Initial impact;
- Scour;
- Bedform migration.

5.1 BURIAL ON IMPACT

The first mechanism for UXO burial to consider is that due to initial impact. In the marine environment, a bomb or air-delivered ground mine's kinetic 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.

Experiments on Mk84 bombs in the USA show that the trajectory of a bomb falling into water at an angle of entry of ~90° is rapidly altered by the new medium. The bomb rotates and orientates to near parallel to the seabed by a water depth of around 5m[6] (see figure 25). Its burial in sandy soils due to impact will be minimal in water depths over 5m. Burial on impact of a large air dropped ground mine will also be minimal at larger water depths. The water depth within the investigation area varies from 15.0 to 34.5 meter (LAT), with an average of 22.6 meter (LAT). Burial on impact is therefore assessed to be null.

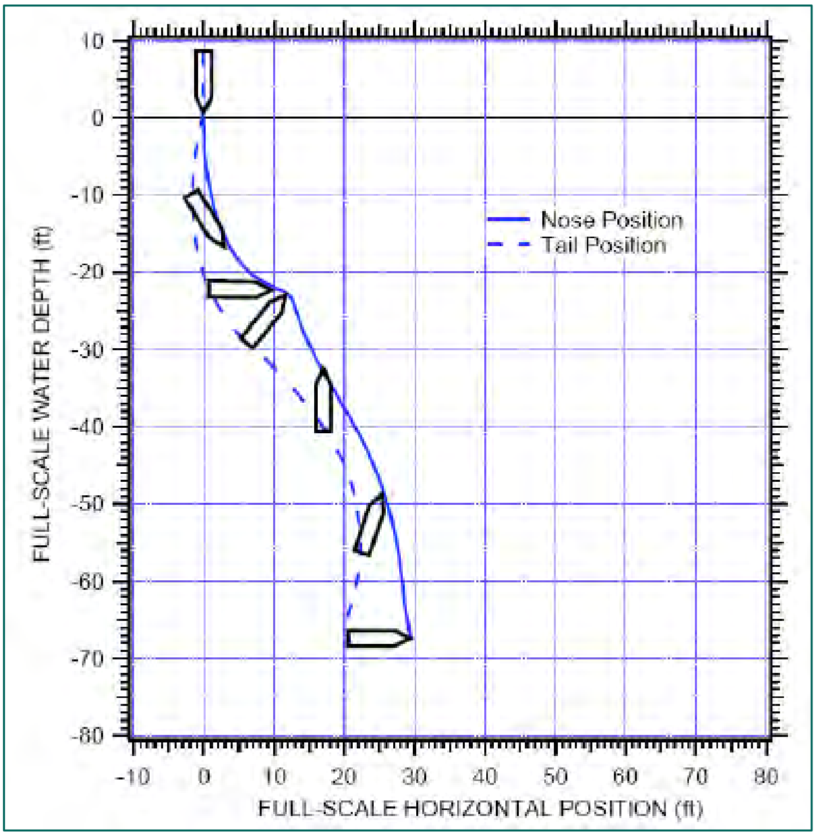

Figure 25: Trajectory of Mk84 with no tail section and water-entry velocity of 296 m/s.

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

5.2 SCOUR[7]

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 movable bed. The presence of the object modifies the flow pattern around the object, generating vortices that locally increase and decrease the bottom flow stresses. The vortices cause depressions and mounds to form on the bed surface. Objects placed on beds where the flow was causing no apparent motion can locally increase the bed stress behind the object and induce bed motion and scour.

Studies of mines placed on sandy bottoms show that subsequent burial occurs through a series of scour events followed by rolling or sliding of the mine into the scour depression. 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 function 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 bodies scour less rapidly than bluff (blunt) bodies. Once scour depressions develop around a UXO, then UXO bury incrementally by moving into the depressions formed by the scour process, either by rolling or sliding (see figure 26).

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. Furthermore three-dimensional UXO (ovoids and hemispheres) bury more slowly than two-dimensional (cylindrical) UXO.

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. UXO burial due to scour to the maximum scour depth is to be expected in the investigation area. The largest 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.

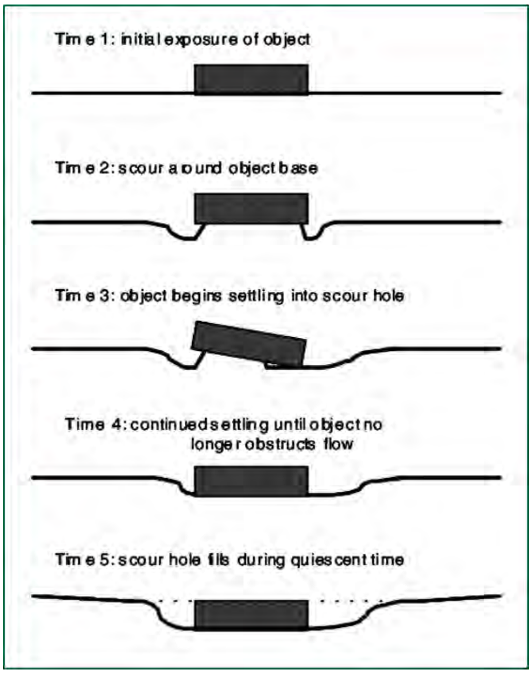

Figure 26: Scour mechanism[8].

[7] Source: Douglas L. Inman et al., Scour and burial of bottom mines, A Mine Burial Primer, September 2002.
[8] Source: www.researchgate.net

5.3 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. The spatial scale of the bed forms range from several meters to several kilometres and migration speeds range from < 1 m/year to > 100 m/year. Table 8 summarizes the six different types of bed forms can be distinguished at 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[9]	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

Table 8: Overview of bed forms located at the Dutch continental shelf[10].

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 to slow to be of importance for the burial assessment. Due to their height and migration rates sand waves are the predominant bed forms in regards to the burial depth of UXO.

The figure on the next page shows a colour depth map based on data from the Hydrographic service (25m grid, 2009) combined with multibeam echosounder data from the Q7A survey (2014)[7]. The depth map shows the seabed in the northwest and southwest consists of sand dunes superimposed on the sand ridges with a west-northwest-east-southeast orientation. The sand waves present in this area have varying dimensions and are quite irregular. The typical height of the sand waves is 1-2 m (trough-crest) with the largest sand waves not exceeding 2.5 m. Wavelengths vary widely from approximately 280 to 650 m (trough to trough)[11]. The distance between the crests amounts to 1,200 meter. The dunes are superimposed by current ripples. The seabed in the centre of the research area is relatively flat. A large sand bar with a height of four meters runs along the eastern border of the research area from north to south.

Each of the morphological features in the area has its typical migration rate. The largest, the shore face-connected ridges, are relatively stable and move with 0 – 1 m/year. Also the north south oriented ridges are stable, with similar migration rates. Observed sand waves migration rates in the Prinses Amalia Wind Park, in the southern part of the study area, were recently assessed to be in the order of 4 m/year by Deltares.

The information above was obtained from the Archaeological Desk Study Hollandse Kust (noord) Wind Farm Zone, Document HKN_20170501_Periplus_Archaeology_Desk_Study_V1.0_D, date may 1, 2017. A detailed study on seabed morphology was not yet available. Based on the information currently available the burial depth of UXO due to the migration of bedforms is assessed to be up to 2.5 m below the seabed. Due to the migration rate and width of the sand waves the conclusion can be drawn

9 Average values. The maximum height/depth ratio observed to be about 1/3.

10 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

11 Forzoni A. et al. 2017. Geological study Hollandse Kust (noord) Wind Farm Zone, reference 11200513-002-BGS-0001.

that the present-day sand waves are sediments from the post war period. Therefore, present day crests may contain (deeply) buried UXO. Present day troughs may contain UXO on the seabed or partly buried. UXO (if present) is assessed to be located near the base level of the sand waves.

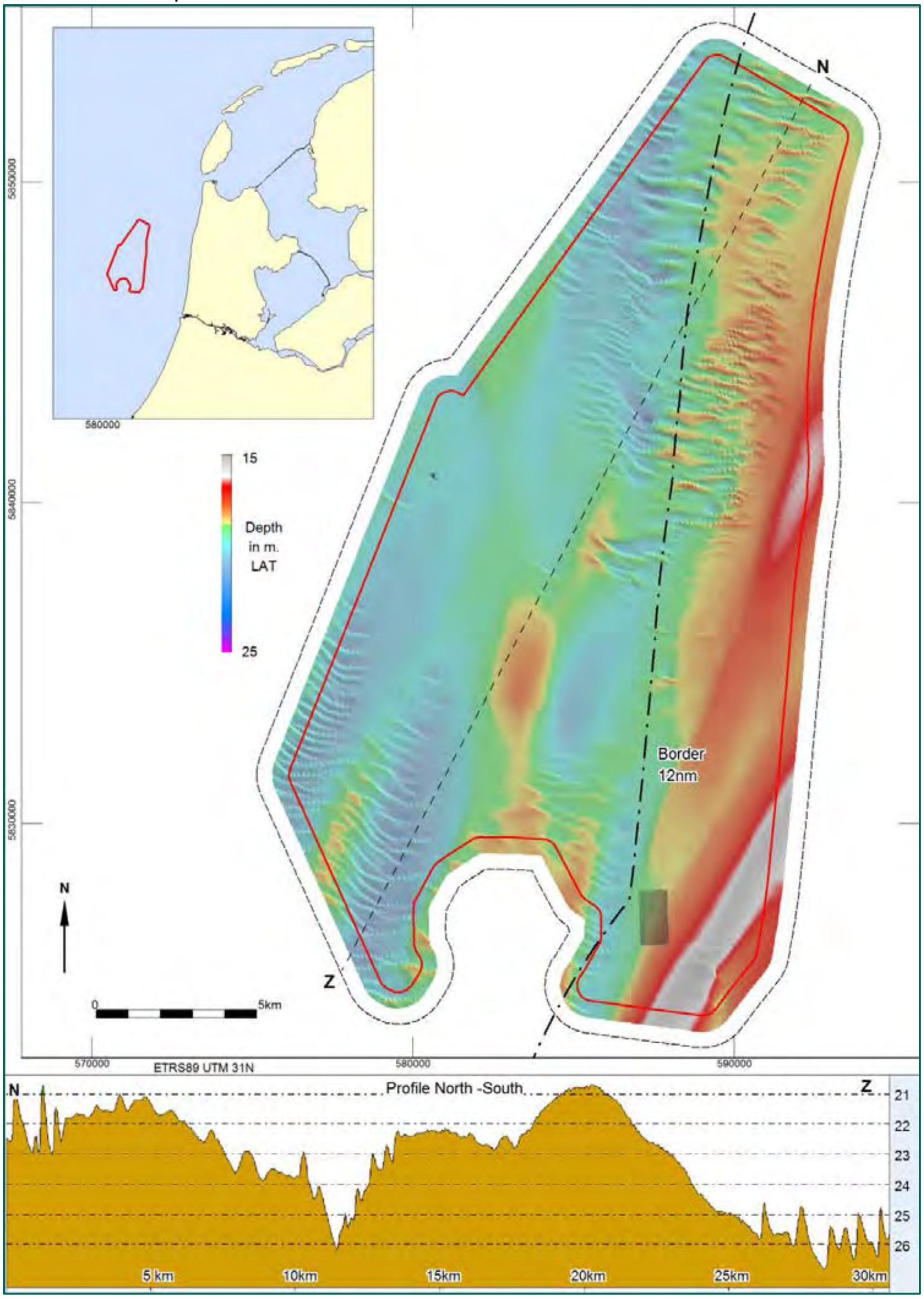

Figure 27: General bathymetry of the seabed[12].

5.4 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:

MBD = 0 (burial on impact) + 0.6 x 1.2 (UXO diameter) + 2.5 (height of bedform) = **3.2 m**

[12] Source: Archaeological Desk Study Hollandse Kust (noord) Wind Farm Zone, Document HKN_20170501_Periplus_Archaeology_Desk_Study_V1.0_D, date may 1, 2017.

6 UXO MIGRATION ASSESSMENT

In preparation for the geophysical UXO survey, 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.

6.1 MIGRATION BY NATURAL CAUSES

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

6.1.1 Hydrodynamics in the wind farm zone

The hydrodynamics whitin the wind farm zone is characterized by tide and wind generated currents and waves. The tide is predominantly semi-diurnal tide. Table 9 presents the mean tidal water levels at IJmuiden to illustrate the tidal characteristics. The mean tidal range is 1.69 m, with a mean high water of NAP+1.01 m and a mean low water of NAP-0.68 m.

Tide	HW [m NAP)	LW (m NAP)	Tidal range (m)
Mean tide	1.01	-0.68	1.69
Spring tide	1.16	-0.72	1.88
Neap tide	0.76	-0.61	1.37

Table 9: Tidal water levels IJmuiden[13].

The average tidal streams during average weather conditions (wind south-west force 3 to 4) reaches speeds up to 1.5 kts (2.3 kts at spring tides)[14]. The given speeds of tidal streams are average calculated speeds. The actuals speeds depend upon a large number of variables. Therefore the actual speeds may be higher than the calculated speed.

The shapes, dimensions and weights 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. In contrast, scour will develop around the object and this may result in burial[15].

6.1.2 Morphodynamic behaviour

The migration of objects is more likely to be influenced by morphological changes in the area. Horizontal channel migration or erosion on the slopes of sand waves may cause horizontal UXO migration. An object may for example be buried in a channel side slope or other steep slope. If the channel or sand wave migrates and erosion occurs on the slope in which the object is buried, it may become unburied and released from the slope. The object is then likely to roll down the side of the slope towards the deepest section of the channel, where it will remain or become buried by vortex scouring.

13 Source: Rijkswaterstaat, Kenmerkende waarden getijgebied 2011.0, July 22, 2013.
14 Source: HP33, Waterstanden en stromen 2014, 2014. Mentioned speeds are current speeds at the surface.
15 Source: ARCADIS, Memo UXO mobility TenneT cable, reference 078983999 0.2, June 21, 2016.

Observed migration rates in Prinses Amalia Wind Park were recently assessed to be in the order of 4m/year[16]. This means sand waves in the HKNWFZ have migrated approximately 250 – 300 m since the war. The width of the crests of the sand waves 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 well above the non-mobile reference level of the seabed. The risk of UXO getting unburied in the slopes of sand waves is assessed to be negligible. Therefore UXO migration due to morphodynamic behaviour is not a factor to consider in the determination of the maximum permissible safe time interval between the conclusion of a geophysical UXO survey, UXO clearance operations and the commencement of construction works.

6.2 MIGRATION DUE TO HUMAN ACTIVITY

Human activity may have a more significant impact on UXO migration than natural causes. Especially dredging and fishing activities have the capacity to move items of UXO.

Particularly in areas where beam and pair trawling is prevalent. Currently the investigation area is fished several times a year[17]. It is expected that some trawlers may have unintentionally moved UXO. These UXO items may have been transported with the movements of the vessel's nets for considerable distances before they are returned to the seabed. In such circumstances, fishing nets have been known to move UXO up to 30 miles (48km) from their original location[18].

Wind farm zones are not navigationally controlled. After completion the wind farm zone may be crossed by vessels smaller than 24 m. Therefore the risk of UXO being moved unintentionally by fisherman after conduction of the UXO survey and completion of the wind farm remains.

It is not possible to quantify the UXO migration due to human interaction. Therefore human interaction is not a factor in the ALARP sign off certification process. This migration factor is part of the baseline residual risk. If a large calibre UXO is unintentionally dragged into the area of investigation by fisherman, it will lie on the seafloor. Therefore it will most likely be visible in for example SSS data.

6.3 MAXIMUM PERMISABLE 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 interference. However it proved not to be possible to quantify the horizontal migration rate.

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[16] Source: Deltares, Seabed mobility study for route comparison Windpark Hollandsche Kust Zuid, reference 1221505-000, March 24, 2016

[17] Source: http://www.clo.nl/indicatoren/nl2093-ecologische-duurzaamheid-bodemvisserij, Visserij Intensiteit op het Nederlands Continentaal Plat, 2007-2011

[18] Unexploded Ordnance Munitions Migration Assessment, Report Number: P3872-E3MMA, August 2014

The maximum permissible safe time interval between the conclusion of a geophysical UXO survey, UXO clearance operations and the commencement of construction works is assessed to be approximately two years.

7 HAZARDS OF UXO LIKELY TO BE ENCOUNTERD

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 forms the input for outlining the UXO mitigation strategy (see chapter 11).

7.1 AERIAL BOMBS

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

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

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

Fuzes can have various timer devices to make the timing of the blast more effective. Some function at a given time after arming, e.g. chemical long delay pistol such as tail pistol no. 37 Mk.I (see Figure 28). More common are short delay or instantaneous pistol/fuzes to delay the detonation for a few fractions of a second.

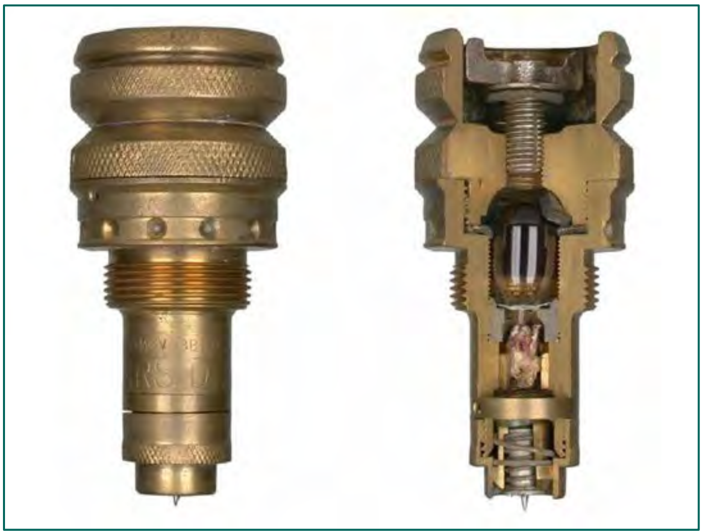

Figure 28: Tail fuze no. 37 MkI.

Once a fuze is armed, shock, movement or manipulation can cause the bomb to detonate. Fuzes, and chemical long delay fuzes in particular, are sensitive to movement and accelerations with an amplitude > 1 m/s^2 in the surrounding soil. This kind of accelerations can occur as a consequence of vibrations caused by piling operations.

7.2 DEPTH CHARGES

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

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

7.3 TORPEDOES

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

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

7.4 NAVAL MINES

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

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

Moored mines and ground mines are the most commonly used. 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.

7.4.1 Contact mines

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

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

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

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

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

7.4.2 Influence mines

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

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

7.5 ARTILLERY SHELLS

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

The types of fuzes most commonly used would cause the shell to detonate or release its contents when its activation conditions were met. This action typically occurred on time after firing (time fuze), on physical contact with a target (contact fuze) or a detected proximity to the ground, a structure or other target (proximity fuze).

7.6 ANTI-HANDLING DEVICES

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

7.7 SELF-DESTRUCTION DEVICES

The Hague Conventions of 1907[19] states that is forbidden (article 1):

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

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

[19] Laws of War: Laying of Automatic Submarine Contact Mines (Hague VIII); October 18, 1907.

8 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.

8.1 EFFECTS OF UNDER WATER DETONATIONS

The damage that may be caused by an underwater detonation depends on the "shock factor value", a combination of the initial strength of the explosion and of the distance between the target and the detonation. When taken in reference to ship/vessel hull plating, the term "Hull Shock Factor" (HSF) is used, while keel damage is termed "Keel Shock Factor" (KSF). If the explosion is directly underneath the keel, then HSF is equal to KSF, but explosions that are not directly underneath the ship/vessel will have a lower value of KSF[20]. The effect of a detonation mainly depends on the amount of explosive content (Net Explosive Weight) of the UXO and the type of explosive content (e.g. TNT, Torpex, etc.). The type of explosive is of less importance.

8.1.1 Direct damage

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

It is unlikely that ship/vessel direct damage will occur due to seabed activities, unless operating in very shallow water. For this area if investigation, UXO will only be present in or on the seabed, unless otherwise brought to the surface.

8.1.2 Bubble jet effect

The bubble jet effect occurs when a mine or bomb detonates in the water under (e.g. on the seabed), or a short distance away from a ship. The explosion creates a bubble in the water, and due to the difference in pressure, the bubble will expand from the bottom. The bubble is buoyant and rises towards the surface. If the bubble reaches the surface as it collapses it can create a pillar of water that can go over a hundred meters into the air (a "columnar plume"). If conditions are right and the bubble collapses at the ship's hull the damage to the ship can be extremely serious, flooding one or more compartments, is capable of breaking smaller ships apart and causing fatalities to the crew within the affected areas.

8.1.3 Shock effect

If a UXO detonates at a distance from the ship, the change in water pressure causes the ship to resonate. The whole ship is dangerously shaken and everything on board is tossed around. Engines and equipment can be dislodged from their positions etc. A ship which experiences a large shock effect usually sinks quickly, with hundreds, or even thousands of small leaks all over the ship and no way to power the pumps. The crew fare no better, as the violent shaking tosses them around[16,21]. This shaking is powerful enough to cause disabling injury to knees and other joints in the body, particularly if the affected person stands on surfaces connected directly to the hull (such as steel decks).

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20 The Response of Surface Ships to Underwater Explosions. DSTO-GD-0109, September 1996

21 TNO-rapport Beveiligd 'baggeren Maas, stuwpand Sambeek', 11th may 2012

In Table 10 the distances on with a certain amount of shock damage is expected are shown for the common types of allied bombs. The distances are calculated by TNO. Leakage is to be expected in case of a Hull Shock Factor (HSF) > 0.3 $kg^{0.5/m}$. Damage to equipment is to be expected in case of a HSF > 0.02 $kg^{0.5/m}$[22].

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

Table 10: Distances for shock damage due to detonation[18].

Table 10 shows that in case a UXO detonates, it is highly likely severe damage to the equipment and injury of personnel will occur. Furthermore damage to foundations (mono piles) cannot be ruled out, depending on the distance between the detonation and the foundation.

8.1.4 Shredding effect or spalling

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

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

8.1.5 Lethality of fragments

Fragments from explosives charges in water quickly lose energy. A scientific study on the effects of fragments travelling under water after detonation, is used by the Dutch EOD for calculating the safe distances[23].

In the HKNWFZ UXO with explosive weights (TNT equivalent explosive weight) up to 1,000 kg can be present. To detain all fragments a water depth > 16 m is needed. Because of the actual water depths at the site (> 15 m) it is unlikely that lethal fragments are ejected above the surface of the water (see Figure 29).

[22] TNO-rapport Beveiligd 'baggeren Maas, stuwpand Sambeek', 11th may 2012

[23] VS 9-861, Voorschrift Opruimen en Ruimen van Explosieven, 29th september 2010

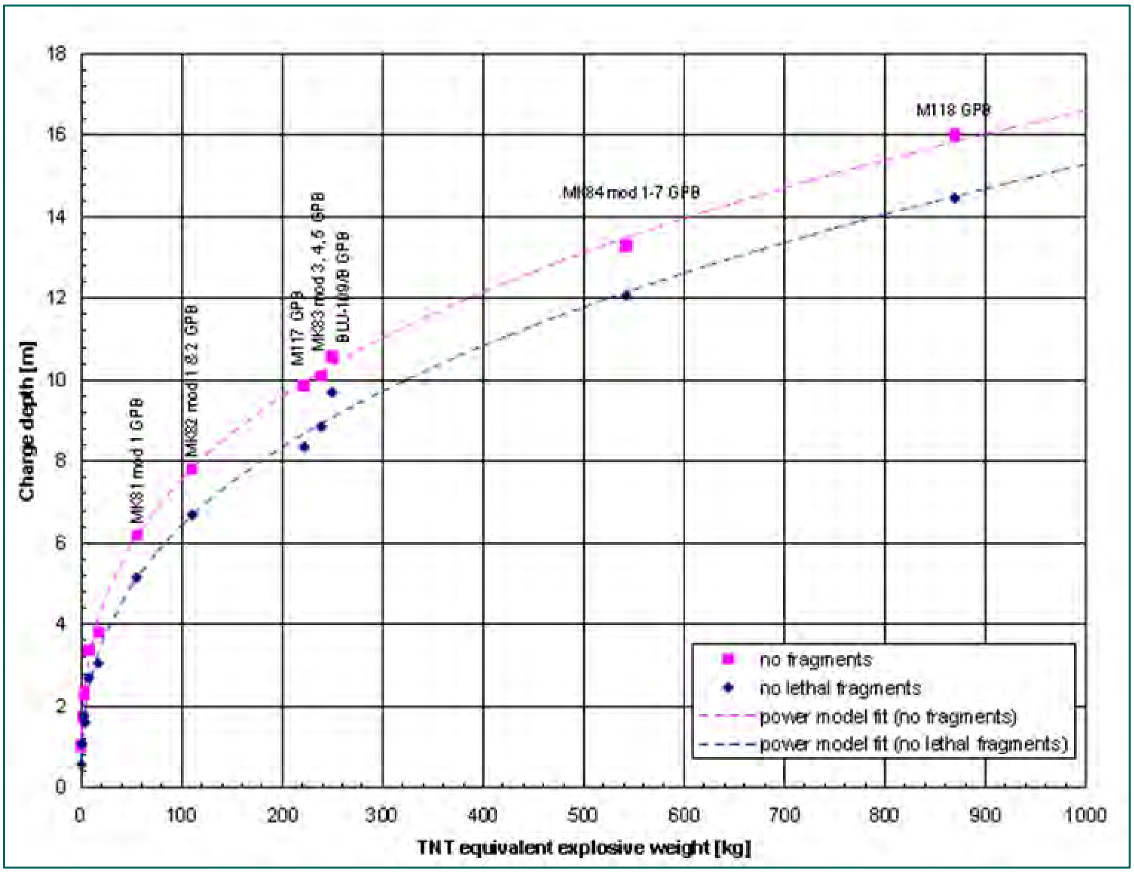


Figure 29: Minimal water depth to detain fragmentation of explosives with a Net Explosive Weight of 0-1,000 kg TNT equivalent [12].

8.2 SAFE DISTANCES

The Dutch EOD regulation provides formulas for calculating the safe distances in case of a controlled demolition of UXO in water. In case of a controlled demolition of UXO in water in the stated area[24]:

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

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

[24] VS 9-861, Voorschrift Opruimen en Ruimen van Explosieven, 29th september 2010

In Table 11 the safe distances for UXO with a net explosive weight of 100, 200, 300 and 1,000 kg TNT are given. The safe distances are calculated with the formulas stated above. The explosive weights are representative for the types and calibres of UXO likely to be present in the wind farm area (e.g. naval mines, aerial bombs, depth charges and torpedoes).

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

Table 11: Safe distances for controlled demolition.

9 INTRUSIVE ACTIVITIES

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

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

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

9.1 PREPARATION PHASE

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

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

<u>Potential UXO risks</u>

Potential UXO risks are:

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

9.1.1 Metocean measurements

In order to optimize the energy output from a wind farm, detailed statistical information on wind direction, speed and altitude is desirable. In order to collect this information, a metocean campaign is started by RVO.nl. A metocean buoy is installed in the area. The buoy is kept in place with a bottom weight. For the UXO risk assessment only the intrusive activities of the metocean campaign are relevant.

<u>Potential UXO risks</u>

Potential UXO risks are:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels installing the metocean buoy and conducting the investigations.
- Direct contact between a UXO and divers/ROV's during inspections and as-built checks.

9.2 EXECUTION PHASE

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

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

9.2.1 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 (all activities that influence the soil) are relevant. There are several suitable foundation options. The decision for a foundation type will be based on a range of factors, including water depth; tidal, wind and wave conditions; logistical practicalities; commercial factors; ease of construction and installation; and the type and size of turbine chosen. Figure 30 shows three possible foundation types. Suction anchors may also be a suitable solution.

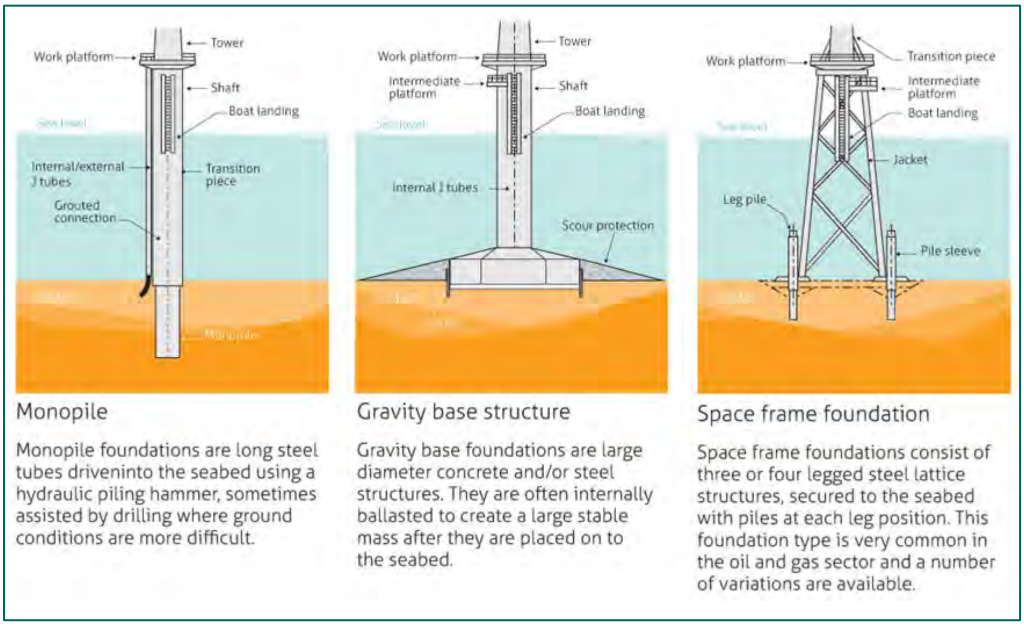


Figure 30: Example of suitable foundation types[25].

<u>Potential UXO risks</u>

Potential UXO risks are:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels installing the foundation.
- Direct contact between a UXO and dredging equipment and/or gravel or rock during the removal of obstructions, the preparation of the seabed and/or gravel/rock dumping.
- Direct contact between a UXO and the foundation during the placement of the foundation.
- Accelerations with an amplitude > 1 m/s^2 in the 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).
- Accelerations with an amplitude > 1 m/s^2 in the soil surrounding a UXO during operation of the turbines.
- Direct contact between a UXO and divers during cable connection operations.

[25] Source: www.navitusbaywindpark.co.uk

- Direct contact between a UXO and divers/ROV's during inspections and as-built checks.

9.2.2 Converter- and transformer stations

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

Potential UXO risks

Potential UXO risks are:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels installing the foundation.
- Direct contact between a UXO and dredging equipment and/or gravel or rock during the removal of obstructions, the preparation of the seabed and/or gravel/rock dumping.
- Direct contact between a UXO and the foundation during the placement of the foundation.
- Direct contact between a UXO and divers during cable connection operations.
- Direct contact between a UXO and divers/ROV's during inspections and as-built checks.
- Accelerations with an amplitude > 1 m/s^2 in the 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).

9.2.3 Scour protection

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

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).

9.2.4 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.

9.3 OPERATIONAL PHASE

The North Sea is a highly dynamic morphological system. The action of the tides and the waves constantly move objects on the sea bed and over a period of time an area which was previously cleared, may no longer deemed to be clear. In 2011 a good example of the dynamic nature of the North Sea was shown when 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[26]. This bomb had drifted towards the monopile from elsewhere. Another noticeable example is a torpedo being discovered in 2002, having drifted against a North Sea oil pipeline[22].

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 drifting in an offshore wind farm (previously cleared), these intrusive activities may cause safety and exploitation risks.

Potential UXO risks

Potential UXO risks are:

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

[26] Unexploded Ordnance Risk, Considering Unexploded Ordnance Risk on and around the British Isles, 27-04-2011

10 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:
- Source, Pathway and Receptor,
- Likelihood of Presence,
- Type of encounter,
- Likelihood of Occurrence,
- Hazard severity.

In Annex 11 the key terms and parameters used in the SQRA are explained. Chapter 8 provides a brief description on the effects of a detonation.

10.1 RISK ASSESSMENT MATRIX

The following matrix is used to quantify the risk. Each generic UXO hazard is assessed for 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

(red)	Unacceptable
(orange)	ALARP with reduction measures
(yellow)	ALARP
(green)	Acceptable

Table 12: 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 risks are mainly source orientated. The source of the risk is eliminated usually by survey, avoidance was possible, identification of objects that cannot be avoided and removal of positively identified UXO that cannot be avoided.

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.

10.2 RISK ASSESSMENT RESULTS HOLLANDSE KUST (NOORD) WIND FARM ZONE

Table 13 shows the UXO risks within the HKNWFZ prior to the conduction of 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.

UXO risk is generally considered a low probability but very high consequence event, therefore it is the latter factor that usually dictates the overarching risk score. The potential consequence of a UXO detonation is by far the dominant factor in the calculation.

Severity of consequence, for example, will depend on the precise circumstances of the receptor (construction, equipment/personnel, vulnerability, depth of water, lay-back etc.). Likelihood of encounter will be governed by, inter alia, whether the UXO is likely to be completely buried, and to what depth, measured against the depth of intrusion into the sediment of a particular activity. The values assigned cannot be absolute or based upon statistical data (for example, of previous occurrences) because the data is not generally available and there are a great many permutations of the factors involved. The UXO specialist provides a professionally informed judgement based upon empirical, qualitative and anecdotal evidence employed in a consistent approach.

The purpose of the risk calculation at this stage is only to produce a relative order of merit to provide input for the Risk Mitigation Strategy. Nevertheless, despite its limitations, the risk assessment matrix as currently used is suitable for adequately assessing and grading Health and Safety (H&S) risk, which is generally mandated by legislation as well as individual company policy. It is also a robust tool for assessing project risk tolerability.

RISK ASSESSMENT RESULTS

Hollandse Kust (noord) Wind Farm Zone

Source	Likelihood of Presence	Pathway	Receptor	Type of encounter	Likelihood of Occurrence	Hazard Severity	Risk Result
Allied HE Bombs	Certain	See appendix 11	Personnel Equipment	Primary Secondary	3 = Possible	5 = Very High	15 = HIGH
Naval mines	Probable	See appendix 11	Personnel Equipment	Primary	3 = Possible	5 = Very High	15 = HIGH
Artillery shells 40 mm	Certain	See appendix 11	Equipment Personnel	Primary Secondary	2 = Unlikely	1 = Negligible	2 = LOW
Artillery shells 28 cm	Remote	See appendix 11	Equipment Personnel	Primary Secondary	1 = Very Unlikely	3 = Moderate	3 = LOW
Torpedoes	Remote	See appendix 11	Personnel Equipment	Primary	1 = Very Unlikely	4 = High	4 = LOW
Depth charges	Feasible	See appendix 11	Personnel Equipment	Primary	2 = Unlikely	4 = High	8 = MODERATE

Table 13: Risk Assessment results for the HKNWFZ.

There is sufficient and indisputable evidence that aerial bombs are present within the investigation area. There is also strong evidence indicating the presence of naval mines in the area. Since 2005 several mines have been encountered in the vicinity of the site. The planned construction works may cause an aerial bomb or naval mine to detonate. A detonation is assessed to be 'possible' and may be initiated by e.g. crushing with a cable trencher during cable lay operations, a kinetic energy created during pile foundation operations, etc.

In case of a detonation under water, the water column provides protection against fragmentation. The bubble jet and shock effect however, may cause serious damage to the vessel, compromising the integrity of the ship. Also personnel may be injured or killed due to the shock or sinking of the vessel.

Artillery shells originating from military exercises are certain to be present. These shells however do not pose a significant threat for installation operations.

11 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 (by reducing the probability or consequences).
- Carried with the balance of any residual risk transparently exposed to those parties involved with site works.

Although mitigation is generally the most cost effective and efficient 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.

11.1 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 HKNWFZ 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 risk to personnel to ALARP. The objectives of the mitigation strategy, are:

- Reduce the H&S risks to ALARP,
- 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.

11.2 METHODOLOGY

The conducted historical research has shown that several calibres of aerial bombs, naval mines and depth charges 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 as low as reasonably practicable (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 and disposal of actual UXO objects.

12 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 HKNWFZ. Due to the types and sizes of UXO likely to be present there is no "silver bullet solution" 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 HKNWFZ are as follows:
- Magnetometry (MAG);
- Electro Magnetic (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.

12.1 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 5-8 m distance to the MAG sensors (dependent on the type of sensors).

12.1.1 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.

12.1.2 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.

12.2 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.

12.3 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 HKNWFZ, 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.

12.4 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 0.2m 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.

12.5 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.

12.6 COMPARISON OF SURVEY TECHNIQUES

In table 14 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 preform 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	• Will detect ferrous UXO either buried or below the seabed (within bounds). • Not as susceptible to weather as other methodologies. • Ability to model the source target using the anomaly response. • Can detect larger ferrous objects at deeper depths than EM methods. • Multiple systems can be linked together in an array to enhance production rates and increase efficiency. • Data can be analysed to estimate target size and depth.	• Influenced by some geological features and manmade features. • Small survey footprint per magnetometer. • Will not detect non-ferrous UXO. • Instrument response may be affected by nearby power lines and cultural features.

Method	Strengths	Limitations
Electro Magnetic	• Advanced systems have multiple frequency and time gates. • Ability to detect all types of metallic munitions (ferrous and non-ferrous). • Additional data can provide information on target shape, orientation, and material properties. • Multiple sensors can be linked together in an array to enhance production rates and increase efficiency. • EM systems are less susceptible to cultural noise sources, such as utilities, than magnetic methods.	• Smaller detection range than a magnetometer. • Only specialist organisations operating with the equipment. • Could be affected by saline conditions.
Side Scan Sonar	• Large swath of data can be captured per run line. • Side scan sonar is the most suitable tool when searching for debris lying on the seabed. • A wide range of equipment and different frequency tow fish are commercially available. • Likely to identify large NEQ items of UXO. • 200% coverage allows contact position to be improved.	• Data quality influenced by marginal weather and water turbidity. • If USBL positioning is compromised then the positioning accuracy of seabed contacts may be limited. • Length dimensions may be exaggerated by a number of reasons including tugging. • Will not identify buried UXO. • Difficult to distinguish between UXO and other seabed feature such as boulders.
Multi Beam Echo Sounder	• Ability to identify UXO size targets on the seabed, with better accuracy than the side scan sonar. • Positional accuracy is very good, especially as the equipment is hull mounted. • Option of exceptionally high sounding accuracy, and a dense pattern of soundings to cover the seafloor in order to reveal small seabed features. • In addition to the soundings, the multibeam echo sounders produce seabed image data similar to a side scan sonar image (backscatter).	• Will not detect buried UXO. • A multibeam system can produce excellent results in this application only when positioned very close to the seabed. • The option to use echo sounder backscatter data analysis to characterise the seabed is complex and not commonly used for UXO identification. • Discrimination performance is degraded in rocky, uneven seabed conditions.
Seismic Sub Bottom Profiling	• Potential to detect buried UXO. • Option for LMB threat.	• Small survey footprint. • Difficult to discriminate between manmade and geological features.

Table 14: Comparison of survey techniques.

For a dedicated advice regarding survey techniques to be applied for HKNWFZ see chapter 13.

13 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[27], 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 HKNWFZ need to be determined. In determining the thresholds, the possible presence of non-ferrous UXO need to be taken into account. This chapter provides the provisional thresholds needed to mitigate the risk to a level that is considered ALARP. The threshold levels need to be reassessed based on the preliminary design and proposed installation methodologies.

13.1 SPECIFICATIONS OF UXO THAT REQUIRE MITIGATION MEASURES

Table 15 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 in air (kg)	NEQ (kg) (dependent on type of charge)	Ferrous mass (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	GP MK IV - VII	250 lbs	UK	26	70 / 142	104	30.7	73.3
Aerial bomb	GP	250 lbs	US	27.7	91.4 / 115.3	117	56.1 / 58.5	60.9 / 58.8
Aerial bomb	Demolition	300 lbs	US	27.7	100 / 123.4	124	62	62
Aerial bomb	GP	500 lbs	UK	32.6	94.5 / 179.3 or 141.2	213.4	64.8	148.6
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	GP	1.000 lbs	US	47.8	135 / 170	443	240 / 253	203 / 190
Aerial bomb	MC	250 lbs	UK	26	70 / 133.4	102	37	65
Aerial bomb	MC	500 lbs	UK	32.8	94.5 or 104 / 145 or 179	226	92 / 101	124 / 125
Aerial bomb	MC MK I	1.000 lbs	UK	45	133.4 / 183	549	215 / 238	334 / 311
Aerial bomb	MC MK III	1.000 lbs	UK	41	140 / 180	550	166 / 195	384 / 355
Aerial bomb	HC	4.000 lbs	UK	76	189 / 279	1707	1006 / 1102	701 / 605
Aerial bomb	LC	4.000 lbs	US	86	241 / 298	1860	1472 / 1525	388 / 335
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	SAP	500 lbs	US	30	120 / 147	227	73.5	153.5
Aerial bomb	AS	250 lbs	UK	29	89.5 / 147	112	60 / 62	52 / 50

[27] Objects that meet the set survey thresholds.

Category	Type	Calibre	Origin	Diameter (cm)	Length (cm) (without / with tail section)	Weight in air (kg)	NEQ (kg) (dependent on type of charge)	Ferrous mass (dependent on main charge)
Aerial bomb	Fragmentation	260 lbs	US	21.5	82 / 111	118	15	103
Underwater ordnance	Depth charge (Mk. VIII & MK XI)	n.a.	UK	28	98	134	73	61
Underwater ordnance	Torpedo	18 inch	UK	45,7	495	789	202	Unknown
Underwater ordnance	Moored contact mine Mk XIV	n.a.	UK	79	n.a.	255	145 / 204 / 227	110 / 51 / 28
Underwater ordnance	Moored acoustic mine Mk XVII	n.a.	UK	79	n.a.	255	145 / 227	110 / 28
Underwater ordnance	Moored mine UMB	n.a.	GER	84	n.a.	40	190	150
Underwater ordnance	Ground mine LMB	n.a.	GER	66	264 / 300	987	676	10
Underwater ordnance	Moored mine EMC	n.a.	GER	120	n.a.	630	300	330

Table 15: Specifications of UXO possibly to be present.

13.2 THRESHOLD LEVELS FERROUS UXO

Taking the results of the SQRA into account, it is assessed that the 250 lb bomb is deemed 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 between 30 and 60 kg of HE. 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 set on 50 kg ferrous mass. This threshold is also sufficient to detect ferrous naval mines which are likely to be present in the area. The risk also posed by the possible presence of depth charges, torpedoes and large calibre artillery shells will be mitigated sufficiently by applying the recommended threshold value.

13.3 THRESHOLD LEVELS NON-FERROUS MINES

Normally, in order to mitigate the risk of encountering an LMB mine, an additional Electro Magnetic (EM) and side scan sonar (SSS) survey is necessary. However, for HKNWFZ, there is no undisputable factual evidence to conclude non-ferrous LMB mines are likely to be present within the area of investigation. The historical information about the exact amount and type of mines in the nearby minefield C.35 is ambiguous.

The time, effort and costs involved in mitigating the risk posed by the presence of LMB mines is extremely high, excessive and, within our understanding of ALARP, is not considered to be reasonably practicable. Therefore an EM survey is not recommended. To enhance the evaluation process it is recommended to perform an SSS survey and correlate the SSS data with the magnetometer data.

The residual risk can be accepted as tolerable and can be assumed to be ALARP. Nevertheless, the decision as to whether the residual risk is tolerable must remain the developer's. Although we assess it as low, the residual UXO risk, post-mitigation (specifically from LMB mines) to project activities cannot be zero.

SSS thresholds

For the SSS the following thresholds are recommended:

- Size

  There were different types of LMB-mines in armament. All LMB-mines had a diameter of 0.66 m. The length varied from approximately 1.8 m to over 3.0 m. Based on these dimensions the size threshold is set to 1.5 x 0.5 m.
- Shape

  All LMB-mines are cylindrical. Therefore the shape threshold needs to be cylindrical.
- Structure

  LMB-mines were fitted with several small external features. These features may be noticed during evaluation of the SSS data.

13.4 REQUIRED DETECTION RANGE

The required detection range for UXO is to the intended installation depth +0.5m (interarray cables) or the assessed MDB (turbine and platform foundations). Therefore the maximum required detection range is assessed to be 3.2 m below seabed.

13.5 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 assessed in an additional risk assessment based on the (provisional) design of the wind farm and the relevant site data. The exact scope for the survey, identification, removal and disposal operations needs to be determined in a detailed UXO mitigation strategy.

13.6 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 WSCS-OCE 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.

13.7 REGULATION AND STANDARDS

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

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.

14 CONCLUSIONS

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

- *Identification of possible constraints for offshore wind farm related activities in the HKNWFZ as a result of the possible presence of items of UXO.*

  Based upon the analysis of historical sources, it is evident that different war related events took place within and nearby the area of investigation. Due to these events the entire area of investigation is to be considered a UXO risk area. A large variety of UXO are likely to be present which include artillery shells, aerial bombs, naval mines, depth charges 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).

- *Identification of areas within the HKNWFZ that could preferably not be selected for the installation of offshore wind farms and/or cables.*

  Within the proposed area there are no UXO risk free areas identified, however since the entire HKNWFZ 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 HKNWFZ can be selected for the installation of offshore wind farms and/or cables.

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

  The conducted historical research has shown that several calibres of aerial bombs, naval mines and depth charges 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 structure if possible and disposal of UXO items if required.

  Evaluating the results of the SQRA, it is assessed that the 250 lbs Air Dropped Bomb is deemed the smallest ferrous threat item for an ALARP sign-off. The ferrous weight of these bombs can range from 50 kg 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 set on 50 kg ferrous mass. This threshold is also sufficient to detect ferrous naval mines which are likely to be present in the area. The risk also posed by the possible presence of depth charges, torpedoes and large calibre artillery shells will be mitigated sufficiently by applying the recommended threshold value.

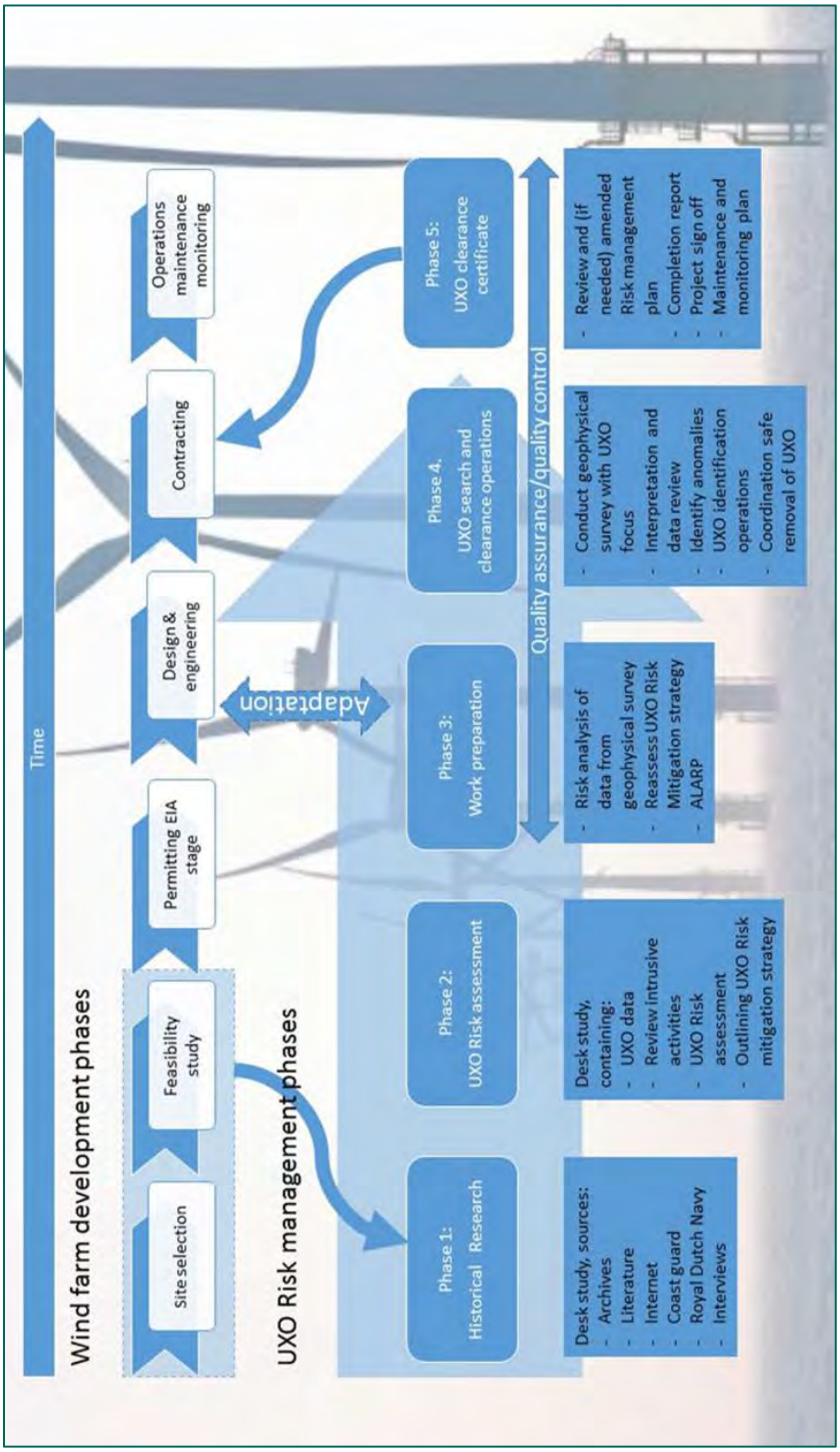
Annexes

15 ANNEXES

ANNEX 1 GLOSSARY OF TERMS

AAA	Anti-aircraft artillery
ALARP	As Low As Reasonably Practicable
BAMA	Bundesarchiv – Abteilung Militärarchiv (in Freiburg)
EEZ	Dutch Exclusive Economic Zone
EMC	Einheitsmine C (German moored contact mine)
EO	Explosive Ordnance
EOD	Explosive Ordnance Disposal
FLAK	Flugabwehrkanone (anti-aircraft gun)
GIS	Geographical Information System
HE	High Explosive
HKNWFZ	Hollandse Kust (noord) Wind Farm Zone
HMS	His Majesty's Ship
IMW	Imperial War Museum
Km	Kilometre
lb	Pound (weight)
LMA	Luftmine A (German ground mine)
LMB	Luftmine B (German non-ferrous ground mine)
m	Metre
mm	Millimetre
MW	Mega Watt
NEQ	Net Explosive Quantity
NM	Nautical Mile
SAP	Semi Armour Piercing
SS	Steam Ship
SQRA	Semi Quantitative Risk Assessment
TNA	The National Archives (in London)
UKHO	United Kingdom Hydrographic Office
UMB	U-bootmine B (German moored contact mine against submarines)
UTM	Universal Transverse Mercator
UXO	Unexploded Ordnance
WWI	World War One
WWII	World War Two

ANNEX 2 UXO RISK MANAGEMENT PHASES (IMAGE)



ANNEX 3 UXO FIGURES

Naval mines

E-Mine

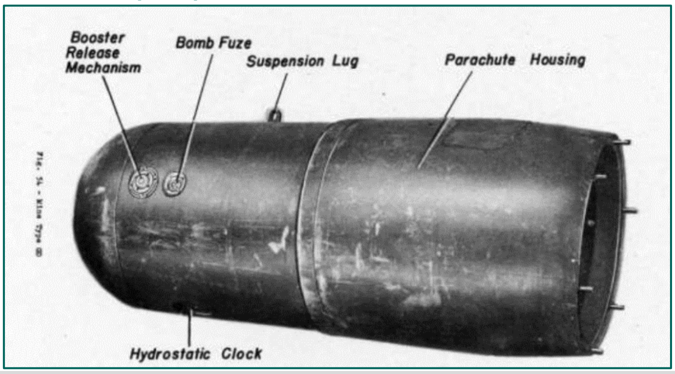
Characteristics

Utilised in (conflict): World War I

Nationality: German

Type: Moored contact mine

Luftmine A (LMA)



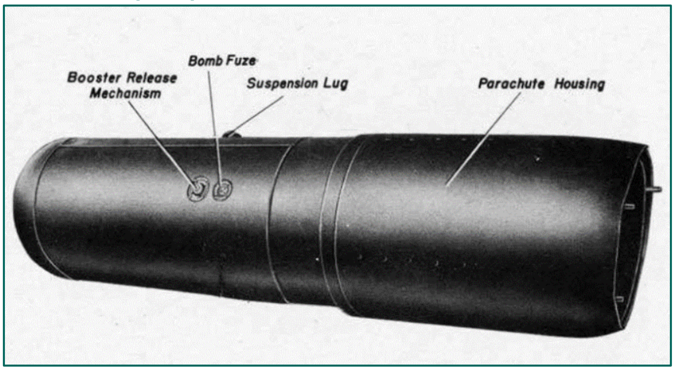
Characteristics

Utilised in (conflict): World War II

Nationality: German

Type: Magnetic ground mine. Later fitted with acoustic or acoustic/magnetic triggers.

Luftmine B (LMB)



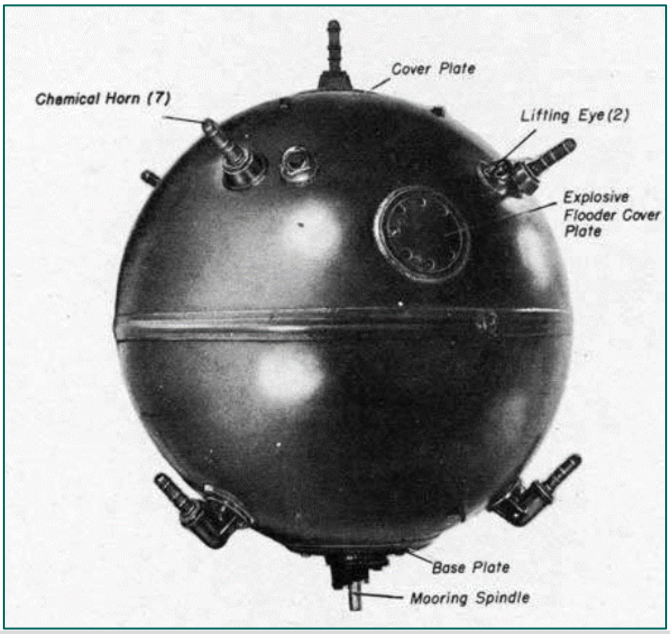
Characteristics

Utilised in (conflict): World War II

Nationality: German

Type: Magnetic and acoustic ground mine. Late in 1944 some were fitted with pressure/acoustic triggers.

Einheitsmine C (EMC)



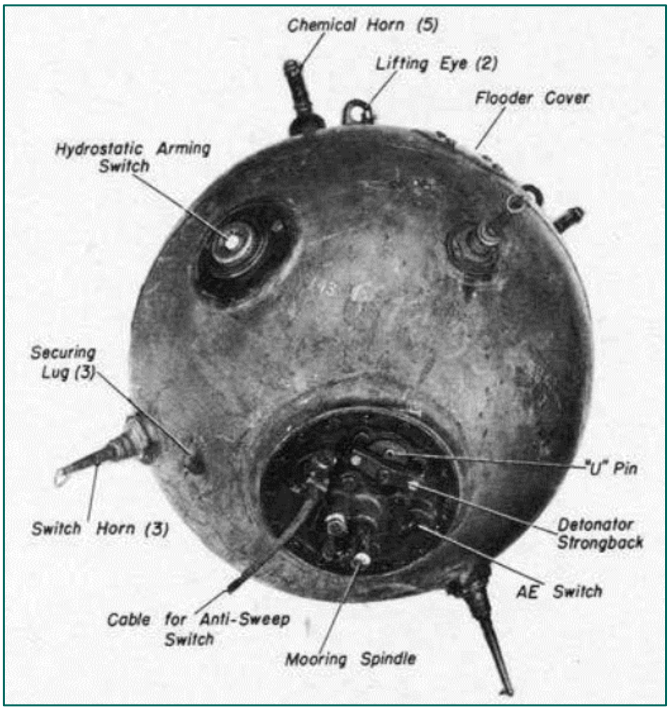
Characteristics

Utilised in (conflict): World War II

Nationality: German

Type: Moored contact mine.

Ubootmine B (UMB)



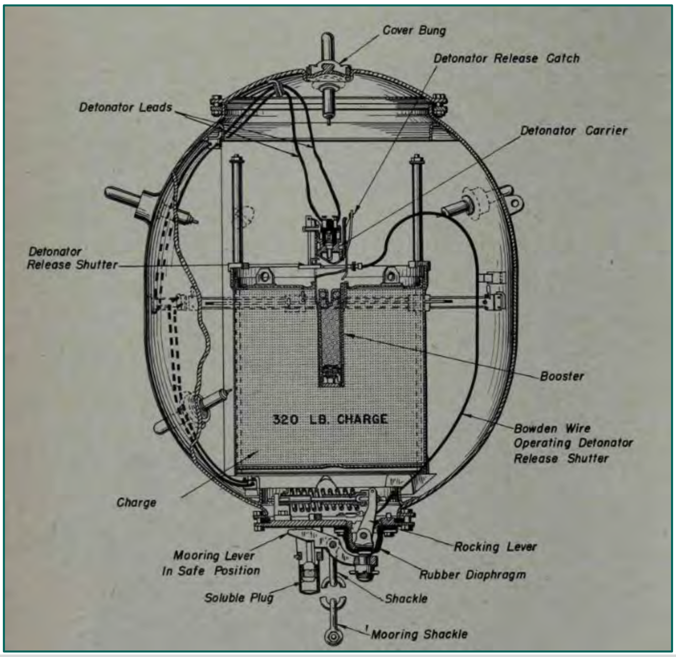
Characteristics

Utilised in (conflict): World War II

Nationality: German

Type: Moored contact mine.

Mark XIV



Characteristics

Utilised in (conflict): World War II

Nationality: British

Type: Moored contact mine.

Mark XVII

See Mark XIV mine

Characteristics

Same as Mark XIV mine. The main exception is that the Mark XVII is fitted with 11 switch horns.

A Mark I-IV

Characteristics

Utilised in (conflict): World War II

Nationality: British

Type: magnetic, induction of acoustic ground mine.

Aerial bombs

Characteristics

Utilised in (conflict): World War II

Nationality: British, US

Type: GP, MC, HC, fragmentation, demolition

Torpedoes

Characteristics

Utilised in (conflict): World War II

Nationality: British

Type: 18 inch, Aircraft launched

Depth Charges

Characteristics

Utilised in (conflict): World War II

Nationality: British

Type: Mk. VIII & MK XI

ANNEX 4 LITERATURE

For this research the following literary sources are consulted:

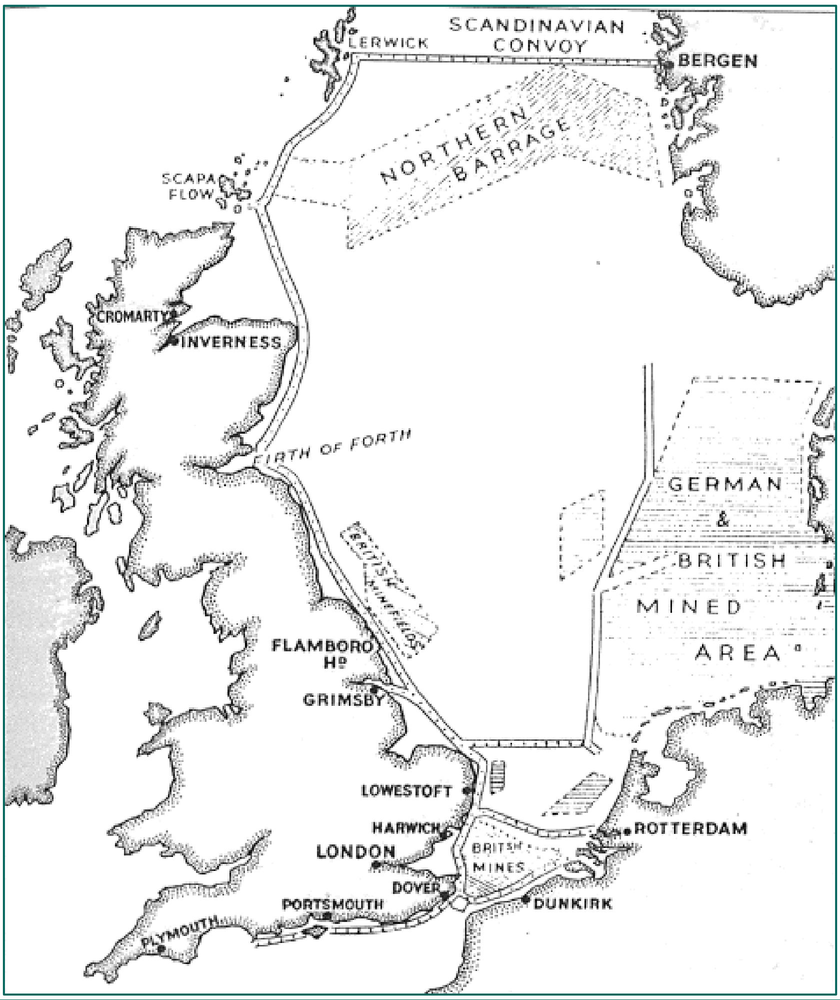
Abbreviation	Author	Title	Relevant
BEZ 1&2	Bezemer, K.W.L.	*Geschiedenis van de Nederlandse Koopvaardij in de Tweede Wereldoorlog* (2 dln.; Amsterdam).	Yes
BOW	Bowyer, Ch.	*Coastal Command at War* (1979).	No
BRO	Brongers, D.	*Op tegengestelde koersen. De kustvaart in oorlogstijd* (Deventer 1996).	No
BUR	Burg, G. van	*Oorlogsstorm over zee en havens. IJmuiden 1939-1946* (Schoorl 1995).	Yes
CRO	Crossley, J.	*The Hidden Threat. The story of mines and minesweeping by the Royal Navy in World War I* (South Yorkshire 2011).	Yes
DDH	Dienst der Hydrografie	*HP39. Wrakkenregister Nederlands Continentaal Plat en Westerschelde.* (Den Haag 2014).	
DIS	Dissel, A. van e.a.	*De Nederlandse koopvaardij in oorlogstijd* (Amsterdam 2014).	Yes
DUR	Durrieu, A. e.a.	*Atlantic Wall. Its most incredible remains.*	No
HAR	Harff, P. and Harff, D.	*Bergen (NH) 1940-1945. Bergen en Bergan aan Zee. Duitse bezetting, Atlantikwall en gevolgen voor de inwoners* (Bergen 2016).	Yes
KUR	Kurowski, F.	*Seekrieg aus der Luft. Die Deutsche Seeluftwaffe im Zweiten Weltkrieg* (Herford 1979).	No
MID	Middlebrook, Ch.	*The Bomber Command War Diaries. An operational reference book 1939-1945* (Leicester 1996).	Yes
MVL	Ministerie voor Luchtvaart	*Coastal Command speurt, beschermt, valt aan* (London, z.j.)	No
NES	Nesbit, R.C.	*The Strike Wings. Special Anti-Shipping Squadrons 1924-45* (London 1995).	Yes
RON	Rondèl, C. en Dalenberg, C.	*Ach ja, de LUA* (Hoorn 2007).	Yes
SCH	Schroeder, W, Kutzleben, K. von	*Minnenschiffe. Marinekleinkampfmittel* (1974).	Yes
SGLO	Studiegroep Luchtoorlog	*Crash database. Dutch Air War Studygroup. http:www.verliesregister.studiegroepluchtoorlog.nl*	Yes
VER	Verbeek, J.R.	*Kustversterkingen 1900-1940* (Wassenaar 1988).	Yes
ZWA 1&2	Zwanenburg, G.J.,	*En Nooit was het Stil. Kroniek van een Luchtoorlog* (2 dln. & supplement; Oldemarkt).	Yes

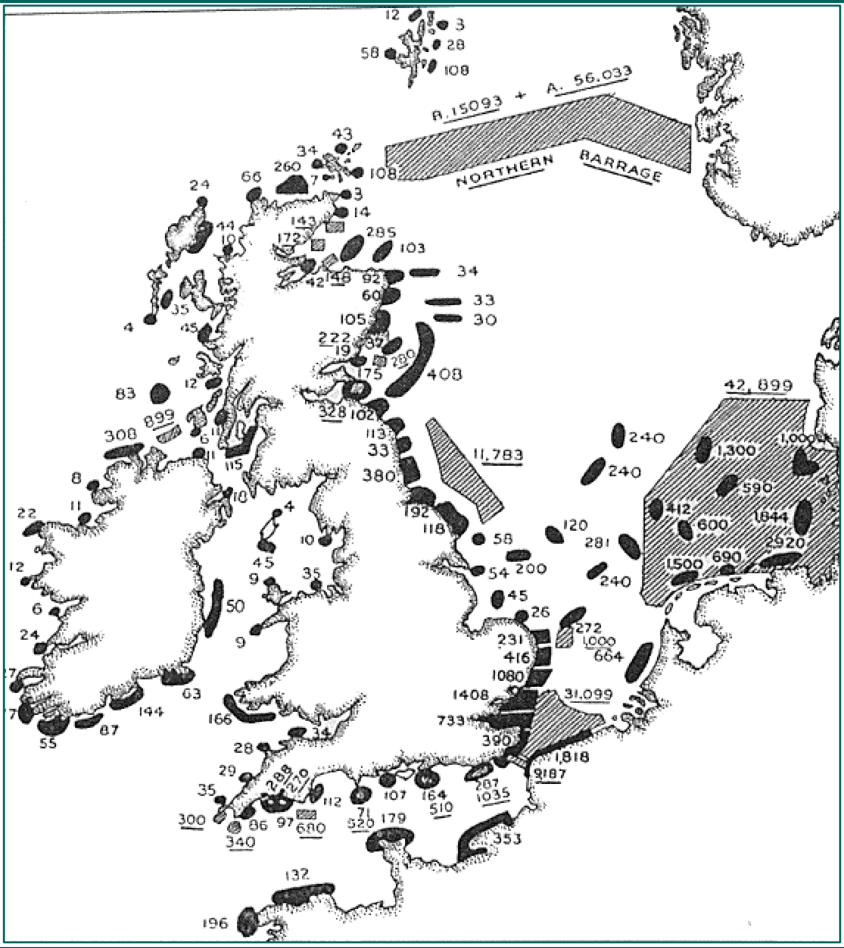
Table 16: Reference to literature.

In the following tables the information about relevant war events are reproduced per period.

Pre-war period and the First World War 1914-1918

During the second half of the 19th century and the 20th century tension were rising in Europe. Most countries were increasing their military expenses by producing weapons, cannons and shells. The great powers at the time were divided in two blocks. Great-Britain, France and the Russian Empire were joined into the Triple Entente. The German Empire together with the Austrian-Hungarian Empire and Italy formed the Triple Alliance. Italy left the Alliance in 1915, instead came the Ottoman Empire. Both alliances assured military support for its own members. The assassination of the Austrian-Hungarian crown prince Franz Ferdinand on the 28th of June 1914 in Sarajevo eventually lead to the outbreak of the First World War. The Netherlands were neutral during this war.

Date / year	Event	Source	Page
1914-1918	Mined areas during the First World War. The East Coast Swept Channel. Patrolled regularly by trawlers, this provided a safe route for coastal traffic. The system was extended to cover all coastal passages around the British Isles. Naturally, the German-laid minefields off the British coast were a hazard for German raiders as well as for British commerce.  	CRO	55
	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 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.	CRO	62

Date / year	Event	Source	Page
			
August 1914	The German government announced already in August 1914, they would probably have to lay mines in front of enemy harbours. In October 1914, the British government declared a certain area in the North Sea as mined area, but a small route will remain open. During the war, more and more allied and German mines were laid in different parts of the North Sea, which were declared as a war zone or dangerous zone by the belligerent parties. Mainly moored contact mines were laid. This mines were not dangerous anymore as soon as they were loose. This was the intention although the reality was different. During the war, 6,000 mines washed ashore on the Dutch coast. most mines were British (4,981; against 431 German, 81 French and more than 500 mines from unkown origin). Many of this mines did explode.	BEZ	24
2 November 1914	England declared the whole North Sea as war zone. Sea routes near the British coast were forbidden in order to force merchant ships to follow a route trough the Chanal. This provided the British Navy to controll the cargo. This decision made the Germans think about using U-boats to attack allied shipping.	BEZ 1	18
End of 1916	At the end of 1916 a total of 29 Dutch ships were sunk by mines. About one third of the mines were laid by U-boats.	BEZ 1	25
February 1917	Till the unlimitted U-boat war in february 1917, mines were the main treath to Dutch merchant ships. After 1 February 1917, the amout of Dutch ships destroyed increased fast. In total, 38 Dutch ships were sunk by German U-boats. Sometimes with torpedoes, then with artillery or charges.	BEZ 1	24, 26
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 origina1	CRO	149-160

Date / year	Event	Source	Page
	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 mine clearance activities and reported regularly to the IMCC, who issued regular charts and updates showing safe areas and known danger zones. 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. 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. Normally, deep fields 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. The intensive mining of the eastern North Sea also contributed to Germany's 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.		

Table 17: Overview war events during the First World War, 1914-1918.

Interwar period 1919-1939

After the areas devastated and damaged areas of WWI were rebuild, rural fields were brought back into cultivation and remainders of the war, like UXO, were cleared to a certain extent. Nowadays it is known that many tons of UXO were dumped, e.g. in the North Sea. During the interwar period, as the economies developed, construction and infrastructural works took place. During the 1930's international tensions rose again and many countries anticipated by building defence works.

Date / year	Event	Source	Page
1939	The last mine catastroph in 1939 was a ship which ran on a Dutch mine. Short before and shortly after the outbreak of war, the Royal Dutch Navy laid minefields with moored mines in front off the Dutch coast. One minefield, 'Schulpengat Buiten', was situated in front of de kop van Noord-Holland, between Den Helder and Callantsoog. The minelayer Willem van der Zaan laid 98 and 97 mines on 3 and 22 September 1939. The minefield was expanded on 11 April 1940 with a new row of 95 mines. On 9 December 1939, a ship ran on one of those mines.	BEZ 1	137

Table 18: Overview war events during the interwar period, 1919-1939.

The Second World War 1940-1945

After the German invasion of Poland on the 1st of September 1939, France and Great-Britain declared war with Germany. For about six months, different countries mobilized their armies but the fighting was very limited. In April 1940 Germany invaded Denmark and Norway. About one month later, on the 10th of May 1940, the German army invaded The Netherlands, Belgium and the Grand Duchy of Luxembourg. France was also invaded. From July 1940 till October 1940 the German Luftwaffe waged war over the North Sea and the British air space. Between 1941 and the first half of 1943 little movement was seen on the western front. This changed with the allied landing in Italy (3rd of September 1943) and the landings on the Normandy beaches (6th of June 1944). It would take the allied forces in Western Europe about ten months to liberate large parts of Europe and to enter German to force an unconditional surrender.

Date / year	Event	Source	Page
1940-1945	Ships had to deal with certain dangers. First, mines and later allied airplanes that attacked ships with bombs and machine guns. Fishing trawler from IJmuiden, who were fishing relatively close near the shore, could encounter mines and torpedoes in their fishing nets. They could also be attacked by planes.	BUR	53
Jan – 10 May 1940	During the last 4 months, no less than 16 merchant vessels were lost. 10 were struck by torpedos, 4 ran on a mine, 1 was sunk by an aerial attack and 1 was hit by naval guns. Furthermore, 4 fishing trawlers were lost; 2 by mines, 1 by an aerial attack and 1 was shelled.	BEZ 1	144
10 May 1940	The Luftwaffe dropped magnetic mines in front off the Dutch coast. The Nieuwe Waterweg was not suitable for shipping anymore. German magnetic mines were also dropped in front off IJmuiden harbour. With the help of British minesweepers, it was tried to clear the routes, but soon new mines were dropped.	DIS	22-23
13 May 1940	The British HMS Princess Victoria laid a large minefield in front off the Dutch coast. It existed of 236 mines and was situated 5 miles out off the coast of Castricum. This minefield coverd British operations in near the Belgian and Dutch shore.	BUR	22
14 May 1940	Luftwaffe. Mines. 23 Heinkels He-115's 106 and 12 Ju-88's took off for mine laying. In total 24 LM/A en 24 LM/B mines were dropped in the sea zone near Texel, Den Helder and IJmuiden.	ZWA 1	28
28 May 1940	Coastal Command. Offensive patrolls by 9 Swordfishes and 8 other Swordfishes to attack 3 MTB's 60 km WNW van IJmuiden and 6 MTB's near Ameland. No results were reported.	ZWA 1	41
27 Jun 1940	A Blenheim bomber of 235 Squadron crashed into the North Sea north-north west of Egmond/Noordwijk.	SGLO	T0732
12/13 July 1940	Coastal Command. Zes Swordfishes legden mijnen bij Ijmuiden.	ZWA 1	60
11 September 1940	9 Blenheims on sea sweep and ports reconnaissance; 1 aircraft bombed a convoy off Dutch coast.	MID	81
4 October 1940	A Beaufort of 42 Squadron crashed in the North Sea off IJmuiden.	SGLO	T0858A
8 October 1940	Coastal Command. 2 Beauforts on 'Rover-patroll' between IJmuiden and the Eems. One Beaufort spotted a flak ship near IJmuiden and another 16 km west off Terschelling. Due to technical failure, the torpedo of this Beaufort fell into the sea 22 km SW off Texel.	ZWA 1	113
18 October 1941	Mines washed ashore on different places (the next day, 12 mines were encountered on the beach near Egnomd).	BUR	71
23/24 October 1940	Coastal Command. 4 Swordfishes laid mines off IJmuiden.	ZWA 1	123
27 October 1940	9 Blenheims on sea and coastal sweeps. Ships attacked off Dutch coast. No losses.	MID	99
	Bomber Command. 7 Blenheims on 'Roving Commission'. A Blenheim attacked a small cargo ship near IJmuiden, but bombs fell 60 meters short.	ZWA 1	125
	Twee Beauforts 'Rover' from Borkum to Texel. Eén Beaufort spotted two cargo ships near IJmuiden. A torpedo attack was unsuccessful.	ZWA 1	125
11 January 1941	Bomber Command. 9 Blenheims carried out the following attacks. On a convoy of six ships 22 km west off Den Helder, Rotterdam harbour, airfield Haamstede, Flushings harbour, four E-boats 8 km west of IJmuiden etc.	ZWA 1	147

Date / year	Event	Source	Page
14 January 1941	2 Blenheims; 1 bombed a ship off Dutch coast but scored no hits. No losses.	MID	117
17 January 1941	Coastal Command. Four Beauforts escorted by three Blenheims attacked 12 km west off IJmuiden a convoy of four cargo ships and three flak ships. Hits were scored on two cargo ships, also near misses were scored.	ZWA 1	148
19 January 1941	Coastal Command. A Blenheim, on patroll along the Dutch coast, spotted 25 km NW off IJmuiden a non-escorted convoy of five ships. A dive attack was carried out against the last ship, but no hits.	ZWA 1	149
1 February 1941	3 Blenheims; 1 aircraft bombed a ship off the Dutch coast but scored no hits. No losses.	MID	119
18 March 1941	Coastal Command. A Blenheim attacked 70 km NW off IJmuiden, with 2 small bombs, a fishing trawler. Near misses.	ZWA 1	171
22 March 1941	6 Blenheims on coastal sweep. 1 aircraft attacked a convoy off Holland. No aircraft lost.	MID	137
	Bomber Command. Six Blenheims on ships. 15 ships in a convoy near IJmuiden were spotted. One Blenheim attacked. Bombs fell across one of the ships.	ZWA 1	172-173
24 March 1941	9 Blenheims on coastal sweeps. 1 fishing vessel was sunk off the Dutch coast. 1 aircraft lost.	MID	138
25 March 1941	5 Blenheims off Holland and the Frisian Islands. Convoy attacked and 1 ship claimed as hit. No aircraft lost.	MID	138
26 March 1941	Bomber Command. Twelve Blenheims on anti-shipping patroll off the Dutch coast. Three attacked a steam trawler of 4 to 500 ton. Others Blenheims attacked various small ships during a low-levell attack. Near misses were scored. The attacks took place between IJmuiden and Texel.	ZWA 1	174
	Coastal Command.	ZWA 1	174
29 March 1941	4 Blenheims off Belgium and Holland. 1 aircraft attacked a tanker heavily defended by Flak ships.	MID	139
6 April 1941	14 Blenheims to Belgian and Dutch coasts. Shipping and harbours were attacked. No losses.	MID	141
7 April 1941	A Blenheim bomber of 139 Squadron crashed into the North Sea, 25 km west of IJmuiden. The bomber was hit by German anti-aircraft and shot down by a German fighter.	SGLO	T0982
14 April 1941	16 Blenheims attacked Leyden and Haarlem power stations. 14 Blenheims on shipping patrols; a convoy off Holland was bombed. 1 Blenheim lost.	MID	144
18 April 1941	20 Blenheims and 6 Hampdens on operations to enemy coasts. A convoy off Holland was bombed and barges containing troops were also attacked. 1 Blenheim and 1 Hampden lost.	MID	146
30 April 1941	13 Blenheims on sweeps of Dutch and German coasts. 3 aircraft attacked a convoy off Holland. The defences of the convoy – 8 Flak-ship escorts for just 1 tanker, together with an Me 110 air cover – illustrate how the recent Blenheim operations forced the Germans to increase their protection of coastal shipping. 1 Blenheim was shot down attacking this convoy and another badly damaged; no hits were scored on the tanker.	MID	149
7/8 May 1941	Bomber Command. One Blenheim attacked a 300 ton ship 7 km off IJmuiden. A direct hit was scored.	ZWA 1	194
10/11 May 1941	Minor Operations: 18 Blenheims to the Dutch coast	MID	154
13 May 1941	Coastal Command. A Blenheim on patroll attacked a trawler of 800 ton with bombs and cannon and four other trawlers 40 km west of IJmuiden.	ZWA 1	200
14 May 1941	Coastal Command. Three Beauforts on 'Rover' patroll along the Dutch coast spotted 25 km WNW off IJmuiden a convoy of five merchant ships and two escorting vessels. One Beaufort attack a 5,000 ton ship with a torpedo. Afterwards, thick black smoke was spotted.	ZWA 1	200

Date / year	Event	Source	Page
23 May 1941	20 Blenheims on coastal sweeps. 1 ship was hit off Holland. No losses.	MID	157
27 May 1941	14 Blenheims on shipping sweeps off Holland and Germany.	MID	158
7 June 1941	Bomber Command. One Blenheim attacked a ship of 5 to 6,000 ton in a convoy near IJmuiden. Two hits were scored and the ship was left burning on its side. An other Blenheim successfully attacked a 5,000 ton ship in the same convoy. The ship was hit and started burning.	ZWA 1	206
16 June 1941	25 Blenheims on coastal sweeps off Holland and Germany. Several ships were attacked including a trawler well out to sea and suspected of being a radio warning ship. One of the Blenheims attacking this ship was so low that it hit the trawler's mast and crashed into the sea. 3 Blenheims were lost on this day.	MID	163
21 June 1941	23 Blenheims on coastal sweeps and a *Circus* operation to St-Omer airfield. The airfield was bombed and a ship attacked off the Dutch coast. 1 Blenheim was lost.	MID	165
29 June 1941	Coastal Command. A Blenheim attacked a convoy of seven ships from 2 to 4,000 ton, 28 km NNW off IJmuiden.	ZWA 1	216
5 July 1941	14 Blenheims on coastal sweeps off the Frisians and Holland.	MID	171
7 July 1941	20 Blenheims on coastal sweeps. Aircraft of 105 and 139 Squadrons made an attack on a convoy off Holland and hit 2 ships but lost 3 aircraft.	MID	172
12 July 1941	A Blenheim bomber of 107 Squadron was shot down during an attack on ships, 40 km west of Den Helder. The bomber crashed into the North Sea off IJmuiden.	SGLO	T1106
14 July 1941	Bomber Command. 8 Blenheims intercepted a convoy 13 km N off IJmuiden. 4 Blenheims attacked a 6,000 ton ship and hit it. Two others attacked a 3,000 ton ship and reported a hit. An other Blenheim reported a hit on an escorting vessel of 1,500 ton. All ships were claimed tob e destroyed.	ZWA 1	228
16 July 1941	5 Blenheims carried out sweeps off the Dutch coast without loss.	MID	181
2 August 1941	Bomber Command. 1 Blenheim attacked two small trawlers 5 km west off IJmuiden but the bombs missed their targets.	ZWA 1	237
14 August 1941	26 Blenheims on coastal sweeps over a wide area. Ships off the Dutch coast and in Boulogne docks were bombed. 1 aircraft lost.	MID	192
	Bomber Command. 31 Blenheims to five ships off the Dutch coast. One attacked a fishing trawler 52 km SW off IJmuiden and anther Blenheim attacked a drifter 65 km NNW off IJmuiden, but bombs were overshot. Three other Blenheims attacked a steam trawler 50 km west off IJmuiden and two drifters and a trawler 65 km NW of IJmuiden. Near misses were scored. Results were not observed.	ZWA 1	239
16 August 1941	Bomber Command. One Blenheim attack from 15 meter high a watch ship 10 km NW off IJmuiden. The bombs missed the target, that was strafed afterwards.	ZWA 1	244
18 August 1941	Bomber Command. One Blenheim attacked 52 km NW off IJmuiden a trawler of 2 to 300 ton. Due to the attack the rear end fell off and the ship sank within 45 seconds.	ZWA 1	245
21 August 1941	A Spitfire of 130 Squadron crashed into the North Sea near IJmuiden.	SGLO	T1223A
	A Spitfire of 130 Squadron crashed into the North Sea, 20 km west of IJmuiden.	SGLO	T1213B
26 August 1941	Bomber Command. Six Blenheims attacked 37 km north off IJmuiden eight control ships of 500 ton each. One was sunk, two others were hit. One Blenheim missing.	ZWA 1	247-248
7 September 1941	12 Blenheims on shipping attacks off the Dutch coast. 2 ships were hit and sunk or severely damaged. 2 Blenheims lost.	MID	200

Date / year	Event	Source	Page
11 September 1941	23 Blenheims on shipping sweeps from Holland to Norway. A convoy off Holland was attacked without success. No aircraft lost.	MID	202
12 September 1941	11 Blenheims on sweeps off the Dutch coast. 1 ship was hit. No aircraft lost.	MID	202
14 September 1941	12 Blenheims on sweep off the Dutch coast. Ships were attacked but not hit. No losses.	MID	203
20 October 1941	8 Blenheims on sweep of Dutch coast. 1 Flak ship was attacked off Terschelling, with either a hit or a near miss. No Blenheims lost.	MID	211
21 October 1941	Bomber Command. 17 Blenheims, 9 for ships near Ameland and the German islands and 8 with fighter escort for ships near Texel. Attacks were carried out 8 km west of IJmuiden on a convoy of sever or eight ships from 1 to 4,000 ton, escorted by flak ships.	ZWA 1	278
26 October 1941	8 Blenheims on a sweep off the Dutch coast. Ships were attacked but not hit. 1 Blenheim lost.	MID	214
27 October 1941	6 Blenheims on sweeps off the Dutch coast. A convoy was attacked but no results were seen. 2 Blenheims lost.	MID	214
11 November 1941	A Hudson and a Beaufort of Coastal attacked a 900 ton ship 18 km west off Den Helder. Direct hits caused the ship to sink within four minutes.	BUR	55
29 November 1941	Coastal Command. About 14.20 hour, three Beauforts took off fors hips near the Dutch coast. One Beaufort carried out an attack on a ship escorted by four torpedoboats, about 18 km off IJmuiden. schepen bij de Nederlandse kust. Results were not observed due to heavy anti-aircraft artillery.	ZWA 1	298
9 December 1941	4 Stirlings to Germany but only 1 aircraft bombed ships off the Dutch coast. No aircraft lost.	MID	225
First half 1942	During the first half of 1942, airplanes laid more than 4,000 mines of various types (magnetic and accoustic) in the sea routs along the Dutch Coast. This forced the German Navy to sweep the safe passages between known minefields for every convoy. Also escorting ships were equipped with minesweeping gear.	BUR	88
6 January 1942	Coastal Command. A Hudsons on patroll along the Dutch coast attacked about 18.18 hours a 1,000 ton ship 20 km NNW off IJmuiden. Results were not observed.	ZWA 1	319
19 January 1942	Coastal Command. A patrolling Beaufighter saw 35 km NNW off IJmuiden small armed vessels. An attack with cannon was carried out on one ship, resulting in white smoke.	ZWA 1	321
22 January 1942	A Beaufighter of 248 Squadron crashed into the North Sea near IJmuiden.	SGLO	T1392
29 January 1942	Coastal Command. A Beaufighter on recce attacked 15 miles north off IJmuiden a 300 ton ship with cannon. Hits on the deck.	ZWA 1	323
16 February 1942	8 Bostons, of 88 and 226 Squadrons, commenced the first regular operations with this new type of day bomber. They searched for German shipping off the Dutch coast without success or loss.	MID	236
11 March 1942	the KW. 26 AAFJE, an in 1915 constructed schip of 140 ton, was lost after running on a mine. The ship was situated about 24 miles NNW off IJmuiden.	BUR	55
8 April 1942	4 Bostons on a sweep off the Dutch coast. A ship was bombed but not hit. No aircraft were lost.	MID	254
17/18 April 1942	Coastal Command. A Hudson attacked a 4,000 ton ship 16 km west off IJmuiden. Results were not observed.	ZWA 1	345-346

Date / year	Event	Source	Page
18 April 1942	A Hudson of 407 Squadron crashed into the North Sea, 16 km west off IJmuiden.	SGLO	T1485A
17 July 1942	16 Wellingtons on cloud-cover raids to Emden (9 aircraft) and Essen (7 aircraft). Only 3 aircraft from the Essen force bombed and machine-gunned a convoy off the Dutch coast. Only near misses were achieved by the bombs. No aircraft lost.	MID	286
5/6 August 1942	Minor Operations: 57 aircraft minelaying off France, Holland and Germany.	MID	293
9/10 August 1942	Coastal Command. Eleven Swordfishes laid mines along the Dutch coast between IJmuiden and Texel. Seven were successful, one dropped a mine on a different position, an other returned early due to motor problems. Two aifcraft were missing.	ZWA 1	393
13/14 August 1942	Minelaying. 36 aircraft to many locations along the German and Dutch coasts. 1 Stirling lost.	MID	295
11 September 1942	11.20 hours, British and German MTB were fighting each other just north of IJmuiden. According to a German report, fourteen Germand boats of S-boat A were involved. One British ship was severly damaged and was enterd by German soldiers.	BUR	90
9 November 1942	A Hudson of 320 Squadron crashed into the North Sea off IJmuiden.	SGLO	T1905A
25 November 1942	1 Wellington bombed ships off the Dutch coast.	MID	326
	Coastal Command. 16.00 hours, twelve Hudsons were sent for an attack on a convoy, which was reported by a Spitfire near Hoek van Holland and heading north. Eight Hudsons attacked north off IJmuiden a convoy. A direct hit was observed on the front deck of a 2,000 ton ship and caused a big explosion. Another bomb was possibly also a direct hit, near misses were scored on two other ships. Four Hudsons did not attack.	ZWA 1	426
3/4 January 1943	Minor Operations: 39 Wellingtons and 6 Lancasters minelaying off the French and Dutch coasts	MID	341
29 January 1943	A Spitfire of 118 Squadron crashed into the North Sea, 15 km north west of IJmuiden.	SGLO	T2017
5/6 March 1943	A Stirling bomber of 214 Squadron crashed in the North Sea, 30 km north north west of IJmuiden.	SGLO	T2098
8/9 April 1943	A Wellington of 300 Squadron crashed into the North Sea, 20 km west of IJmuiden.	SGLO	T2182
3 May 1943	A Ventura of 487 Squadron crashed into the North Sea, 19 km west of IJmuiden.	SGLO	T2248
23/24 May 1943	A Lancaster bomber of 57 Squadron crashed into the North Sea, 40 km west of Egmond.	SGLO	T2359
25/26 May 1943	A Stirling bomber of 90 Squadron crashed into the North Sea, 70 km west of Alkmaar.	SGLO	T2381
11/12 June 1943	A Halifax bomber of 405 Squadron crash landed into the North Sea, 80 km west of IJmuiden.	SGLO	T2421
	A Lancaster bomber of 83 Squadron crashed into the North Sea, 40 km west of Alkmaar.	SGLO	T2425
21/22 June 1943	A Wellington bomber of 300 Squadron crashed into the North Sea, 65 km west of IJmuiden.	SGLO	T2517
23/24 August 1943	A Lancaster bomber of 115 Squadron ditched into the North Sea, 20 km west of Castricum, due to battle damage.	SGLO	T2851
1 September 1943	Heading from Rotterdam to Hamburg, the Baloeran ran on a mine just north off IJmuiden. The ship was stranded and later destroyed by British airplanes and MTB during the night of 19-20 September 1943.	BEZ 1	176

Date / year	Event	Source	Page
15/16 September 1943	Coastal Command. One out of six Hampdens on anti-shipping patroll, torpedoed a passenges ship 2 miles off IJmuiden. Results were unobserved.	ZWA 2	82
19 October 1943	The vessel *Strassburg*, a German liner of 17.000 tons, was sunk by 236 and 254 squadron, Coastal Command, off IJmuiden.	NES	259
31 December 1943 / 1 January 1944	There were no bomber operations on New Year's Eve; 2 Stirlings laid mines off the Dutch coast and returned safely.	MID	462
27/28 January 1944	Berlin. 515 Lancasters and 15 Mosquitoes. The German fighters were committed to action earlier than normal, some being sent out 75 miles over the North Sea from the Dutch coast. Extensive operations were carried out in support of the Berlin raid. 80 Stirlings and Wellingtons flew to the Dutch coast and laid mines there	MID	465-466
16/17 March 1944	3 Stirlings minelaying off the Dutch coast.	MID	480
29 March 1944	A Boeing B-17 bomber of 91 Bomb Group crashed into the North Sea, 50 km west off IJmuiden.	SGLO	T2559A
1/2 April 1944	34 Halifaxes minelaying off the Dutch coast	MID	489
7/8 April 1944	12 Halifaxes minelaying off the Dutch coast.	MID	490
18 April 1944	A P-38 of 20 Fighter Group crashed in the North Sea, 35 km west of IJmuiden.	SGLO	T3600
26/27 April 1944	16 Halifaxes and 6 Stirlings minelaying off the Dutch coast and in the Frisians	MID	498
	Three Stirlings laid fifteen mines off IJmuiden.	ZWA 2	224
	Coastal Command. 00.19 uur. A Wellington on armed recce in Den Helder area attack a convoy of three carriers 12 miles NNW off IJmuiden. Five 500 lbs MC were dropped. Results from the first two bombs were unbserved, the others felt across one of the ships and caused an orange flash and smoke.	ZWA 2	205
27/28 April 1944	Three Stirlings laid fifteen mines off IJmuiden.	ZWA 2	224
15/16 May 1944	Coastal Command. 03.52 uur. An Avenger attacked a small carrier, 8 miles north off IJmuiden. Four 250 lbs bombs were dropped from 1,400 ft.	ZWA 2	214
28/29 April 1944	Bomber Command. A Stirling laid five mines off IJmuiden.	ZWA 2	225
29/30 April 1944	Bomber Command. In the Netherlands Nederland a Halifax laid four mines off IJmuiden.	ZWA 2	225
31 May / 1 June 1944	Bomber Command. A Halifax laid four mines off IJmuiden..	ZWA 2	227
8/9 June 1944	Bomber Command. A Stirling laid five mines off IJmuiden.	ZWA 2	233
15/16 June 1944	Bomber Command. A Stirling laid six mines off IJmuiden.	ZWA 2	239
6/7 July 1944	4 Stirlings minelaying off the Belgian and Dutch coasts.	MID	537
15 July 1944	The V 1412 was sunk by 2 British MTB west off IJmuiden.	BUR	116
August 1944	By August 1944, the Germans had been forced to cease sending convoys by day along the Dutch coast. The toll taken by the allied air forces had become too heavy. The only possible tactic was to sail the convoys by night., in short hops from port to port, sheltering in heavily defended harbours during the long daylight hours. In response, Coastal Command tried to attack the convoys at night, employing the Torbeaus of the Strike Wings. These squadrons were joined by two bomb-carrying squadrons	NES	181-182

Date / year	Event	Source	Page
	based at Bircham Newton in Norfolk, the Wellingtons of 524 Squadron and the Avengers of 855 (Fleet Air Arm) Squadron. During moonlit nights these aircraft would roam along the Dutch coast on patrols called Rovers, taking off singly at set intervals and seeking 'targets of opportunity'. On dark nights, they would sometimes adopt more involved tactics, known as Operation Gilbeys. These were combined bombing and torpedo attacks, and the method had been worked out as early as January 1944, based on experiments carried out by the Torbeaus of 254 Squadron at North Coates. The tactics of Operation Gilbey involved the extensive use of flares. The Beaufighter could carry only four flares but the Wellingtons could carry as many as seventy as well as a load of 500 lb medium-capacity bombs. The Wellingtons, equipped with Gee radar and ASV (anti-surface vessel) radar, would hunt along the Dutch coast and try to locate a convoy.		
1 September 1944	The Tilly, a German minelayer of 146 tons, was sunk by 254 Squadron, Coastal Command, off IJmuiden.	NES	264
15 September 1944	A Spitfire of 229 Squadron crashed into the North Sea, 48 km west off IJmuiden.	SGLO	T4025
5 December 1944	A P-51 D of 479 Fighter Group crashed into the North Sea, 25 miles off Egmond.	SGLO	T4746
1945	Mines have continued to evolve since 1918. During the Second World War mines dropped from aircraft and laid by ships formed an important part of British and German strategy. Magnetic and acoustic mines, as well as conventional contact mines, were used by both sides, and increasingly sophisticated systems were used for mine clearance.	CRO	160

Table 19: Overview relevant events during the Second World War, 1940-1945.

Post-war period

Like the interwar period, countries began to rebuild. As a part of this reconstruction defence works and remaining UXO were cleared. Also, the sea was cleared of mines.

Date / year	Event	Source	Page
1955	Anti-aircraft artillery exercise camp at Den Helder. 	RON	61

Table 20: Overview post-war period.

ANNEX 5 MARINEMUSEUM, NOORDZEELOKET EN DIENST HYDROGRAFIE

ANNEX 5 MARINEMUSEUM, NOORDZEELOKET EN DIENST HYDROGRAFIE

Marinemuseum

This annex contains the information which is derived from the maps and charts of the Royal Netherlands Navy. Figure 31 shows the area of investigation projected on the NEMEDRI 227 mine map.

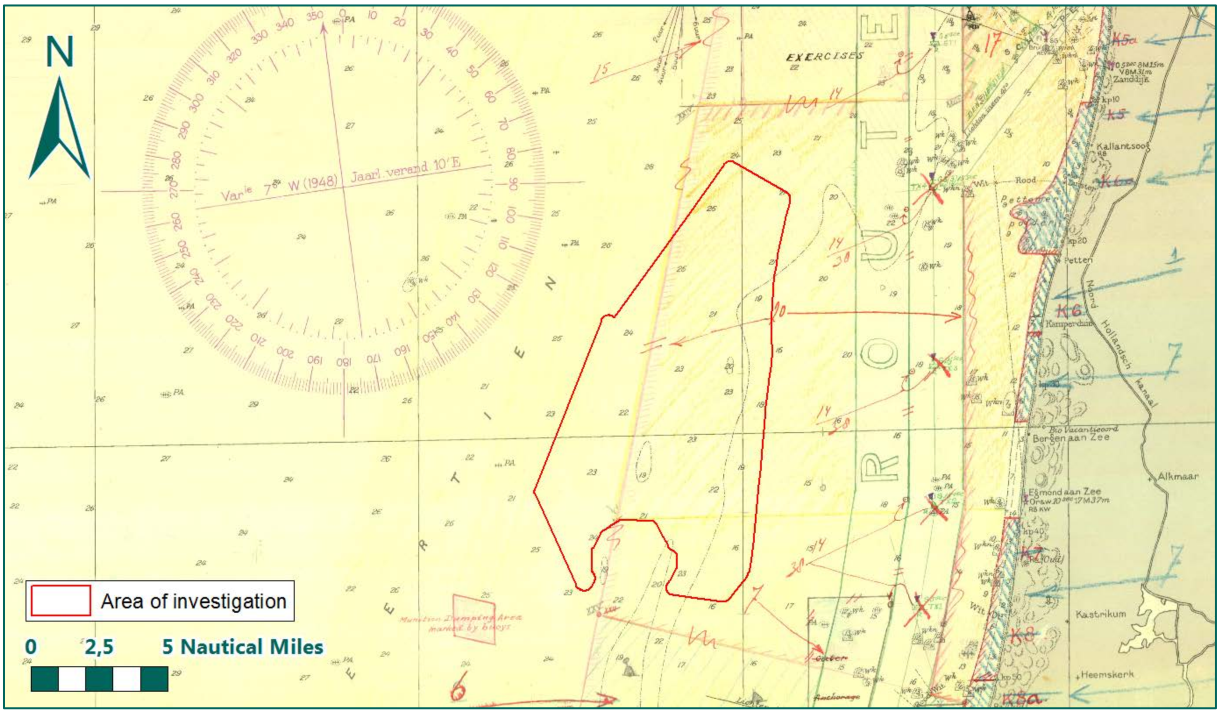


Figure 31: Extract of NEMEDRI 227 mine map.

The map shows the following elements:

- About 1.99 NM (= 3.7 km) to the north of HKNWFZ lies an area designated for naval exercises.
- A large part of the WFZHKN lies within a former danger area.
- About 3.02 NM (= 5.6 km) to the south of HKNWFZ lies a munition dumping area, which is marked with buoys.

Noordzeeloket

The North Sea Desk ('Noordzeeloket') is a cooperation between different departments of the Dutch Government that deal with the North Sea. This desk can be consulted at: https://www.noordzeeloket.nl. The website contains the map 'Military Use'. Figure 32 shows this map.

The following UXO-related events are indicated on the map:

- A former munition dump site. This site is also shown on the NEMEDRI 227 mine map from the Marinemuseum (Navy Museum).
- An exercise area for mine clearance. This area has overlap with the area for naval exercises as shown on the the NEMEDRI 227 mine map from the Marinemuseum (Navy Museum).
- Different shooting areas. The large zone has overlap with the area of investigation.

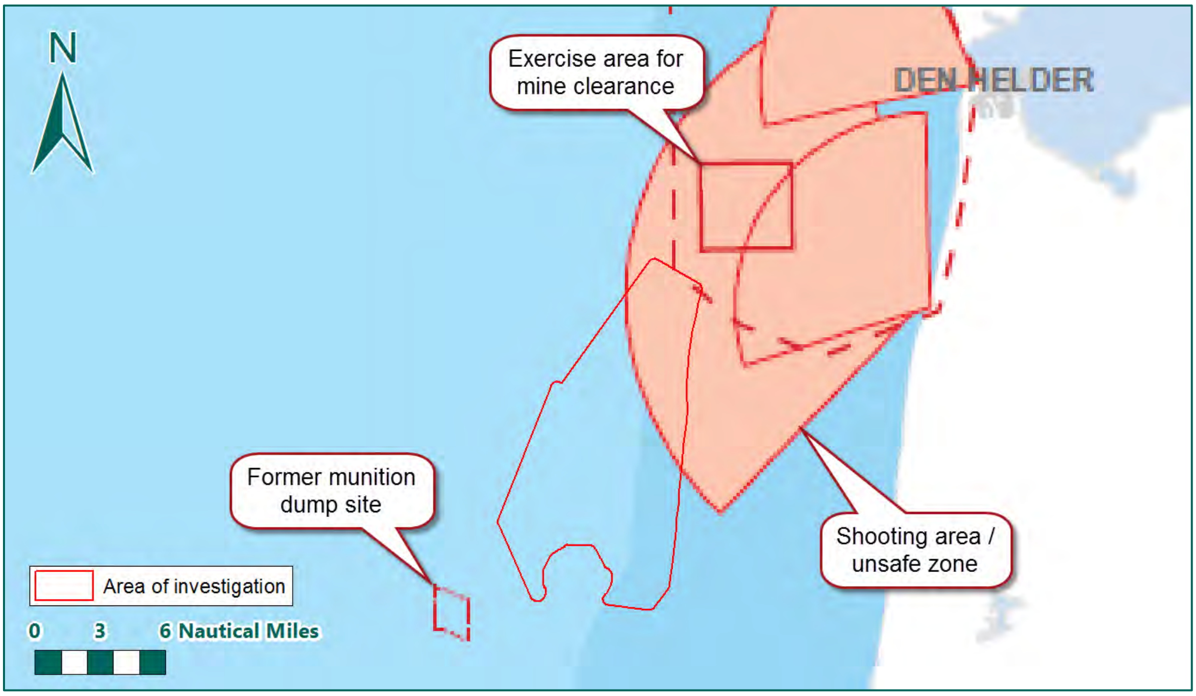


Figure 32: Extract of the map Military Use.

Dienst Hydrografie Defensie

REASeuro ordered the Sea chart *DKW1801: Noordzeekust. De Panne tot Den Helder* from the Hydrographic Service of the Royal Netherlands Navy. This chart is shown in Figure 33.

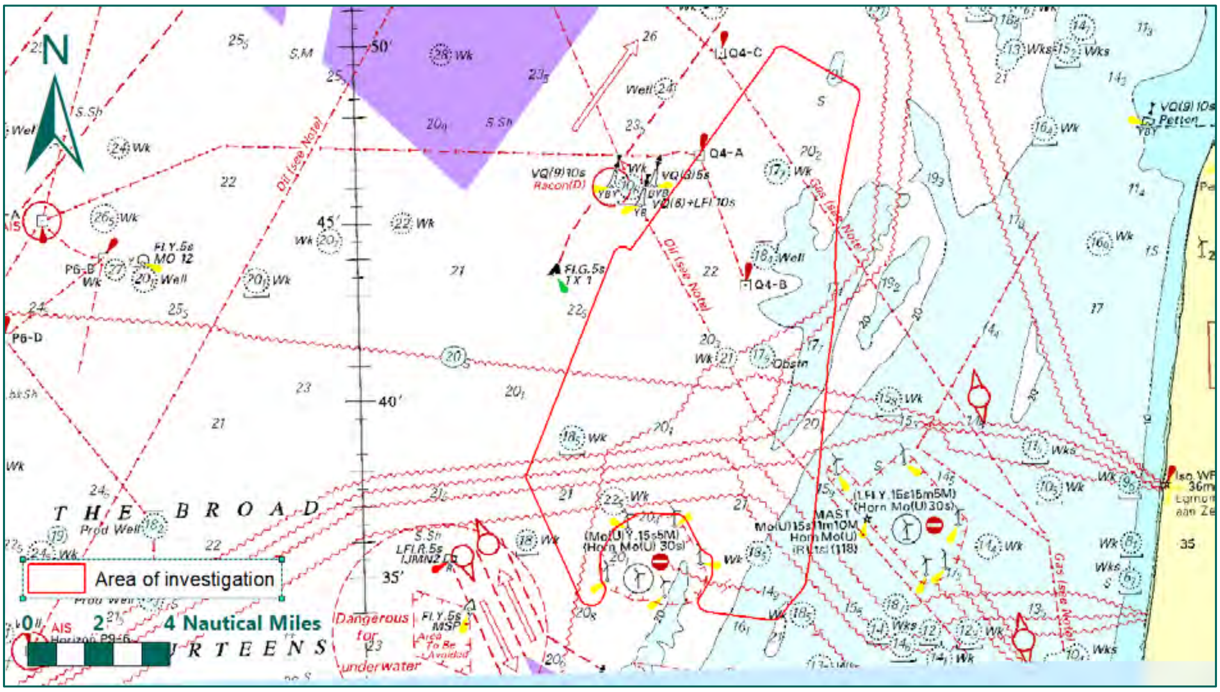


Figure 33: Extract from the Sea chart DKW1801: Noordzeekust. De Panne tot Den Helder.

The following elements, possibly related to war and/or UXO, are indicated on the chart:

- Area to be avoided, to the southwest of HKNWFZ. This location is also present on the Noordzeeloket chart and is indicated as a former munition dump site.
- Wreck within and in the vicinity of HKNWFZ:

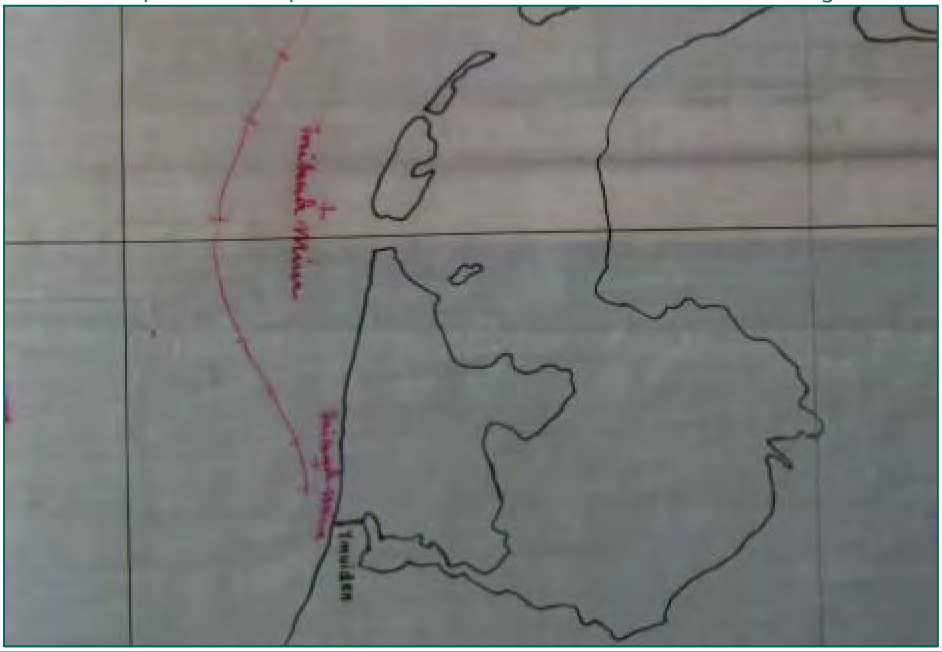
ANNEX 6 BUNDESARCHIV-MILITÄRARCHIV, FREIBURG

REASeuro has conducted archival research in the Bundesarchiv-Militärarchiv (BaMa) in Freiburg, Germany. Objective of this research was primarily to gain more insight in German naval and coastal warfare during the First and Second World War. German Air Force documents were also consulted. The destruction wreaked upon Germany during World War II destroyed large parts of the archival material, leading to large gaps in the documentation. Documents from the following record groups were consulted:

- 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 35-II: Marinegruppenkommando West der Kriegsmarine.
- RM 43: Dienststellen und Kommandostellen der Kaiserlichen Marine im Heimatbereich.
- RM 45-II: Dienststellen und Kommandostellen der Kriegsmarine im Bereich Deutsche Bucht und Niederlande.
- RM 48: Flottenkommando der Reichsmarine und Kriegsmarine.
- RM 51: Geschwader und Gruppen der Kaiserlichen Marine.
- RM 52: Führer von Torpedobootstreitkräften der Kaiserlichen Marine.
- RM 65: Handelsschutzverbände der Kaiserlichen Marine.
- RM 86: Befehlshaber der Unterseeboote der Kaiserlichen Marine.
- RL 2-II Generalstab der Luftwaffe / Luftwaffenführungsstab.
- ZA 5: Deutscher Minenräumdienst (German Minesweeping Administration).

The following relevant documents were acquired during this research:

RM 5 Admiralstab der Marine / Seekriegsleitung der Kaiserlichen Marine	
RM 5/4721k	Streuminen": Minenverseuchung, Verluste durch Minenlegen. Bd. 2 Dez. 1914-Juni 1915 Kartenanlagen.
Relevant, map shows a suspicious mine area in front of the Dutch coast during the First World War.	



RM 7 Seekriegsleitung der Kriegsmarine	
RM 7/86	Heft II: Lageübersicht Westraum/Nordsee.- Kriegstagebuch Teil B II. 15. Okt. 1941 - 31. Dez. 1943

Relevant. The records refer to British aerial and naval attacks, give information about mine clearance in front of the Dutch coast. Examples are given:

- Lageübersicht Westraum vom 15. – 31 März 1942.
  - Ein geleiter Erzdampfer ("Islande") lief nahe Hoek van Holland auf eine Mine, konnte aber eingeschleppt werden.
  - Küstenbatterien beschossen am 21 März abende vor der holländische Küste in Gebiet zwischen Hoek van Holland und Scheveningen geortete Ziele.
- Vom 1. – 15 März 1943.

<u>Minenräumerfolge:</u>

Während der Berichtszeit wurden im Gebiet des BSN insgesamt 95 Minen geräumt, davon
84 ELM/I und
11 ELM/A.
Der größte Teil dieser Minen wurde vor den Westfriesischen Inseln, vor Ymuiden und Den Helder, ein weiterer Teil vor Borkum und der kleinere Rest im Gebiet der Deutschen Bucht geräumt.

Die 12. Vp.-Flottille hat vom 23.2. - 2.3. 97 treibende Minen abgeschossen.

<u>Minenlage:</u>

Die großen Räumarfolge auf den Geleitwegen der Nordsee, vor der holländischen Küste und dem Kanal sind auf die erheblich günstigere Wetterlage in der Berichtszeit gegenüber dem Monat Februar zurückzuführen. Andererseits hat der Gegner diese günstige Wetterlage dazu benutzt, hauptsächlich mit Flugzeugen eine stärkere Verminung dieser Wege vorzunehmen.

Die starke Verminung vor Ymuiden, Den Helder und Boulogne deutet darauf hin, daß der Feind diese Häfen als Stützpunkte für unsere Streitkräfte ausschalten will. Sie beweist andererseits, daß diese Gegenden

- Vom 16 März – 15 April 1943

Minenräumerfolge:

Jnsgesamt 157 Minen geräumt.

38 Mark 19 mit Ziehleine aus dem verseuchten Gebiet vor Scheveningen.

Bei den übrigen Minen handelt es sich hauptsächlich um Grundminen. Sie wurden vor der holländischen Küste und auf den Geleitwegen vor den West- und Ostfriesischen Jnseln geräumt.

Feindberührungen:

Am 12.4. Pos.-Boote vor Ymuiden Gefecht mit engl. S-Booten. Treffer auf 2 S-Boote.

Luftangriffe:

Am 27.3. M 4 westlich Scheveningen von 2 Zerst. Flugzeugen angegriffen.

Am 10.4. M 3406 vor Ymuiden von 4 engl. Jägern angegriffen.

Am 15.4. Luftangriff auf M 3412 zwischen Den Helder und Ymuiden.

Verluste und Beschädigungen:

Am 27.3. M 82 westl. Scheveningen Ate- Minentreffer. Boot mit eigener Kraft eingelaufen.

- Vom 16 -30 April 1943.

Feindberührungen:

Am 17.4. vor Ymuiden Gefechtsberührung der Vorp. Pos. mit feindlichen S-Booten.

Am 18.4. Gefecht der Vorp.Boote auf Pos. Schveningen mit 8 feindlichen S-Booten. Hierbei 1 S-Boot (" Adonis") versenkt, ein weiteres wahrscheinlich, 2 beschädigt.

Am 29.4. Sicherungs-Pos. Ymuiden Gefecht mit feindl. S-Booten. 1 S-Boot versenkt, 1 S-Boot in Brand geschossen. VP

Luftangriffe:

Am 16.4. bei Ymuiden Angriff von 2 Spitfire auf M-Boote 3403, 07, 09, 12.

Am 18.4. Tagesangriff von 20 Bombern und 20 Zerstörern auf Geleit von Hoek nach Elbe vor Den Helder. Hierbei norwegischer Dampfer " Hoegh Carrier" (4906 BRT) durch T-Treffer gesunken. M 201 beschädigt. 2 Abschüsse.

Verluste und Beschädigungen:

Am 18.4. vor Den Helder norwegischer Dampfer " Hoegh Carrier" (4906 BRT), Ladung Kohle, durch T-Treffer vom Flugzeug gesunken.

Am 21.4. dänischer Dampfer " Catja Lau " (1224 BRT), Ladung Koks, vor Ymuiden Grundminentreffer. Beschädigt nach Ymuiden eingeschleppt.

Am 28.4. VP 1408 durch T-Treffer vom S-Boot vor Ymuiden gesunken.

Luftangriffe:

Am 14.5. Angriff von 12 Flugzeugen auf 3 Boote der 34. Minensuchfl. bei Ymuiden und Angriff auf Hochofenwerk Ymuiden.

Verluste und Beschädigungen:

Am 14.5. M 8 vor Scheveningen nach Gefecht mit S-Booten durch 2 T-Treffer gesunken.

- Vom 1-30 Juni 1943.

Luftangriffe:

18.6. Fliegerangriff auf VP-Pos. bei Ymuiden, Boote Personalschäden.

22.6. 1 Abschuß bei Vlissingen
22.6. Angriff von 45 Bomben- und T-Flugzeugen auf Geleit vor Scheveningen, BAW auf Booten, starke Personalausfälle.

- Vom 1-15 Juli 1943.

Minenräumerfolge:
44 Minen wurden in der ersten Monathälfte auf den Geleit-Wegen in der Nordsee und auf den West-und Nordfriesischen Jnseln geräumt.

Luftangriffe:

8.7. Ein Abschuß bei Den Helder.
Zweimaliger Angriff auf HS-Boote vor Den Helder durch 2 Feindflugzeuge.
1 Abschuß durch Mar. Flak.
Angriff auf Vlissingen.
1 Abschuß.

Verluste und Beschädigungen:

Kraft Cuxhaven eingelaufen.
5.7. Holl. Fischkutter " Scheveningen 140 " (250 BRT)
NW Ymuiden durch Minentreffer gesunken.

Feindberührungen:
Jn der Nacht vom 5. zum 6.7. westl. Den Helder Gefecht zwischen 34. Msfl. und feindl. S-Booten. Die Angriffe wurden abgewehrt.

- Vom 16-31 Juni 1943.
  Feindberührungen:

25.7. 0119 Uhr 34. Msfl. xGr.Ymuiden Gefecht mit feindl. S-Booten in Höhe Nord-Wijk. 1 S-Boot versenkt, 3 weitere in Brand geschossen.
0243 Uhr erneutes Gefecht mit feindl. S-Booten und 34. Msfl. und VP-Booten 1313/14 bei Ymuiden. 2 Boote in Brand geschossen.

Verluste und Beschädigungen:

20.7. VP 805 durch Min.Det.
23.7. Jm S-Boots-Gefecht vor Ymuiden R 107, 103, 87 schwer beschädigt.
Fischereifahrzeug "KB 158" zwischen Ymuiden und Den Helder nach U.W. Det. gesunken.
feindl. Gun-Booten nördl. Vlie

- Vom 1-15 September 1943.

Gefechte mit S-Booten setzten erst am 14. ein. An diesem Tage gingen um 0213 Uhr ein M-Boot zwischen Ymuiden und Scheveningen durch Torpedo-Treffer eines feindlichen S-Bootes verloren. Am 15.9. 0115 Uhr kam es vor Ymuiden zwischen Vorpostenbooten und S-Booten und 2 Stunden später zwischen R-Booten und S-Booten zu ergebnislosen Gefechten, bei denen der Feind sich durch Anwendung von Nebel und eines neuartigen Brandsatzes der deutschen Waffenwirkung entzog.

RM 7/172	Heft VI: Minenkriegführung Kriegstagebuch Teil C VI

	Bd. 13. Sept. 1939 - 21. Jan. 1941

- 15 Okt 1940
  Map shows British minefields in front of the Dutch coast.

Holländisch-belgische Küste:

- 26 Juni 1940. Englische magnetische Minen.

  e) Ijmuiden:
  im seew_rtigen Halbkreis (Radius 1 sm) um
  52°28'N 4°33,1' O

- 19 September 1940. Englische Minensperren.

  19.9.40 Englische Minensperren:
  a) Ijmuiden:
  vom Punkt 52°33'00"N 4°28'18" O in Richtung
  280° 6,1 sm
  (bereits durch Beuteseekarte bekannt)

  b) Ijmuiden:
  im Umkreis von 3 sm um 52°42'N 4°10' O

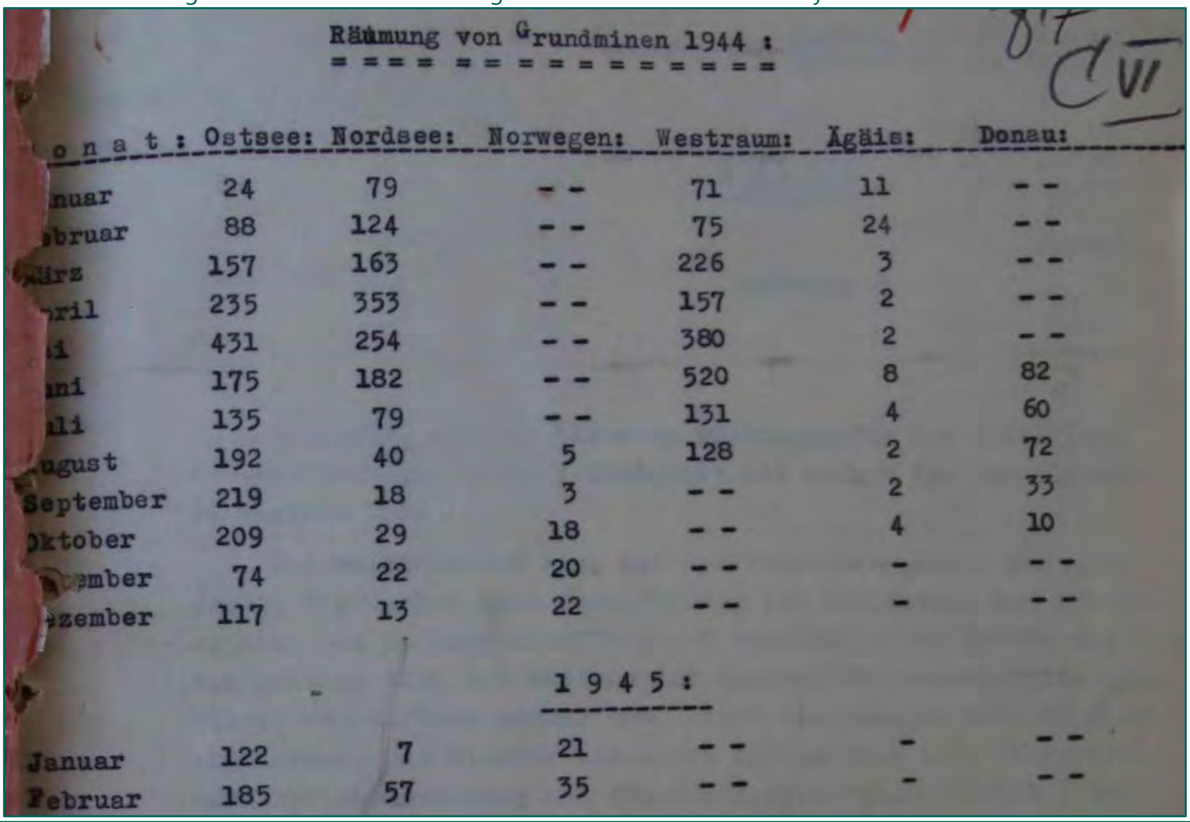
  c) Scheveningen:
  im Seegebiet begrenzt durch die Punkte:
  1) 52°06'30"N 4°05'48" O
  2) 52°04'00"N 4°06'48" O
  3) 52°00'30"N 3°39'30" O
  4) 52°03'06"N 3°38'48" O
  (bereits durch Beuteseekarte bekannt)

RM 7/174	Heft VI: Minenkriegführung Bd. 3 3. Jan. 1942 - 11. Jan. 1945

Relevant, records show that three ships of the German Maas Fleet were damaged as a cause of a British aerial attack with bombs or torpedoes.

RM 7/175	Heft VI: Minenkriegführung Anlage zum Kriegstagebuch Teil C VI und C XV Jan. - 3. Apr. 1945

Relevant. A table gives an overview of cleared ground mines in 1944 and early 1945.



Räumung von Grundminen 1944 :

C VI

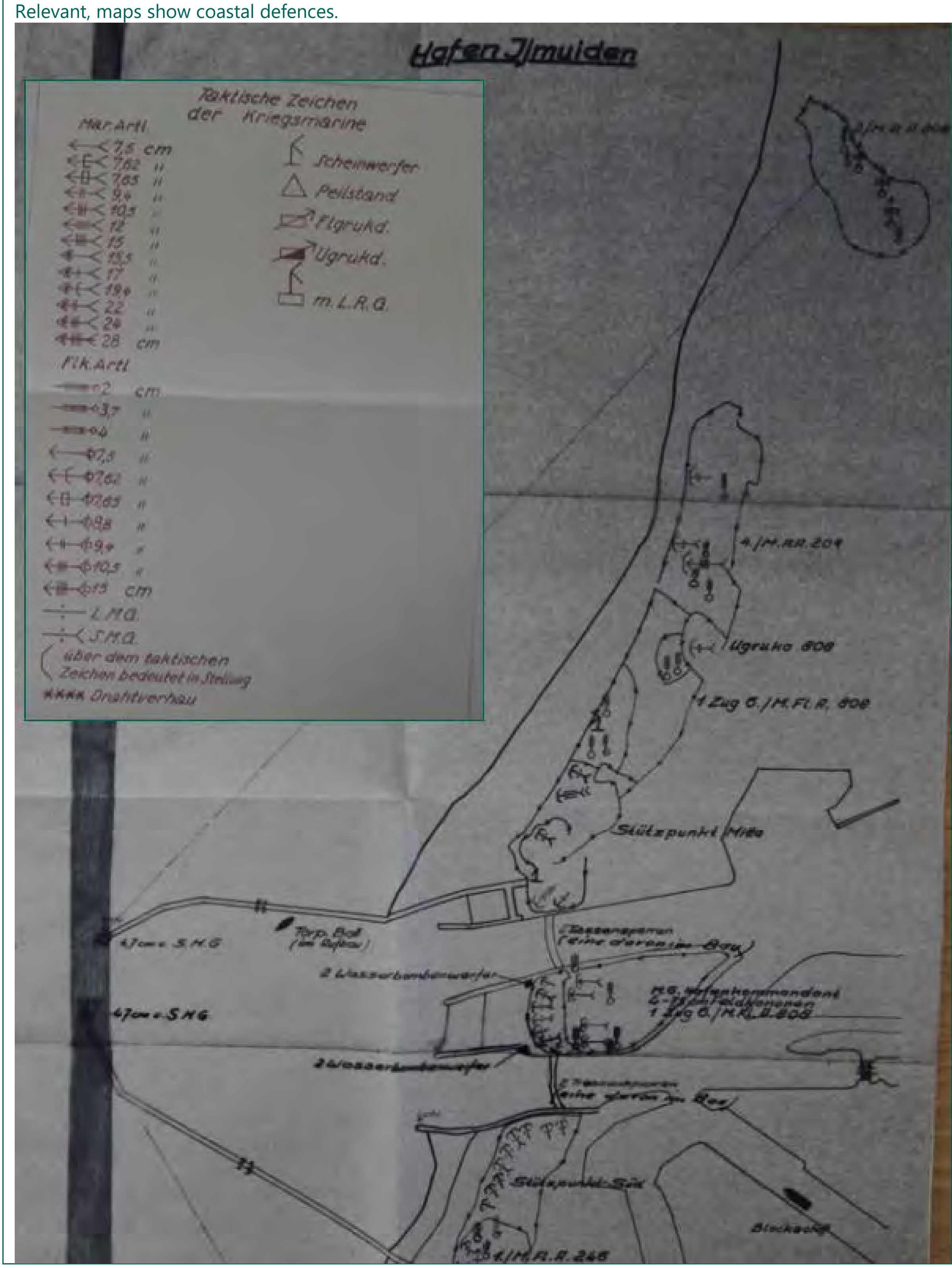
onat :	Ostsee:	Nordsee:	Norwegen:	Westraum:	Ägäis:	Donau:
nuar	24	79	- -	71	11	- -
bruar	88	124	- -	75	24	- -
ärz	157	163	- -	226	3	- -
ril	235	353	- -	157	2	- -
i	431	254	- -	380	2	- -
ni	175	182	- -	520	8	82
li	135	79	- -	131	4	60
ugust	192	40	5	128	2	72
September	219	18	3	- -	2	33
ktober	209	29	18	- -	4	10
ember	74	22	20	- -	-	- -
zember	117	13	22	- -	-	- -
1 9 4 5 :						
Januar	122	7	21	- -	-	- -
Februar	185	57	35	- -	-	- -

RM 35-I Marinegruppenkommando Ost / Nord der Kriegsmarine

RM 35-I/267	Minen, Allgemein

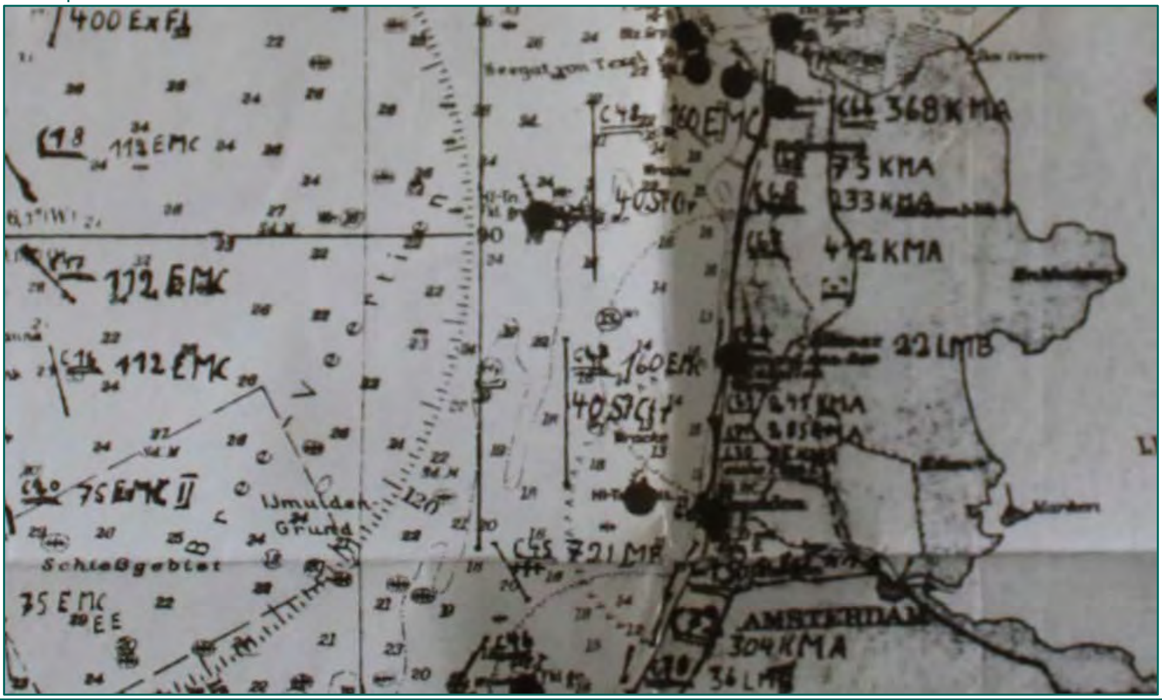
	Minensperren Nordsee 10. Aug. 1940 - 1. Okt. 1943
Relevant, mine laying reports on which the maps in ZA 5 are based..	

RM 35-I/277	Minenlage Nord (M.L.N.) 1. Mai 1942 - 1. Okt. 1943
Relevant, maps show coastal defences.	



ZA 5 Deutscher Minenräumdienst (German Minesweeping Administration)	
ZA 5/27	(Im Kriege geworfene Minensperren in der Ost- und Nordsee etc.)

Relevant. Map indicating the locations of German naval minefields. The mine fields C.35, C.47 and C.48 have overlap with HKNWFZ. Mine field C.45 lies south of HKNWFZ.



ZA 5/28	Minenkarten, Deutsches Hydrographisches Institut (Großformat) 1960 Deutsche Minensperren des Zweiten Weltkrieges 1939 - 1945.- Erläuterungen zu den Minenkarten

Relevant. This record contains information about the clearance of German naval mine fields.

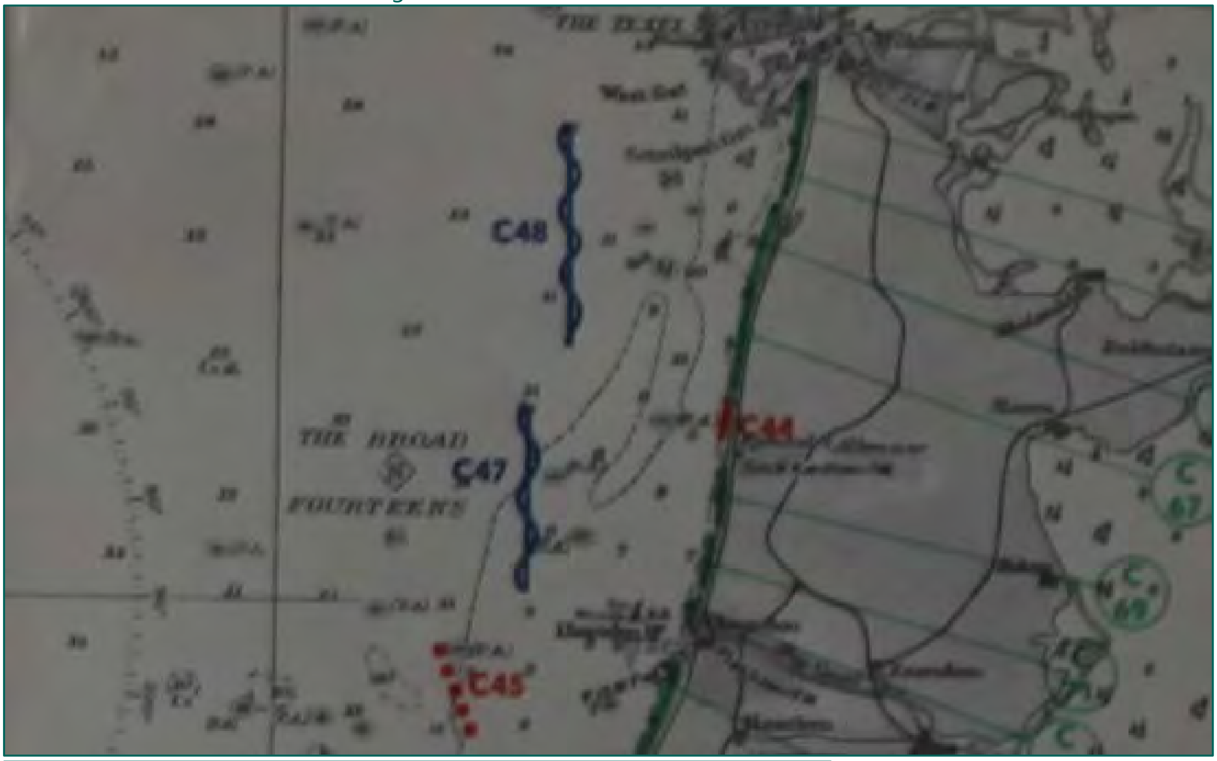
- May 1960.

Sperren-Bezeich-nung	Minen-Anzahl, Typ	Bemerkung
C 35	340 LMB	
C 45	72 "	
C 47	160 EMC	nichts gefunden
C 48	160 "	32 EMC geräumt, Ende 1945

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

Relevant. The records gives an overview of the German minefields. The relevant minefields are registered in Table 21.

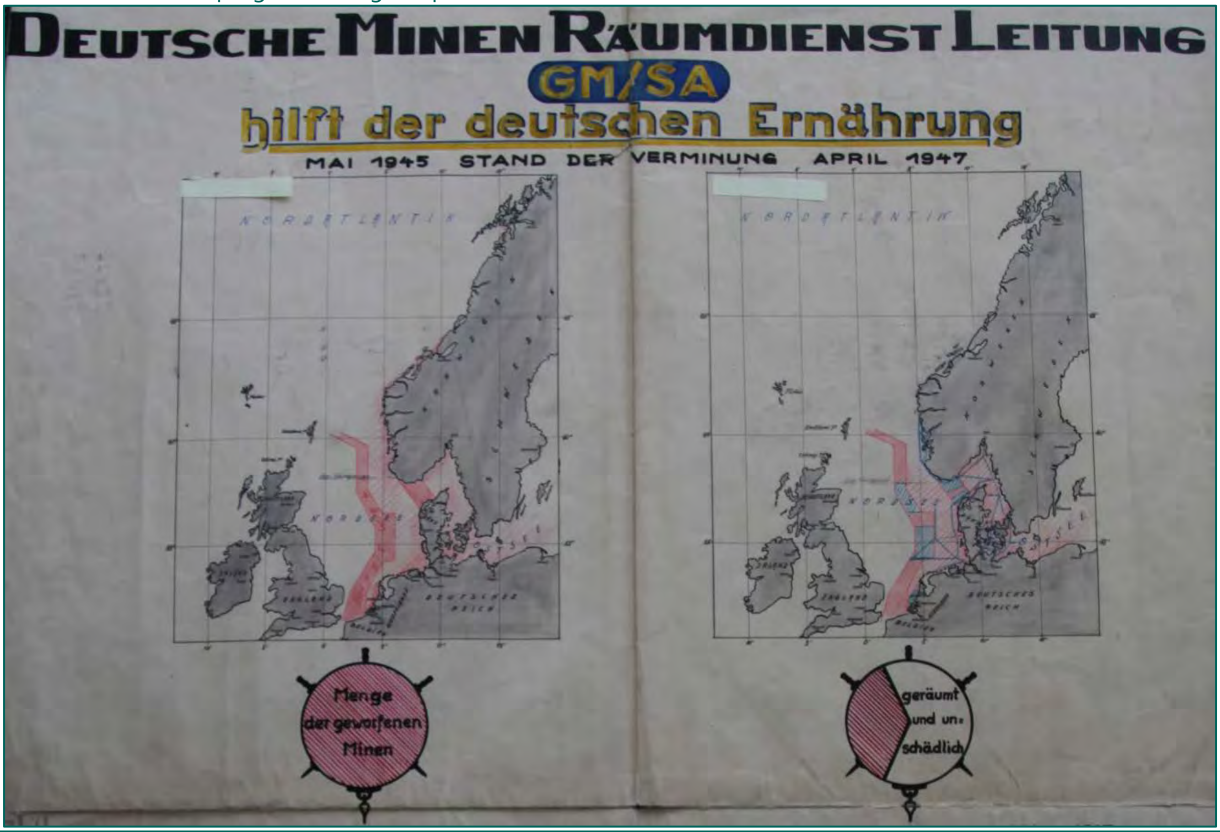
ZA 5 Deutscher Minenräumdienst (German Minesweeping Administration)	
ZA 5/48	German Minelaying 1939 - 1945, Hydrographic Department of the Admiralty (Minenkarten, Großformat) 1945 Chart C: The North Sea.- Southern Sheet (1:754400)
Map indicating the locations of German naval minefields. Minefield numbers refer to ZA 5/44. Several minefields were situated near the area of investigation.	



ZA 5 Deutscher Minenräumdienst (German Minesweeping Administration)
The minefields are geographically positioned on the contemporary map in GIS, based on the information from this chart. The relevant German minefields are registered in Table 21.

ZA 5/66	Stand der Verminung

Relevant, shows the progress during the post-war clearance of naval mines.



Nr.	German name	Date laid	Accuracy (km)	Number and type[28]	Depth (m)	Spacing (m)	Lines, spacing (m)	Remarks
C.35	4c	Okt. 1943	0.4 km	240 UMB	3.7 m	/	3 150 m	Another version shows 340 UMB. With Snag lines. Eight mines are missing from S. end of centre row.
C.45	SWKA-1b	Sep. 1944	0.8 km	72 LMB	/	220 m	2 150 m	Mean mine spacing 120 yds. (≈ 110 m). Arming delay 24 hours (?)
C.47	SWKB-1	Nov. 1944	1.6 km	160 EMC 40 StCtr	3 m	250 m	3 200 m	With chain 4 mines to 1 obstructer. Mean spacing 135 yds. (≈ 123 m)
C.48	SWBK-2	Nov. 1944	0.8 – 1.6 km	160 EMC 40 StCtr	3 m	300 m	3 300 m	Mines with chain. Four mines to one obstructer. Mean spacing 150 yds. (≈ 137m)

Table 21: Information on German minefields, derived from ZA 5/44: Summary of Enemy Minelaying.

28 For information about the types of mines see annex 3 in this report.

ANNEX 7 THE NATIONAL ARCHIVES, LONDEN

A variety of records of the British Royal Air Force, Royal Navy (Admiralty) and War Cabinet were consulted. The results are presented in this annex.

Royal Air Force

AIR 14: Air Ministry: Bomber Command: Registered Files

AIR 14/1557 Sea mining operation results, 1941 Jan. – 1944 July

Relevant. Summary of shipping losses caused by mines laid by aircraft of Bomber and Coastal Command, up to December 31 1941. No known ship losses are mentioned in or nearby the area of investigation.

General overview of amounts of mines laid by Bomber and Coastal Command:

1. Seamining operations have been carried out by aircraft of Bomber Command during the whole of this period and by aircraft of Coastal Command until the end of December 1941. By the end of April 1942 Bomber Command had laid 2324 mines and Coastal Command laid in the period in which they operated 365 mines.

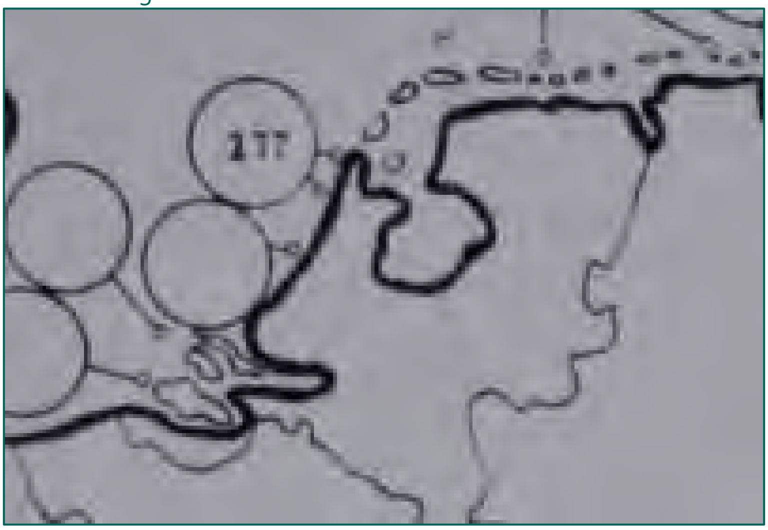
Overview of mines laid by Coastal Command

GARDEN.	PLANTED BY BOMBER A/C.	PLANTED BY COASTAL A/C.	TOTAL PLANTED.	GERMAN SHIPS.	SHIPS OF OTHER NATIONALITY.	TONNAGE.
TEXEL		25	25.	1		1,000
IJMUIDEN		20	20			

AIR 14/1952 Bomber offensive: minelaying, 1944 Feb.-May

Bomber Command mine laying offensive 1 Jan. 1944 – 30 April 1944.

Chart showing 277 mines were laid off IJmuiden and Den Helder:



AIR 14: Air Ministry: Bomber Command: Registered Files

Bomber Command. Minelaying requirements of the pre-'Overlord' and 'Overlord' periods

TACTICAL MINELAYING

1. Phase 3 (D-24 to D-3)

Laying of special mines off:-

Le Havre
Cherbourg
Ijmuiden
Hook
West of Scheldt
Western Frisian Islands
St. Malo
Brest
Chenal de Four.

2. Phase 4 (D-2 to D-1)

Laying of special mines off:-

Ijmuiden
Hook
West Scheldt
Brest
Chenal de Four.

Phase IV (D-2 to D-1)

Laying of special type mines only by available coastal force minelayers, the main concentration being off LE HAVRE, CHERBOURG, CALAIS and BOULOGNE; and by aircraft minelayers off IJMUIDEN, HOOK, WEST SCHELDT, CHENAL DU FOUR and BREST.

AIRCRAFT MINELAYERS

Operations: Routine laying between DUTCH COAST and CHENAL DU FOUR.

AREA	CODE WORD	MINES AND SETTINGS	
DUTCH COAST	TREFOIL	A. Mk. IV	Lives limited
LE HAVRE	SCALLOPS	A. Mk. IV	to
CHERBOURG	GREENGAGE	A. Mk. IV	8 days.

AIRCRAFT MINELAYERS (See Note A)

Operations: I. Y-22 onwards
Routine laying to continue, with special laying as indicated below:-

AREA	CODE WORD		MINES
LE HAVRE CHERBOURG	SCALLOPS GREENGAGE		A. Mk. VI (D. 410 & G. 706)
IJMUIDEN HOOK W. SCHELDT	WHELKS IRIS FIVE IRIS TWO	) See) Note) A	A. Mk. VI (D. 410 & G. 706)

Position of Gardening fields:

AIR 14: Air Ministry: Bomber Command: Registered Files

DUTCH COAST (Q.Z.X.772) - TREFOIL
An area bounded:-

(a) on the north by latitude 52°52' N.,

(b) on the east by the 5 fathom line,

(c) on the south by latitude 52°38' N.,

(d) on the west by longitude 04°29' E.

IJMUIDEN - WHELKS (Aircraft)
An area bounded by lines joining:-

(a) 52°31'00" N. 04°26'30" E.,

(b) 52°30'00" N. 04°34'30" E.,

(c) 52°25'30" N. 04°32'30" E.,

(d) 52°26'30" N. 04°24'30" E.

AIR 15: Air Ministry and Admiralty: Coastal Command: Registered Files

AIR 15/267 Minelaying Areas, 1942 Oct. 1944 Dec.

This record contains information about the allied Gardening operations. This operation is about the dropping of mines by plane in various sea zones. Three zones lie in the vicinity of the area of investigation:

- "Limpets 2" (S. Texel)

All the waters suitable for mining bounded as follows:-
On the North by latitude 53° 04' N
On the East by the five fathom line
On the South by latitude 53°00' N
On the West by longitude 04°30' E

- "Whelks" (IJmuiden)

Within a semi-circular area of radius 1 mile described to seaward of position
52° 28' 00" N
04° 33' 06" E

- "Trefoil" (between Texel and IJmuiden

The area bounded as follows:-

(1) On the North by Latitude 52° 52' N.

(2) On the East by the 5 fathom line.

(3) On the South by Latitude 52° 38' N.

(4) On the West by Longitude 04° 29' E.

AIR 15/772 Sea Mining Sheets Nos. 1-200 Vol 1, 1940 Apr.- 1941 July

Relevant. Coastal Command minelaying reports with summary of minelaying per area and a chart of the Gardening zones. Minelaying reports, drafted per aircraft. Several minelaying operations were carried out in the vicinity of the area of investigation.

SECRET.

COASTAL COMMAND.

STRIKE NO. G 13.

~~CC/N/--/-~~

Summary No. 304.

DATE 18/5/40.

GROUP	SQDN	No. of A/C.	TYPE	STATION
16	812	6	SWORDFISH	NORTH COATES.

TASK.

Minelaying off DUTCH Coast between MAAS Estuary and TEXEL ISLAND.

RESULTS.

~~CC/N/--/-~~

Summary No. 305.

All aircraft completed operations as ordered.

COASTAL COMMAND.

STRIKE NO. G 18.

~~CC/N/--/-~~

Summary No. 307.

DATE 21/5/40.

GROUP	SQDN	No. of A/C.	TYPE	STATION
16	815	6	SWORDFISH	BIRCHAM NEWTON.

TASK.

Minelaying - IJMUIDEN.

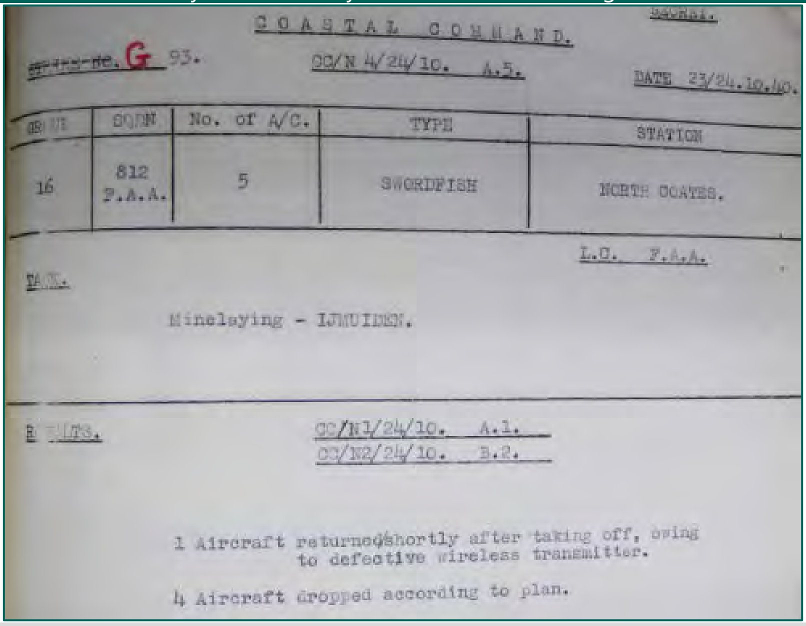
RESULTS.

~~CC/N/--/-~~

Summary No. 308.

All aircraft dropped as ordered.

AIR 15: Air Ministry and Admiralty: Coastal Command: Registered Files


SECRET.

COASTAL COMMAND.

G 93. CC/N 4/24/10. A.5. DATE 23/24.10.40.

GROUP	SQDN	No. of A/C.	TYPE	STATION
16	812 F.A.A.	5	SWORDFISH	NORTH COATES.

L.C. F.A.A.

TASK.

Minelaying - IJMUIDEN.

RESULTS. CC/N1/24/10. A.1.
CC/N2/24/10. B.2.

1 Aircraft returned shortly after taking off, owing to defective wireless transmitter.

4 Aircraft dropped according to plan.

AIR 24: Air Ministry: Bomber Command

AIR 24/230 RAF Bomber Command Operations Record Book, April 1941.

- 6 April, 1941. Cargo ship 2.000 tons beached on sandbank 52° 48'N, 04° 38'E bombed by three Blenheims with 10 x 250 lbs. 4 x 250 bombs undershot by 20 yards. 2 x 250 bombs just missed starboard bow. 4 x 250 by 10 yards.

AIR 24/231 RAF Bomber Command Operations Record Book, May 1941.

- 6 May, 1941. Two Blenheim bombers attacked two 50-ton Trawlers (Dutch Markings) 52° 52'N, 03° 53'N with 8 x 250 lbs. 1 aircraft bombs overshot. Other results not seen. No damage to either boat.
- 6 May, 1941. One Blenheim bomber attacked one or two 1.600-ton cargo ships, 52° 54'N, 04° 40'E, with 4 x 250 lbs bombs. Believed undershot, no damage seen.

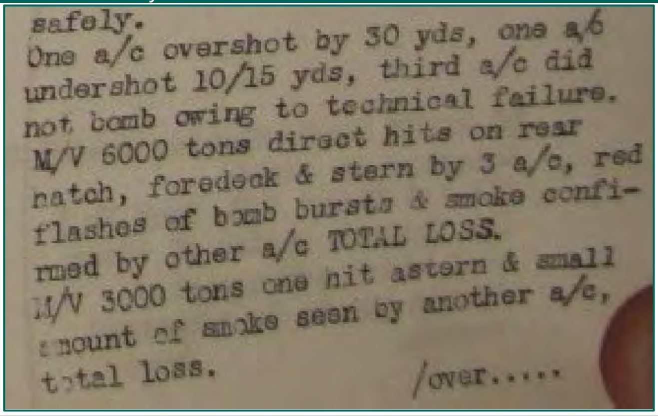
AIR 24/232 RAF Bomber Command Operations Record Book, June 1941.

- 15 June 1941. One Blenheim attacked M/V about 5/6.000 tons escorted by flakships at 52° 54'N, 04° 32'E, with 2 x 500 lbs bombs SAP and 4 x 25 lbs incendiary bombs. Bombs seen to fall and make glancing hits on port side of bow. Intense fire from all ships prevented further observation.

AIR 24/233 RAF Bomber Command Operations Record Book, July 1941.

- 12 July, 1941. 4 Blenheims bombed a 1.000 ton trawler 52° 58'N, 04° 10'E with 16 x 250 lbs bombs SAP. Bombs from 3 a/c overshot and undershot. The fourth a/c bombs fell alongside ship 5 -10 yards to port.
- 12 July, 1941. 100 ft. sailing vessel (believed reporting vessel) 52° 32'N, 03° 58'E, attacked by one Blenheim with 4 x 250 bombs SAP and 0,4 tons incendiary bombs. Bombs overshot by 5 – 10 yards. Vessel also machine gunned.
- 14 July, 1941. 8 Blenheims bombed Convoy off IJmuiden 52° 53'N, 04° 33'E with 32 x 250 lbs bombs SAP and 36 x 25 lbs bombs.

AIR 24: Air Ministry: Bomber Command


safely.
One a/c overshot by 30 yds, one a/c
undershot 10/15 yds, third a/c did
not bomb owing to technical failure.
M/V 6000 tons direct hits on rear
hatch, foredeck & stern by 3 a/c, red
flashes of bomb bursts & smoke confi-
rmed by other a/c TOTAL LOSS.
M/V 3000 tons one hit astern & small
amount of smoke seen by another a/c,
total loss. /over.....

AIR 24/234 RAF Bomber Command Operations Record Book, August 1941.

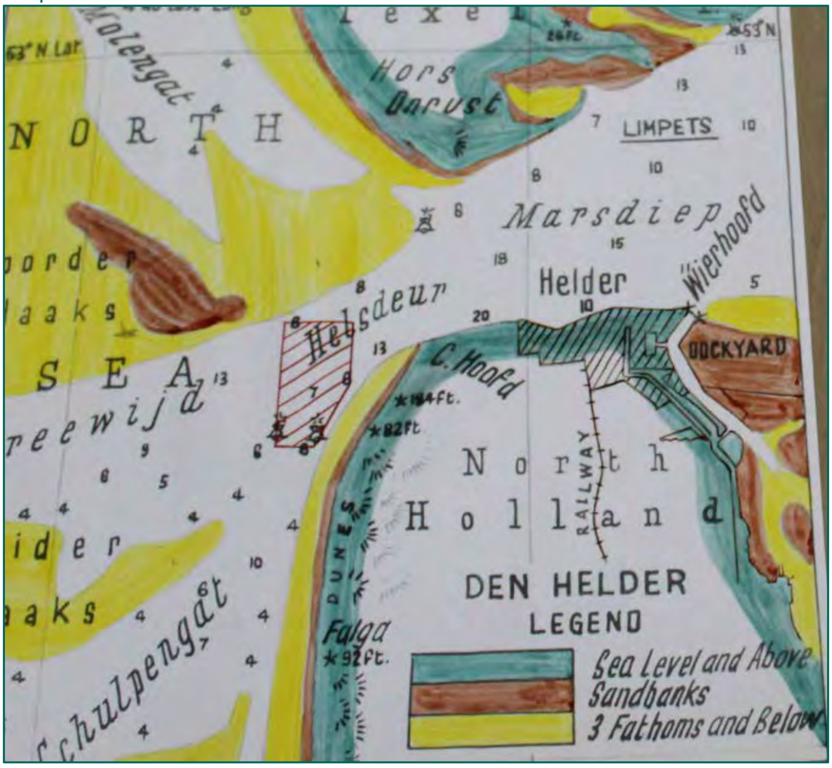
- 18 August, 1941. Two Blenheims bombed a trawler of approx. 100 tons, 52° 49'N, 04° 25'E, with 4 x 250 lbs bombs SAP. Considered two bombs very closes misses. Vessel M/C.
- 19 August, 1941. Trawler 200-300 tons, 52° 37'N, 03° 48'E, attacked by one Blenheim with 4 x 250 lbs bombs SAP and 0,4 tons incendiaries. Undershot. Periscope seen later.
- 27 August, 1941. 31 x 600 ton vessels 52° 49'N, 04° 38'E, were attacked by three Blenheims with 6 x 500 lbs bombs SAP and 10 x 25 lbs incendiaries. Smoke seen from one vessel after attack & believed incends. found their mark. Results from other two a/c unobserved, but believed their bombs over-shot.

AIR 40: Air Ministry: Directorate of Intelligence and Related Bodies: Intelligence Reports and Papers

AIR 40/1961 Air Ministry, Directorate of Intelligence and related bodies: Intelligence Reports and Papers. AIR Intelligence 9. France, Holland and Belgium target identification maps and photographs: emergency port book including "Gardening" charts. 1940 Jun – 1941 July.

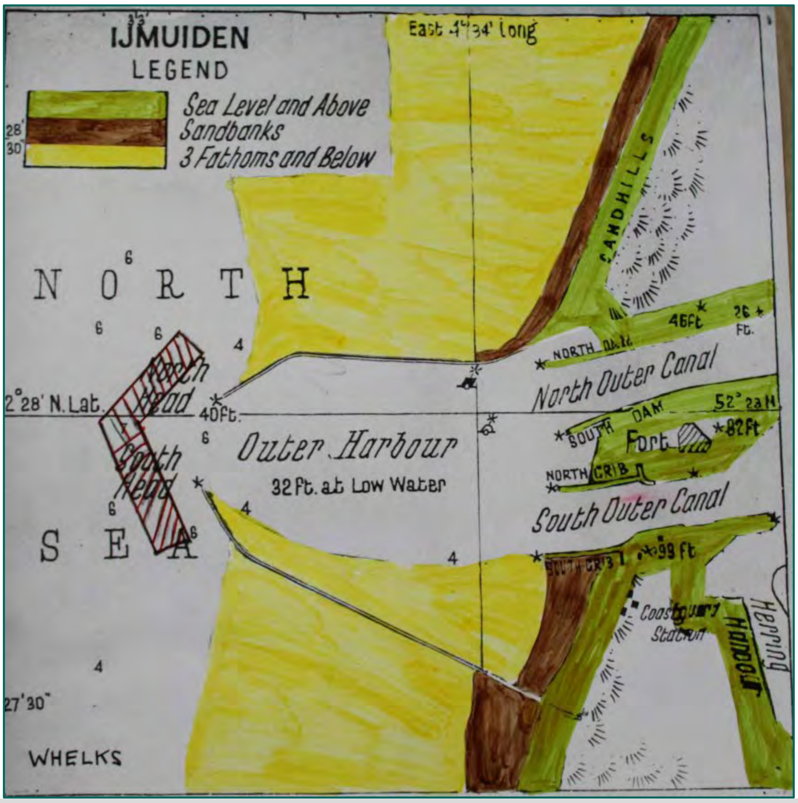
Relevant. Gardening charts of fields near the area of investigation.

Limpets:



AIR 40: Air Ministry: Directorate of Intelligence and Related Bodies: Intelligence Reports and Papers

Whelks:



War Cabinet

CAB 101: War Cabinet and Cabinet Office: Historical Section: War Histories (Second World War), Military.

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

Reports on air offensive operations against enemy shipping and minelaying operations holding several sections on aerial attacks off the Dutch coast and aerial attacks on the E-boat shelters in IJmuiden.

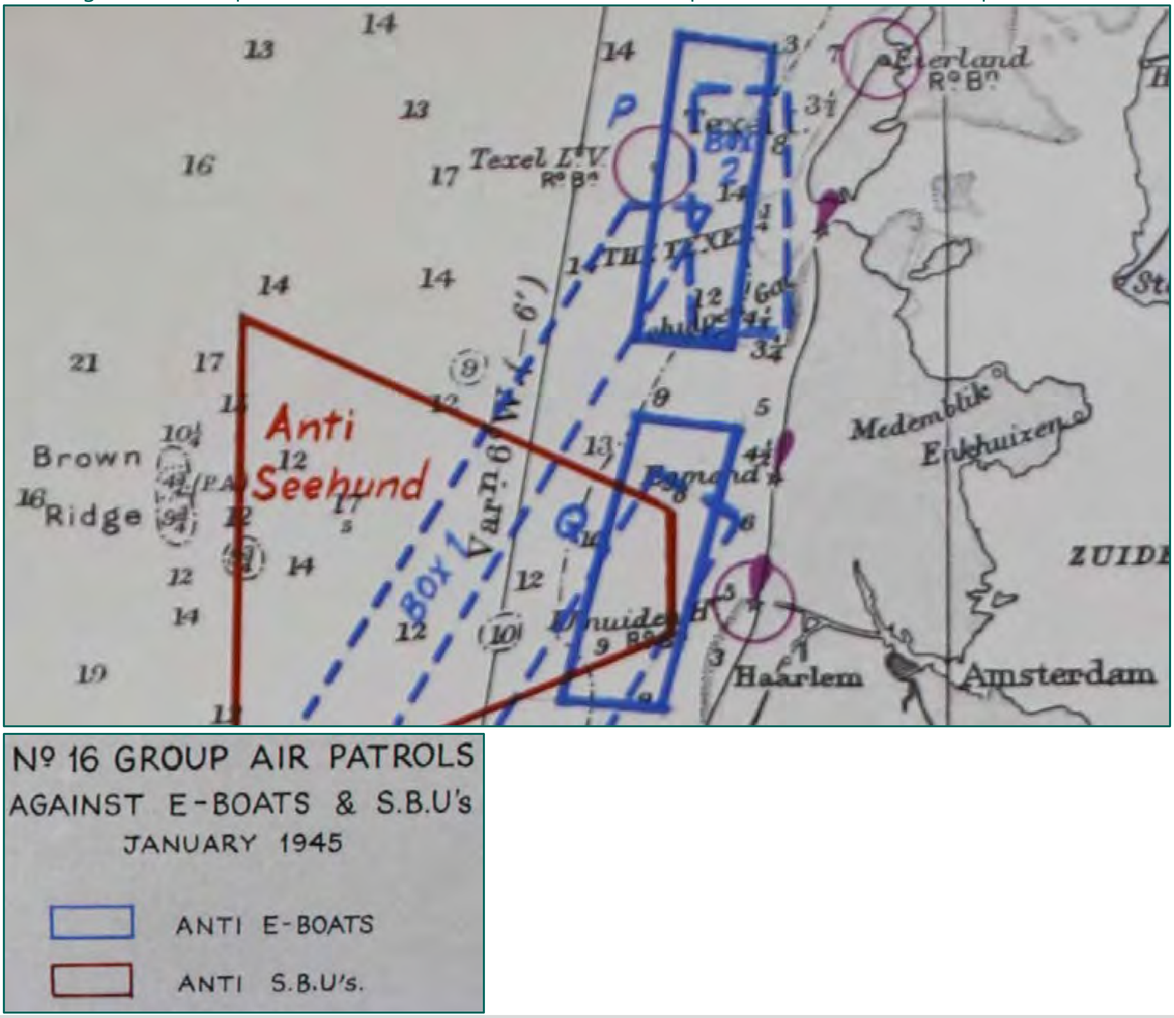
No specific locations are mentioned, but a narrative illustrated with tables shows the general results of the British attacks, for example in September-December 1944:

Summary of the Air Offensive against Enemy Shipping September to December, 1944

Month	Aircraft Sorties	Attacks made	Enemy vessels sunk		Enemy vessels damaged		Air-craft lost
			No.	Tonnage	No.	Tonnage	
September	1,916	557	41	16,061	2	3,886	24
October	1,267	270	15	13,659	3	10,029	12
November	1,154	204	12	13,927	7	18,078	11
December	1,330	251	10	20,417	13	46,532	21
Totals	5,667	1,282	78	64,064	25	78,525	68

CAB 101: War Cabinet and Cabinet Office: Historical Section: War Histories (Second World War), Military.

A chart gives a more specific overview where actions of 16th Group (Coastal Command) took place:



Admiralty

ADM 1: Admiralty, and Ministry of Defence, Navy Department: correspondence and papers

ADM 1/19745	Post-war mine clearance in European waters: first interim report of international Central Board. With charts, 1946-1947.

Chart indicating dangerous area in the European waters due to mining, August 1945

ADM 1: Admiralty, and Ministry of Defence, Navy Department: correspondence and papers

Chart indicating dangerous area in the European waters due to mining, March 1946

The report includes a list of ships sunk by mines in the post-war period:

Dutch Lugger (name unknown)	?/10/45	Off Dutch Coast	Sunk	*Thought to have entered dangerous area in fog.*
Norwegian BETTY (2,450 tons)	12/3/46	Off Ymuiden	Damaged	*Outside swept water.*

ADM 234: Admiralty, and Ministry of Defence, Navy Department: Reference Books

ADM 234/560 British mining operations 1939-1945: Vol 1.

This record contains information about the British offensive minelaying of the coast of Holland.

Operation "CBX", 10 May 1940

ADM 234: Admiralty, and Ministry of Defence, Navy Department: Reference Books

Operation "CBX". 10th May 1940

Before the German attack on Holland, and in anticipation of the event, plans were prepared for the laying of one or more fields between Camperdown and Ymuiden, to protect the flank of our forces operating off the Netherlands and Belgian coasts and shipping evacuating the Netherlands ports. This area was selected in view of the fact that the Netherlands Government had already declared mined areas off

Operations "CBX2" and "CBX3", 16 May 1940

Operations "CBX2" and CBX3". 16th May 1940

Having carried out two lays in the East Coast Barrier and reloaded at Immingham, the 20th Destroyer Flotilla, now reinforced by two more ships, was detailed to lay additional fields off the Netherlands coast as follows:

a. Operation "CBX2". INTREPID and IMPULSIVE (40th Division) to reinforce "CBX".

b. Operation "CBX3". EXPRESS, ESK and IVANHOE (39th Division) to lay a field off the Hook of Holland.

Operations	Date	Mines	Remarks
QU1	5 November 1942	18 A Mk I-IV	Off IJmuiden
QU2(B)	17 April 1943	12 A Mk I-IV	Off IJmuiden
QU11	29 May 1943	16 A Mk I-IV	N of IJmuiden
QU14	5 Augustus 1943	18 A Mk I-IV	Off Egmond
QU11(A)	1 September 1943	8 A Mk I-IV	Off Egmond
QU11(D)	3 September 1943	8 A Mk I-IV	Off IJmuiden
QU11(E)	3 September 1943	16 A Mk I-IV	Off IJmuiden
QU18	4 November 1943	24 A MK I-IV	Off IJmuiden
QU29	17 April 1944	32 A Mk I-IV	Off IJmuiden
QU28	19 April 1944	18 Mk XVII 36 A Mk I-IV	Off IJmuiden
QU27	23 April 1944	16 Mk XVII 36 A Mk I-IV	Off IJmuiden

17 April 1944:

Details of surface minelaying operations in Phase II. Operation "QU 29". 17th April 1944

The individual surface minelays carried out in Operation "Maple", although numerous, are considered to be of sufficient importance, in considering the complex pattern of the plan, to warrant description in detail and this will follow the general remarks on each phase.

The 17th April was a busy day for the minelayers in all areas and the first operation - "QU 29" - took place in the Nore Command. Commencing at 0130, MTBs 234, 245, 83, 80, 223, 225, 233 and 244 of the 21st and 22nd Flotillas operating from Felixstowe, laid 32 A Mk I-IV mines off Ymuiden within an area enclosed by lines joining positions:

a. 52°29'N, 04°31'E

b. 52°29'N, 04°32'E

c. 52°26'N, 04°32'E

d. 52°26'N, 04°31'E

Assemblies: 4 D 413)
16 D 407) standard
12 B 231)

Sterilizers for the D assemblies were set to operate on 3rd May. Those for the B assemblies were set, in error, to operate on the same day as they armed, 8th May.

19 April 1944:

Operation "QU 28". 19th April 1944

MLs 100, 105, 110 and MTBs 234, 223, 244, 233, 225, 245, 83, 88 and 93 left Felixstowe at about 1630 on 18th April to carry out Operation "QU 28" off Ymuiden. Commencing at 0215 on 19th a total of 54 mines were laid within an area enclosed by lines joining positions:

a.	52°25.0'N,	04°21.5'E
b.	52°25.0'N,	04°26.0'E
c.	52°22.0'N,	04°27.5'E
d.	52°22.0'N,	04°23.0'E

The total was made up of:

18 Mk XVII (49/50)/XVIII at a depth of 23 feet

20 A Mk I-IV - B 231)
8 A Mk I-IV - D 413) standard assemblies
8 A Mk I-IV - D 407)

Arming clocks in the B 231 assemblies were set to operate four days after laying. Sinkers were set to release in three groups of six on 26th, 28th and 30th May. Flooders and sterilizers were set for 16th June 1944. The lay was without incident.

23 April 1944:

Operation "QU 27". 23rd April 1944

Coastal forces from Felixstowe visited Ymuiden for the last time on the night of 22nd/23rd April. The minelaying force, consisting of MLs 100, 105, 110 and MTBs 223, 224, 225, 233, 234, 244, 83, 93 and 245, left Felixstowe at about 1600 on 22nd April. "QH" and a radar bearing and range of Ymuiden lighthouse were used for fixing, and commencing at 0145 on 23rd a mixed bag of moored and ground mines was laid within an area enclosed by lines joining positions:

a.	52°30'N,	04°26'E
b.	52°30'N,	04°28'E
c.	52°26'N,	04°29'E
d.	52°26'N,	04°26'E

The total of 52 mines was made up of:

9 Mk XVII (49/50)/XVII - at a depth of 23 feet
7 Mk XVII (49/50)/XVIII - at a depth of 22 feet

12 A Mk VI - K 1011) Special assemblies
6 A Mk VI - D 411)

18 A Mk I-IV - D 413 Standard assemblies

Flooders and sterilizers were set to operate on 17th June 1944 and Mk XVIII sinkers to release on 31st May 1944. The lay was without incident.

"On 26th May the IJmuiden area (Whelks) was passed to Bomber Command, the nights having become too short for Coastal Forces craft to operate."

Standard and special areas to be mined in "Maple" included the following:

"Nectarines Plus"	An extension to the northward of the NW corner of standard aircraft mining area "Nectarines".
"Trefoil"	Standard area for aircraft mining off the Netherlands coast between 52°52'N and 52°38'N.
"Whelks"	New aircraft mining area off Ymuiden, to be used when nights became too short for Coastal Forces operations in Phase III, and during Phase IV.
"Iris V"	New aircraft mining area off the Hook of Holland to be utilised in the same manner as "Whelks".
"Iris II"	New aircraft mining area in the W Scheldt to be taken over as for "Whelks".

..., FRANCE AND IN THE CHANNEL

During Phase II Bomber Command completed the mining of the "Nectarines Plus" area, using special circuits, and aircraft laid a total of 802 mines in support of Operation "Maple", in 81 visits to the following areas:

"Nectarines Plus"	10 visits	358 mines (special)
"Trefoil"	5 visits	44 mines (standard)
"Scallops"	12 visits	54 mines "
"Greengage"	13 visits	70 mines "
"Hyacinth"	13 visits	64 mines "
"Upas Tree"	13 visits	59 mines "
"Sultana II"	6 visits	36 mines "
"Jellyfish"	9 visits	117 mines "

Bomber Command concentrated its main strength in the Channel area and carried out a heavy programme, adding the MXC 16 assembly to its arsenal and spreading the use of the D 414 assembly to all areas. In outside support of this effort two further lays were carried out off Aalborg and Aarhus, and the Heligoland Bight and Biscay ports were topped up. During Phase IV a total of 664 mines were laid in 41 visits to the following areas:

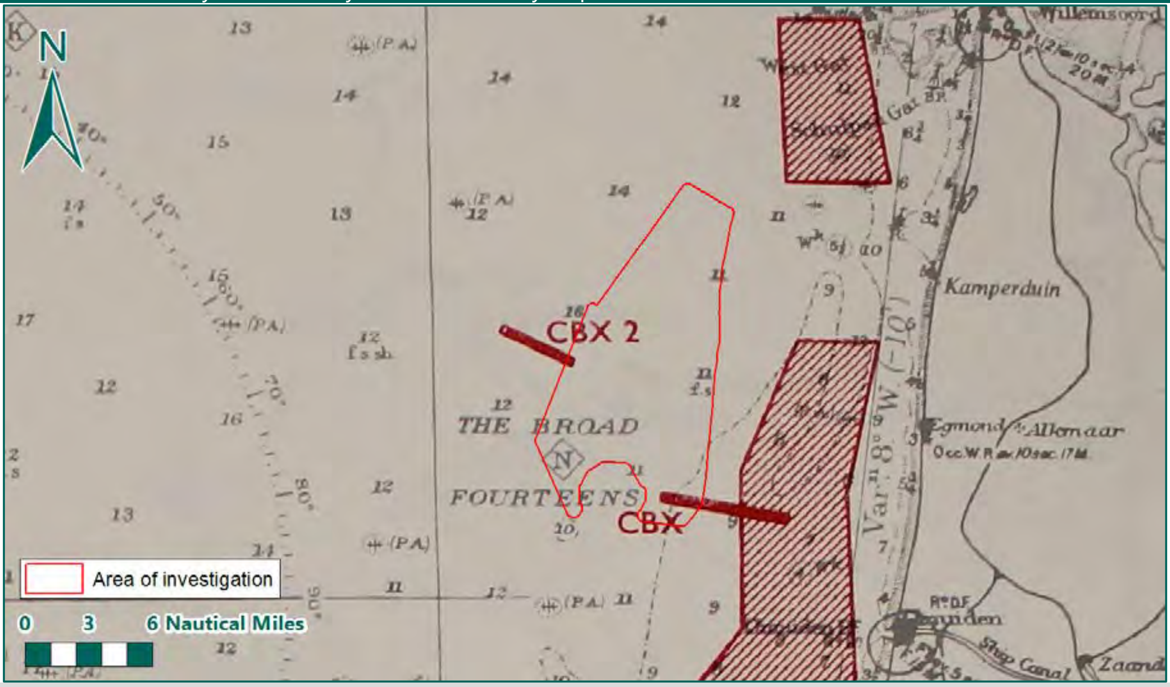
Kattegat	2 visits	29 mines
Heligoland Bight	2 visits	26 mines
"Whelks"	5 visits	52 mines
	5 visits	53 mines

Bomber Command continued in much the same vein as for the previous phase, but a greater proportion of effort was devoted to Brest and the other Biscay ports of Lorient, St Nazaire and La Pallice, with new targets in the Channel Islands added to the list. In all, a total of 1,281 mines were laid in 107 visits to the following areas:

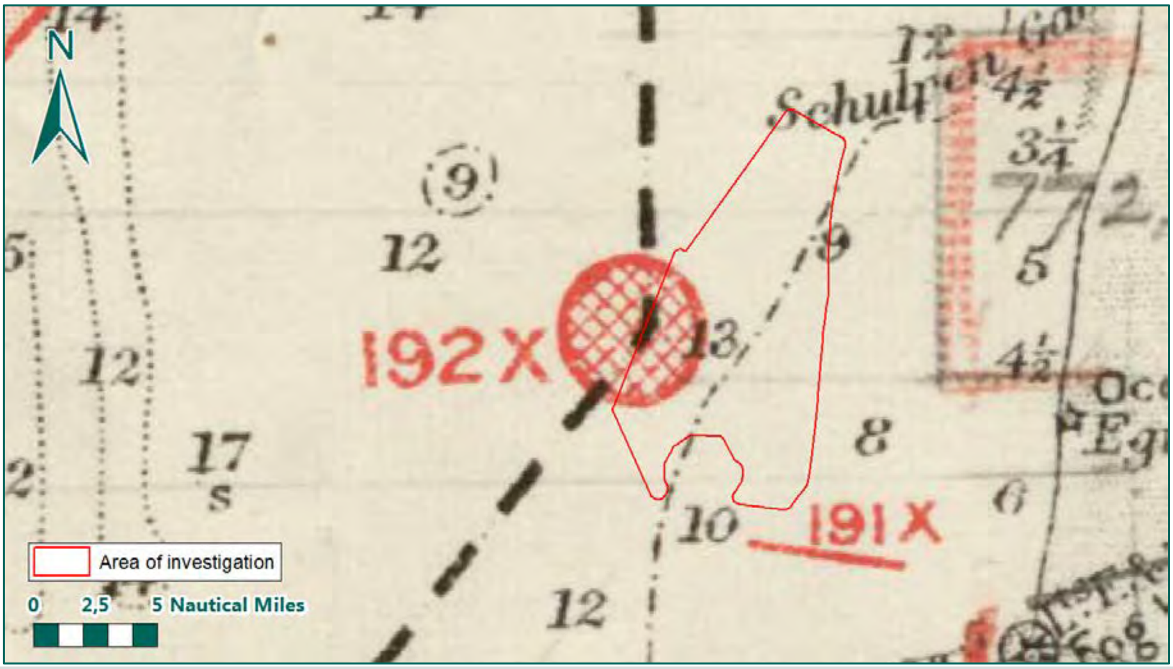
Kattegat	2 visits	8 mines
Heligoland Bight	3 visits	84 mines
"Whelks"	3 visits	23 mines
		29 mines

ADM 234/561 British mining operations 1939-1945: Vol 2.
Annex to Vol 1, containing maps, plans, tables and charts. The following images are relevant to the area of investigation.

ADM 234: Admiralty, and Ministry of Defence, Navy Department: Reference Books



ADM 239/204 North Sea: chart 736 showing position of British and German minefields



ANNEX 8 UNITED KINGDOM HYDROGRAPHIC OFFICE

This annex contains the information of the consultation of the United Kingdom Hydrographic Office.

Mine Charts: Netherlands, Belgium, France, etc.	
MOF 6229	Hook of Holland to Ijmuiden, August 11, 1944
Relevant. Covers a part of the area of investigation. Minefield 191X intersects with the area of investigation.	

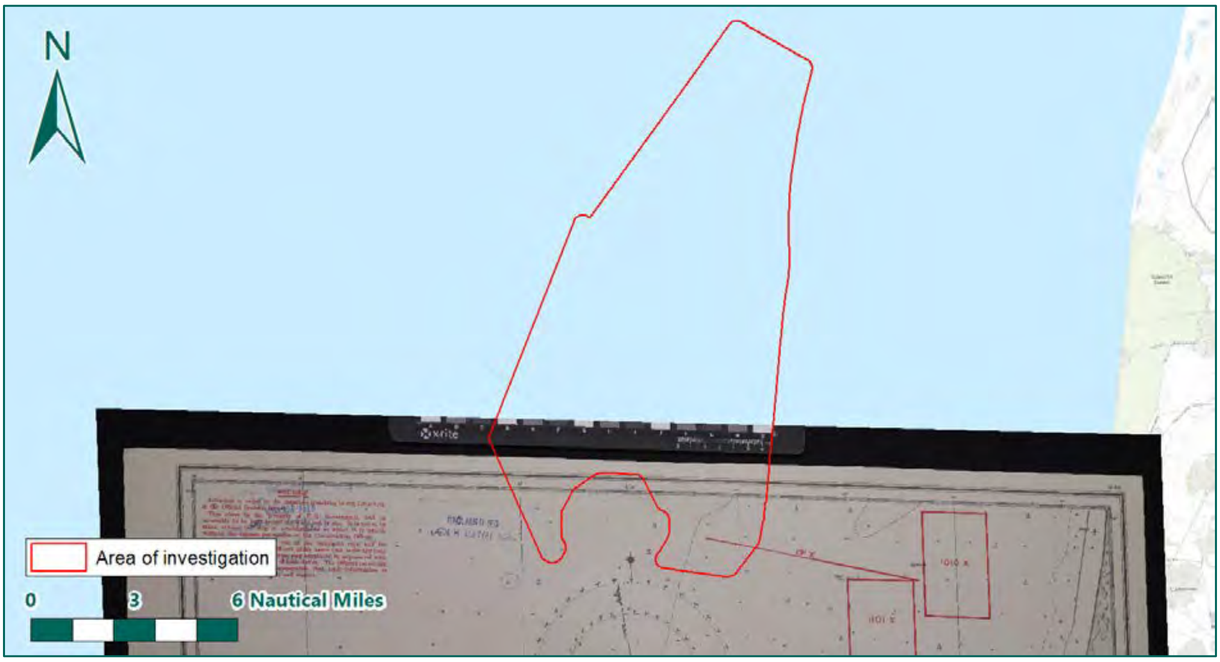


Figure 34: Extract of chart MOF 6229.

ANNEX 9 EOD: UXO-ENCOUNTERS AND -DISPOSAL

The area of investigation is situated 12 Nautical Miles west of the Dutch coast. REASeuro utilises different sources that give an indication about encountered and cleared UXO in the North Sea:

- Dutch Coastguard Archive Records.
- OSPAR Commission.

Dutch Coastguard Archive Records

Since the Second World War, the Dutch fishing fleet have at times experienced weekly encounters with UXO within their fishing nets. To compensate fisherman for the loss of income due to UXO, a deficiency payments regulation was introduced. These payments caused some fisherman 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. Fisherman 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 when an air dropped bomb detonated on the deck of the vessel. This event led to an increase of the threat awareness amongst fisherman and also led to a change in government policy regarding the handling of UXO encountered by fisherman. The Dutch Coastguard implemented the current "Bijstands- en bijdrageregeling11". The aim of this regulation was to reduce the risks attached with encountering of UXO as much as possible. The regulation provides guidelines for fisherman and professional support from the Coastguard and EOD. To prevent fisherman from dumping the UXO a financial compensation scheme was implemented.
After the tragic event with the OD-1 a detailed registration is kept regarding encountered UXO in the North Sea. Up to May 20, 2016, in total 1,656 UXO were reported to the coast guard, Royal Netherlands Navy and other authorities. The Royal Netherlands Navy Mine Counter Measures Service destroyed 1,237 of the reported UXO, 412 could not be found.[29]

Within a distance of 2,7 NM (5 km) surrounding HKNWFZ, items of UXO have been reported since April 2005. Table 22 shows the reported UXO incidents. The coordinates of the reported UXO which are presented in Table 22 and are rendered in Figure 35. The UXO encountered were destroyed and are no longer present. Encounters within the wind farm zone are indicated with red.

ETRS 1989 UTM Zone 31N		UXO Type	ETRS 1989 UTM Zone 31N		UXO Type
N	E		N	E	
52-44.30 N	04-19.50 E	Artillery shell	52-48.316 N	04-26.174 E	Naval mine (moored)
52-42.6554 N	04-14.7043 E	Depth charge	52-48.525 N	04-27.533 E	Depth charge
52-35.4270 N	04-16.5940 E	Aerial bomb	52-44.70 N	04-22.60 E	Artillery shell
52-48.00 N	04-13.00 E	Artillery shell	52-44.10 N	04-25.60	Artillery shell
52-44.228 N	04-08.685 E	Naval Mine (LMB)	52-43 N	04-07 E	Naval Mine
52-42.65 N	04-09.85 E	Unknown	52-35.6058 N	04-04.3385 E	Aerial bomb
52-34.667 N	04-06.128 E	Depth charge	52-34.6229 N	04-07.4121 E	Depth charge
52-34-43N	04-09.074 E	unknown			

Table 22: Reported UXO types within 2.7 NM (= 5 km) of HKNWFZ.

[29] source: http://www.kustwacht.nl/nl/explosieven.html, overview dated May 20, 2016

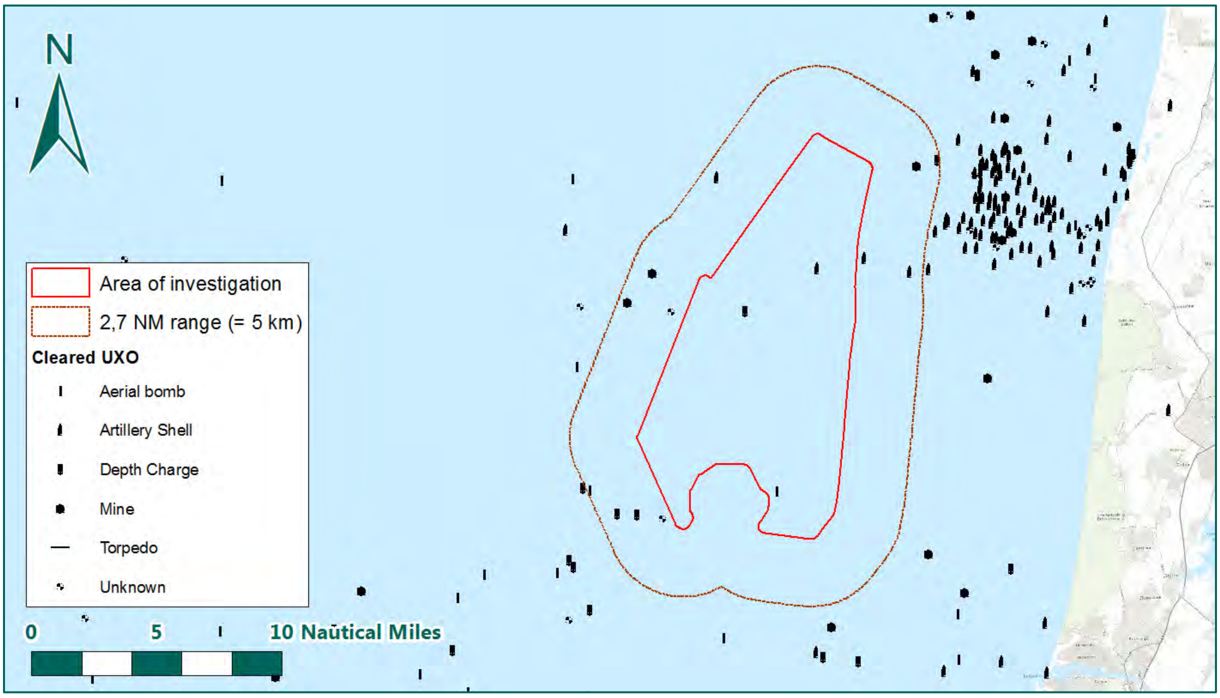


Figure 35: Locations of encountered UXO.

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 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, http://odims.ospar.org/layers/?limit=100&offset=0. The munition encounters from 1999 till 2014 within a distance of 2.7 NM (5 km) surrounding HKNWFZ are rendered in Figure 36. Some of these encounters have overlap with the Dutch Coastguard Archive Records, see above. Despite this overlap, the OSPAR encounters indicate one extra conventional and an unknown encounter within the wind farm zone.

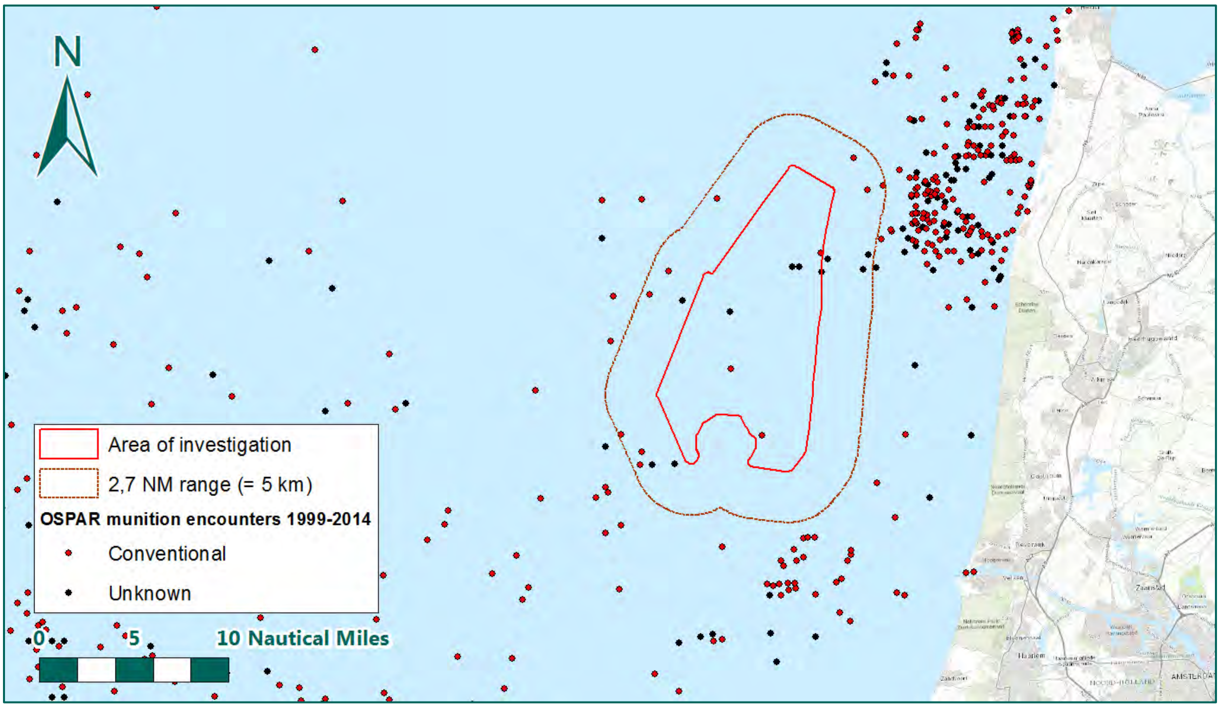


Figure 36: Locations of encountered munitions.

ANNEX 10 PREVIOUS RESEARCH

It is known to REASeuro that previous UXO-related research has been conducted in the recent past. The relevance of this earlier research for the current area of investigation is described in this annex.

Nr.	Author	Date / document code	Title
1.	Saricon	27th January, 2016 / 15S175-VO-03	Vooronderzoek Conventionele Explosieven Potentiële Zandwindlocaties Noordzee / Preliminary UXO Research Potential Sand Source Locations North Sea
2.	REASeuro	12th February, 2016 / HKZ_20160212_REASeuro_UXOdesk-study_EvBerg_V2_F	Site data Hollandse Kust (Zuid) wind farm zone. Unexploded Ordnance (UXO) – Desk Study

Table 23: Previous research.

1. Saricon, 27th January, 2016

In 2016 Saricon Safety & Risk Consultancy conducted a historical UXO research for potential sand source locations in the North Sea, in front of the Dutch coast. The locations lie approximately 10 kilometres (= 4,5 NM) out of the coast, in front of Den Helder, Callantsoog and the isle of Texel, just north of the HKNWFZ, see Figure 37.

Figure 37: Areas of investigation WFZHKN and Sand source locations.

Based upon historical sources, Saricon reports the presence of the following UXO:

- Presence of fired artillery shells, due to coastal guns;
- Presence of British and German naval mines, due to laying and clearance of mine fields;
- Presence of aerial bombs, due to jettisons at sea;
- Presence of rockets, aerial bombs, depth charges and torpedoes, due to allied aerial attacks on German ships and convoys.

The report's conclusion is that these UXO can be encountered within the whole area of investigation of the sand source locations. The UXO suspected area is indicated with red in Figure 38.

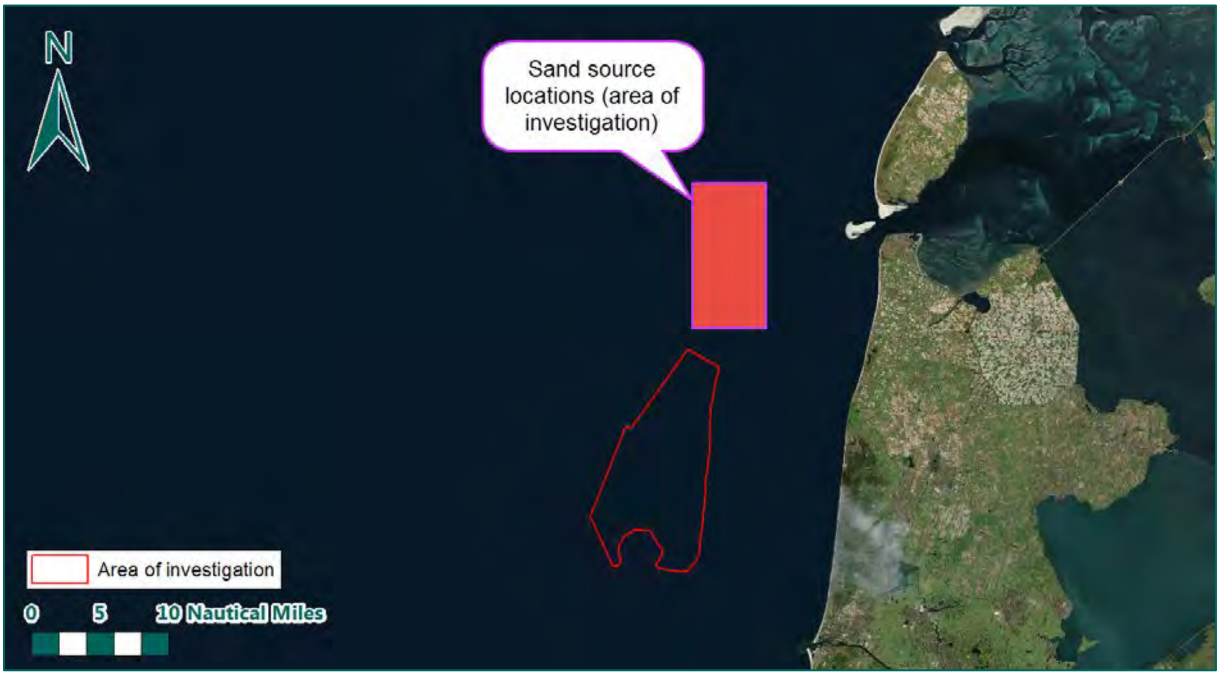


Figure 38: Areas of investigation HKNWFZ and Sand source locations. The red area within the latter area of investigation indicates the UXO suspected area.

2. REASeuro, 12th February 2016

In 2016 REASeuro completed a desk study for the Hollandse Kust (zuid) Wind Farm Zone. This wind farm zone lies about 14.5 km (= 7.83 NM) to the south of HKNWFZ, and 12 NM in front of the Dutch coast, see Figure 39.

Figure 39: Hollandse Kust (zuid) Wind Farm Zone and area of investigation HKNWFZ.

The desk study for Hollandse Kust (zuid) Wind Farm Zone consults different historical sources to recover possible relevant war related events. The following events are discussed in the report:

- Naval mines (German and British).
- Naval warfare.
- Aerial attacks and jettisons.
- Airplane crashes and ship wrecks.
- Ammunition dump.
- Post-war UXO clearance.

Due to the mentioned war related events, it is expected that UXO could have remained within the complete wind farm zone. It concerns naval mines (and destruction charges), aerial bombs, depth charges, torpedoes, and artillery shells.

ANNEX 11: KEY TERMS USED IN THE SEMI QUANTITATIVE RISK ANALISYS

Source

The threat items that might be present in the working areas. Based on the conducted historical research the following sources have been identified:

- Aerial bombs,
- Naval mines,
- Artillery shells,
- Torpedoes,
- Depth charges.

Pathway

The pathway is described as the route by which the hazard could interact/affect the site personnel. Given the nature of the site the pathways would be:

- Direct contact between a UXO and jacks, anchors and/or suction anchors of the vessels conducting the operations.
- Direct contact between a UXO and the cone or drill during the geotechnical investigations.
- Direct contact between a UXO and dredging equipment and/or gravel or rock during the removal of obstructions, the preparation of the seabed and/or gravel/rock dumping.
- Direct contact between a UXO and the foundation during the placement of the foundation.
- Accelerations with an amplitude > 1 m/s2 in the surrounding soil during the placement or removal of the foundation (depending on the type of foundation, there are techniques that are vibration-free).
- Direct contact between a UXO and divers during cable connection operations.
- Direct contact between a UXO and divers/ROV's during inspections and as-built checks.
- Accelerations with an amplitude > 1 m/s^2 during operation of the turbines.
- 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 dredging equipment and/or gravel or rock during the maintenance of scour protection.
- High energetic fields which can possibly influence electrical detonators.

Receptor

The aspects at risk in case of a detonation. Sensitive receptors on the HKNWFZ would be:

- Workers/engineers at the site,
- High-value equipment,
- Shipping in the immediate vicinity.

Likelihood of Presence

An indication of the probability of presence of a type of UXO due to war related events.

"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.

"Presence" Term	Meaning
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 24: "Presence" terms.

Type of encounter
How a piece of equipment interacts with an item of UXO will determine whether a detonation is initiated and the main types of encounter. There are three types of encounter: "primary", "secondary" and "tertiary" encounters. In the table below the "Encounter" terms are explained.

When calculating the risk and potential consequences of an inadvertent detonation of an item of UXO to equipment, a vessel or a crew within a vessel, the primary (or initial) interaction is usually the one considered – i.e. the crushing effect of a jack-up barge leg; the kinetic blow of a dredger bucket; the whiplash to a vessel caused by the "bubble pulse" from an underwater detonation etc.

"Encounter" terms	Meaning
Primary	The initial interaction between the UXO and a piece of equipment, i.e. the crushing effect of a jack-up barge leg; the kinetic blow of a dredger bucket; the disturbance caused by a cable plough; the whiplash to a vessel caused by the "bubble pulse" from an underwater detonation etc.
Secondary	Secondary encounters may occur if UXO are brought to the surface or deck of a vessel, i.e., for small items of UXO – projectiles, small bombs, rocket heads etc. – to be snagged by equipment/flukes of a PLGR hook and brought to the surface. Secondary encounters may also occur in case accelerations caused by e.g. piling initiate the detonator on a UXO thus causing a detonation or in cause a UXO. Another possible situation occurs if a UXO is buried in a slope. If erosion occurs on the slope in which the UXO is buried, it may become unburied and released from the slope. The object is then likely to roll down the side of the slope towards the deepest section. Here it may be encountered by e.g. a TSHD.
Tertiary	Tertiary encounters may occur if UXO are brought ashore during reclamation works. These UXO may cause a risk for future developments at the site.

Table 25: "Encounter" terms.

Likelihood of Occurrence
The likelihood of occurrence is the product of the likelihood of presence and the likelihood of initiation of an item of UXO. The factors to consider in regards to the likelihood of initiation are:
- Likelihood and potential burial depth of UXO,
- Likely density of UXO by type,
- Project activities (pathways).

The potential burial depth of UXO is assessed to be approximately up to a maximum of 3.2 m.

"Occurrence" Term	Meaning
Very Unlikely	A freak combination of factors would be required for a UXO initiation to result
Unlikely	A rare combination of factors would be required for a UXO initiation to result
Possible	Could happen if sensitive UXO exists but otherwise unlikely to occur
Likely	Not certain to happen but sensitive UXO may exist and density may be above average resulting in an accident
Very Likely	Almost inevitable that an UXO initiation would result due to the type and density of UXO

Table 26: "Occurrence" terms.

Hazard severity

"Hazard" is a source of potential harm or a situation with the potential to harm or damage. For the purposes of this report the hazard is termed as "UXO". This is an overarching term which may include all munitions and/or explosive items that have been dumped, fired or unfired. The "Severity" terms are defined in the table below.

"Severity" Term	Meaning
Negligible	Negligible injury or impact on equipment with no lost work
Slight	Minor injury or damage requiring treatment or repair
Moderate	Injury leading to lost time incident and moderate damage to equipment
High	Involving single death and serious damage to equipment
Very High	Multiple deaths and/or sunk vessel, equipment totally destroyed beyond repair

Table 27: "Severity" terms.

This investigation was carried out by REASeuro, commissioned by RVO.nl, an agency of the Ministry of Economic Affairs.

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

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Netherlands Enterprise Agency (RVO.nl) | July 2017