MARELITT Baltic

Interreg Baltic Sea Region

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Ammunition Risk Assessment Study

For DFG search and retrieval actions

EGEOS

Jann Wendt, Ezra Eisbrenner et al.
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Overview

MARELITT Baltic is an EU-funded Baltic Sea Region INTERREG project, with the major aim of mitigating the impact of derelict fishing gear (DFG), also called "ghost gear", in the Baltic Sea marine environment. Within this project, methodologies for the search and retrieval of DFG from the seafloor are explored, developed and tested. Retrieval actions are documented by WWF Poland, the leading project partner for this part of the project. In this context, two impact assessments were commissioned by WWF Germany as the project partner responsible for risk assessments. The "Environmental Impact Assessment Study" focussed on the ecological impact of DFG search and retrieval actions at sea. The "Ammunition Risk Assessment Study" presented here concerns the safety of DFG retrieval crews and divers and the risk imposed by warfare ammunitions potentially encountered on the seafloor or wrecks. The final report from methodology testing in the four MARELITT Baltic partner countries Poland, Sweden, Estonia and Germany will result in recommendations for the retrieval of lost fishing gears, including the findings from these risk and impact assessments. Although the focus of MARELITT Baltic is on the Baltic Sea ecoregion, the recommendations will also be valuable for retrieval operations in other marine regions, especially in the North Sea and the Mediterranean. In both the Baltic and the North Sea, seafloor operations and area searches on the seabed are particularly prone to risks from ammunitions because of the remains of the First and the Second World Wars. As fishing gear was particularly lost on or near ship wrecks prior to the common use of GPS on fishing vessels, ammunition risk is also a concern for divers conducting fishing gear retrieval actions on wrecks.

Spatial distribution

This study provides an overview of the spatial distribution of conventional and chemical munitions based on free (HELCOM and BLANO) and commercially (AMUCAD) available datasets. Analysis of the likelihood of encountering warfare materials during derelict fishing gear retrieval actions is conducted based on currently available information. Based on the spatial likelihood analysis, the most common types of expected warfare materials in the area of interest will be described and grouped into conventional and chemical warfare materials.

Risk Management

The likelihood for encountering conventional munitions in the Baltic See is assumed to be omnipresent and precautions must always be taken. In areas of former dumping activities, military training, offshore conflict and areas which were of interest for mine laying, the likelihood is assumed to be higher. Retrieval of derelict fishing gears is therefore more likely to lead to encounters with warfare material when contaminated areas are approached. Nevertheless, warfare materials can be mobile, and knowledge is insufficient to pinpoint every one of its source in the Baltic Sea.

The likelihood for encounters with chemical warfare materials across the Baltic Sea is high within spatially-confined areas such as dumping sites as well as their corresponding shipping routes and surrounding areas. Restricted areas as marked on sea charts in the Bornholm Basin, south of the Little Belt, the Gotland Basin, the Gdansk Deep and the unrestricted area in the Adlergrund should, in any case, be avoided. Furthermore, the surrounding of those areas should be treated carefully, as fishing activities and natural processes might have displaced warfare materials across the official borders of the known dumping sites.

CAUTION

The risk of encountering warfare materials in the Baltic Sea is always present.

PLANNING PHASE

Research existing data from the area of interest using:

- Available data (e.g., side scan) as well as historical data and documents

Consider dynamics of marine system

- Sedimentation or lateral displacement processes

Avoid regions known or suspected of hosting warfare materials

- Dumping sites and shipping routes to dumping sites
- Wrecks
- Former battle sites
- Mine-deployments

Analyse on-site remote-sensing footage

- Information from sidescan sonar or multibeam/backscatter
- Involve experts and/or data mining technologies for object identification

Hire or train crew members with regards to:

First aid for blast injuries and poisoning from chemical warfare agents

Have multiple crew members trained in first aid

Warfare material detection/recognition

Early detection and avoidance are the most effective risk mitigation measures

Distribute and provide

- First aid equipment
- Guidelines and quick guides
- Protective gear for encounters with chemical warfare agents

Provide information about responsible authorities and raise awareness about reporting findings

MISSION EXECUTION

Spot warfare materials off-board	Leave warfare materials in the sea

Report spotted warfare materials to authorities

Do not move derelict fishing gear

If divers in water	If entangled with warfare materials

Emergency through / Incident with warfare materials

Call for medical care immediately and sea rescue if necessary

Chemical warfare agents	Exploded ordnance
• Equip protective gear • Initiate containment measures (do not spread the chemical warfare agent!) • Start decontamination of affected personnel using protective gear	• First aid appropriate for blast injuries • Check vessel depending on explosion size

On board warfare materials without incident

Notify local authorities immediately	Do not move or touch hazardous materials

Chemical warfare agents	Unexploded ordnance
• Stay upwind and close doors • Wear protective gear • Initiate containment measures	• Water-cool • Wait for military

POST-MISSION FOLLOW-UP

Examine bottom-touching equipment and findings from the sea floor

Wear at least minimal protective gear

If the mission took place in an area potentially contaminated with chemical warfare agents

- Ensure that local authorities are informed about the arrival of the vessel at the port in case security measures ought to be taken.

Conduct a thorough search!

- The focus of attention should be on small ammunition bodies and contaminations in and on the nets and finds.

If contamination of any kind is detected

- Leave area immediately
- Notify local authorities

For repeated diver missions within contaminated areas accumulation of chemicals from conventional warfare material is possible

- Consider screening for divers (e.g., urine tests)

1 Introduction

MARELITT Baltic is an EU-funded Baltic Sea Region INTERREG project with the major aim to mitigate the impact of derelict fishing gear (DFG), also called "ghost gear", in the Baltic Sea marine environment. Within this project, methodologies for the search and retrieval of DFG from the seafloor are explored, developed and tested. Retrieval actions are documented by WWF Poland, the leading project partner for this part of the project. The final report from methodology testing in the four MARELITT Baltic partner countries – Poland, Sweden, Estonia and Germany – will result in recommendations for the retrieval of lost fishing gears. Although the focus of MARELITT Baltic is on the Baltic Sea ecoregion, the recommendations will also be valuable for retrieval operations in other marine regions, especially in the North Sea and the Mediterranean. In both the Baltic and the North Sea, seafloor operations and area searches on the seabed are particularly prone to risks from ammunitions because of remnants from World War I and II. As fishing gear was particularly lost on or near shipwrecks prior to the common use of GPS on fishing vessels, ammunition risk is also a concern for divers conducting fishing gear retrieval actions on wrecks.

Background for the Ammunition Risk Assessment

Ammunition risk is omnipresent in the Baltic Sea. Both active combat actions and dumping especially during and after the Second World War (WWII) led to high concentrations of ammunition along the German Baltic coast, the Pomeranian Bay, and off Bornholm. Corrosion of steel mantles leads to emission of toxic substances such as mustard gas and TNT. During area DFG search operations with creepers or anchors, search crews and vessels can be unknowingly exposed to ammunition risk. The risk of exposure to ammunition occurs during several stages of a DFG search and retrieval operation:

Encountering ammunition during area searches with bottom-touching gear

Exposure of divers to toxic substances and explosives during:

- Evaluation of the underwater situation at wrecks or on the seafloor
- "Hooking of nets" for subsequent retrieval with a vessel winch without diver support
- Professional diver net retrieval including cutting of nets from wrecks and other obstacles and lifting with lifting bags or similar diving equipment

Retrieval of nets entangled with other marine litter by fishing crews or other vessels

With the aim to assess ammunition risk during DFG retrieval actions, WWF Germany commissions a risk assessment study in the framework of the MARELITT Baltic EU INTERREG project. The main focus of MARELITT Baltic is the mitigation of the impact of DFG on the marine environment. As MARELITT Baltic serves as a pilot project for other European ecoregions an outlook towards comparable sea areas such as the North Sea is desirable as well.

The Aim of the Study

The objective of the study is to assess the risks from ammunition and exposure to toxic substances and explosives during DFG retrieval operations with creepers or divers in the Baltic Sea and propose mitigation measures and security recommendations for gear retrieval operators.

At a minimum the following aspects are covered in this assessment:

- Introductory discussion of the spatial distribution of ammunitions in the Baltic Sea and databases to be consulted to minimise the risk of encountering ammunitions, delineation of potential risk areas (high, medium, low) in the area between Sweden and the German-Polish coasts and – if available – for Estonian waters
- Types of ammunitions to be expected during DFG retrieval operations in the Baltic Sea
- Types of chemicals encountered in these ammunitions or on the sea floor
- Health risks of these substances for divers and retrieval teams
  - Exposure to acids, burning, poisoning, risk from explosives
- Risk of damage to equipment and risk avoidance measures
- Security measures against health risks during preparation of retrieval operations
- Mitigation measures in case of medical impairment
- Emergency plan recommendations in cases where ammunition is encountered
- A guideline for risk assessment during DFG retrieval preparation and on-board information for crews

Area of investigation
The area of investigation includes Baltic Sea waters with a focus on the Southern Baltic Sea with high-risk ammunition areas, especially where fishing activities take place.

The focus of the study shall be on the MARELITT Baltic partner countries: Estonia, Germany, Poland, and Sweden. Areas with high fishing intensity are available from the MARELITT Baltic hotspot map for each country. Particular focus has to be placed on the German and Polish coastal zones and the area between Sweden and the German-Polish coasts, where ammunition was extensively used and dumped during and after the Second World War. The areas off Bornholm and the Pomeranian Bay are of particular importance for area DFG searches because of the overlap of dumping sites and active trawling fisheries. For diving actions, the shallower coastal zones down to a depth of 25 meters are most relevant, for instance, the German “Greifswalder Bodden” and the coasts off Usedom, “Peenemünder Haken” and Rügen Island.

The subject of warfare materials such as munitions and other remnants of mainly WWII has been a significant security and health risk for operations in many regions around the world, including both the Baltic and North Sea. During the world wars, both the Baltic and North Sea were conflict areas and, more importantly, after each war dumping sites for large amounts of conventional and chemical munitions. The total amount of conventional munitions in the Baltic Sea is estimated to be on the order of several million tonnes.[1]

1.1 Scope and Objectives

Provide:
- Spatial distribution information
- Guide for planning activities
- Lists of potential warfare materials
- Information about chemicals‘ composition
- Recommendations about mitigation measures
- Information in case of an accident
- Quick guide to minimise warfare material risk during derelict fishing gear retrieval actions

2 Occurrence of Munitions and Warfare Agents

Warfare material in the Baltic Sea can be generally divided into two major categories – conventional and chemical warfare materials. Conventional munitions can be further categorised into explosive, non-explosive and incendiary (inflammable) types. In addition, munitions components that were either dumped or separated due to deterioration may be found. Finally, ship and plane wrecks are located on the Baltic Sea seafloor. Conventional warfare materials might be found throughout the Baltic Sea originating from bombings, offshore battles, mine barriers, military exercises and post-war dumping activities, whereas chemical warfare materials are mostly the result of post-war dumping action.

2.1 Modes of Entry

During the world wars the Baltic Sea was an area of intense battles. Due to the strategic importance of the Baltic, innumerable combat actions of great variety took place, all of which caused entry of warfare materials into the marine environment. These range from naval battle between warships, submarine torpedo attacks and air raids to complex mine-laying operations. In addition, test sites for marine weapons and live-fire navel exercises were established in a variety of places.

Immediately before and after the end of WWII, the dumping of warfare materials constituted an additional mode of entry of warfare materials into the Baltic, which was carried out for a multitude of reasons. With the end of the war drawing closer, warfare materials were dumped by the German Armed Forces in order to remove hazardous materials from areas subjected to imminent attacks, to prevent munitions from being seized by the advancing Allied troops, and to demilitarise prior to the impending surrender. In the immediate post-war period, the Allies chose dumping at sea as modus operandi to conduct swift demilitarisation and removal of warfare materials from German territory. The dumping activities that took place during the final stage of war and during the post-war period were conducted under time pressure, either due to attacks of the Allied forces or by agreed deadlines. In later years, dumping activities were considered an inexpensive and – according to the authorities – a safe alternative to land-based disassembly and decontamination procedures.

2.2 Types of Warfare Materials

The following section describes the most common types of warfare materials in the Baltic Sea and provides a visual impression based on photographs of different kinds of objects.

2.2.1 Conventional Explosives and Non-Explosives

The following paragraphs provide information about selected kinds of conventional explosives based on the occurrence in the area of interest. The term refers to weapons whose ability to damage results from explosive or kinetic energy. This group includes, for example, bombs, mines, artillery shells, grenades, rockets, torpedoes and small arms.

2.2.1.1 Bombs

Bombs are weapons that are transported by aircraft, then dropped from the aircraft on a target, and finally detonate when they reach the target. In 1849, the first attempt of using air bombing – with balloons – was started by the Austrian Army. In 1911, an Italian pilot dropped bombs by hand from an aircraft onto enemy ground structures. Bombs are streamlined metal cylinders that are filled with an explosive charge (filling of the bomb) and an ignition system. Different systems allow for the detonation of the bomb in a distance to the surface, on the surface or after impact. Professional construction and production started during WWI and the development of bombs is still on-going to this day.

Example of bombs in preserved or reworked conditions:

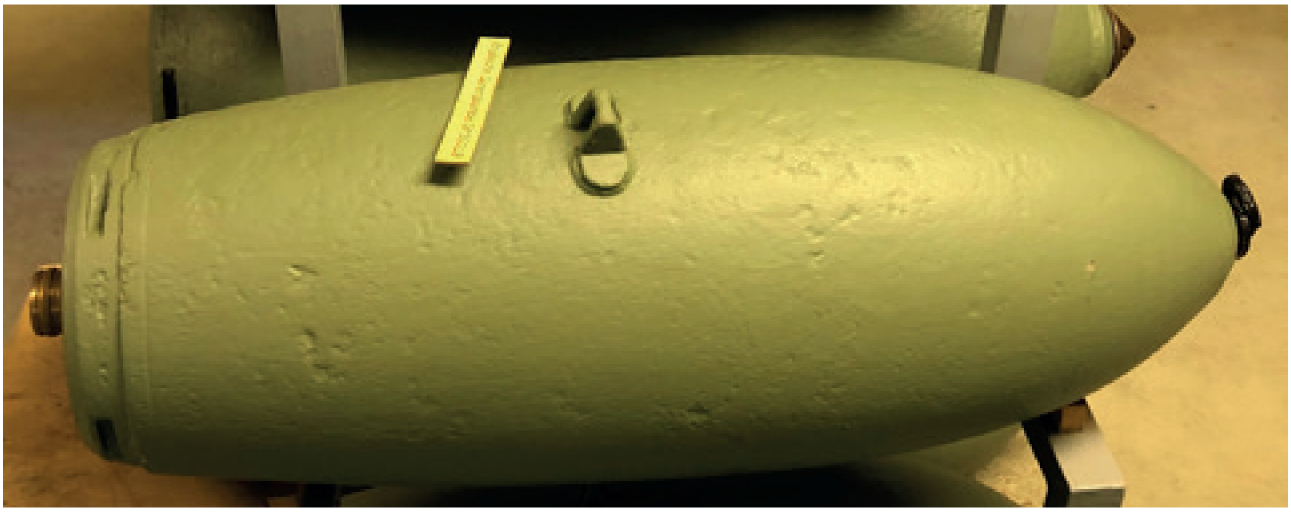
German SC500L2 mine bomb; weight: 500 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

German Flam C250C incendiary bomb; weight: 110 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

German SC 50m PS mine bomb; weight: 50 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

German SC250K mine bomb; weight: 250 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

American exercise bomb (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)



British GP500 LB general-purpose bomb; weight: 250 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

Example of bombs in underwater conditions:

Foreground: suspected bomb; background: suspected torpedo warhead (source: Jana Ulrich, 2018)

2.2.1.2 Depth Charges

Depth charges are anti-submarine warfare weapons working via detonation, resulting in a destructive hydraulic shock. The firing system works by clockwork or pressure to enable a detonation in various water depths. The deployment was carried out by ships and aircraft.

British MK7 depth charge; length: 700 mm, diameter: 450 mm, weight: 185 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

German water bomb (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

German WB water bomb; length: 570 mm, diameter: 450 mm, weight: 185 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

2.2.1.3 Mines

The first trials with mines go back to the 18th century. Serious development started later, and the first-ever minefields were laid by units of the Russian empire in approach of Port Arthur in the Russo-Japanese War (1904–1905). From the beginning of WWI onwards, mines were essential weapons in naval warfare.

The estimated number of mines laid in the Baltic Sea varies between 100,000 and 150,000. Of these mines approximately 20–30 % are still lying on the sea bottom. Due to the variety of mines and the time since their deployment they can be found in various kinds of conditions and shapes. The most common mines deployed were contact mines. In general, two types of naval mines – moored and ground mines – exist, and accidents have shown that even today mines from WWI are fully functional.

Moored Mines

Moored mines were invented prior to ground mines. Their case has a spherical shape, some with an additional belt connecting two hemispheres. Inside the mine casing the charge is stored in a separate container. The explosive charge in a moored mine weighs between 20 and 350 kg, and their size/diameters range from 50 to 112 mm. The mines contain ignition systems that are based on different contact ignition modes. Chemical horns and switch-horns protruding out of the sphere give moored mines their characteristic look. Chemical horns contain a small glass phial with an electrolyte liquid. As a result of a contact between a ship's hull and the horn, the glass breaks and the electrolyte closes an electrical circuit, resulting in the ignition of the mine. Switch-horn systems contain a fully-loaded battery in the mine casing. As a consequence of outside physical contact to the horn, the switch is operated and again a current circuit is closed and the detonation initiated. The mine casing itself is filled with air, thereby acting as a floating body and providing buoyancy. It is moored to the sea floor by means of an anchor. A wire or a chain connecting the mine case to the anchor ensures that the mine's position is maintained. Mines were located at a water depth between one and five meters when targeting surface ships and 100m when targeting submarines. When the mooring was damaged by natural influences or cut by minesweeping gear, mooring mines ascended to the water surface. A secure system would open a hole in the casing, resulting in the mine being filled with water and sinking to the sea floor. Minesweepers also damaged the casing of mines by firing at them.

Examples of moored mines in preserved or reworked conditions:

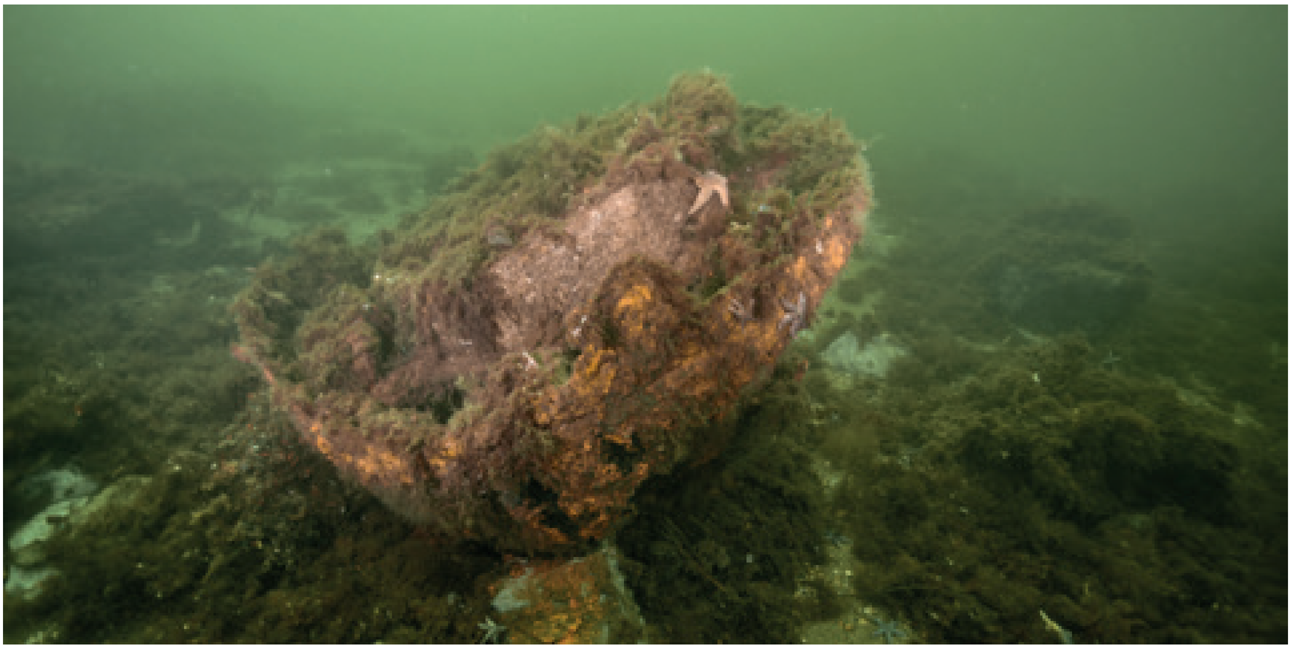
German UMA moored mine; diameter: 800 mm, weight of charge: 30 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

German EMA/EMB moored mine; diameter: EMA800 mm/ EMB 900 mm, weight of charge: EMA 150 kg/EMB 220 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

Anchor of moored mine with mine lying to the left. (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

German EMF moored mine; diameter: 1200 mm, weight: 590 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

Examples of moored mines in underwater conditions:



Blasting-chart container of a German EMC or EMF moored mine (source: Jana Ulrich, 2018)

Ground Mines

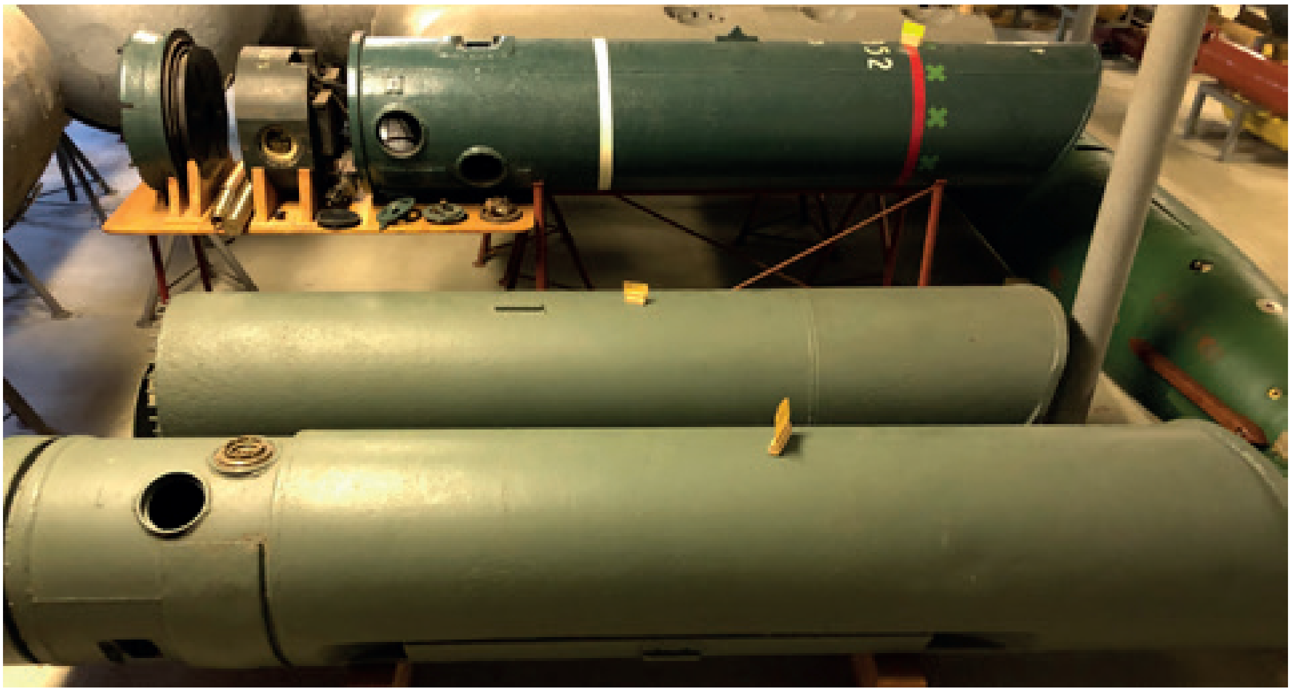
Ground mines were first developed towards the end of WWI, where also a small number of these mine types were being laid. In WWII, ground mines were fully functional and intensively laid in rows or fields which was carried out by airplanes or ships by forces of the United Kingdom, Germany and Russia. The explosive charge of ground mines varies strongly between 45 and 880 kg, their size/diameters range from 33 up to 66 cm. The ignition systems are magnetic, acoustic or pressure-influenced. Combinations of two or all three variants were also developed. The magnetic field of a steel ship, the noise emanating from the engine and the marine propeller or the pressure change resulting from water displacement activated the ignition system. However, in order to function, the ground mine requires a sufficiently charged battery.

Examples of ground mines in preserved or reworked conditions:

German TMB torpedo mine; weight: 740 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

German LMF anchor mine; length: 2,300 mm, weight: 740 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

British Mark VII ground mine; length: 2,300 mm, weight: 500 kg (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)



Several ground mines (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

Examples of ground mines in underwater conditions:

Suspected British ground mine (source: Jana Ulrich, 2018)

German TMB or TMC ground mine (source: Jana Ulrich, 2018)

2.2.1.4 Artillery Shells

The history of artillery shells goes back to the middle ages. Originating from a hollow sphere filled with black powder and using a burning fuse, development over the centuries has resulted in the development of a high-technology warfare material. Naval forces used many kinds of artillery shells. The small calibres of 2.0 cm, 3.7 cm, 4.0 cm and 5.7 cm serve two purposes. The main application is as anti-aircraft defence against planes flying in low and medium altitudes. As such, the guns work in rapid fire. The second application is combat against surface targets over short and medium distances. These calibres were mostly deployed as main weapons on small vessels. The calibres of 7.5 cm, 10.0 cm and 15.0 cm were installed as the main gun of vessels for use against surface targets. They were also applied in their second purpose as antiaircraft guns. Larger calibres from 15.0 cm up to 40.5 cm were used on battleships or as shore-based guns for coastal defence.

Examples of artillery shells in preserved or reworked conditions:

Various artillery shells (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

Various artillery shells (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

2.2.1.5 Torpedoes

A torpedo is a self-propelled weapon with an explosive warhead used in off-shore combat against ships and submarines. It is designed to detonate in contact with its target or in proximity to it.

Examples of torpedoes in preserved or reworked conditions:

German exercise torpedo warhead (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

German "Zaunkönig" torpedo warhead (source: Explosive Ordnance Disposal Unit of the Federal State of Schleswig-Holstein)

Examples of torpedoes in underwater conditions:

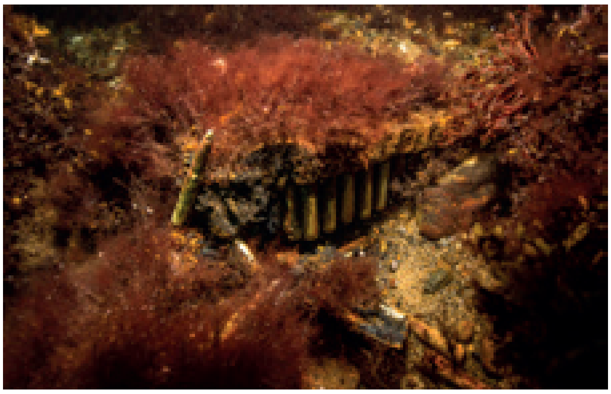
Suspected torpedo warhead (source: Jana Ulrich, 2018)

Suspected torpedo warhead (source: Jana Ulrich, 2018)

2.2.1.6 *Other Ordnance*

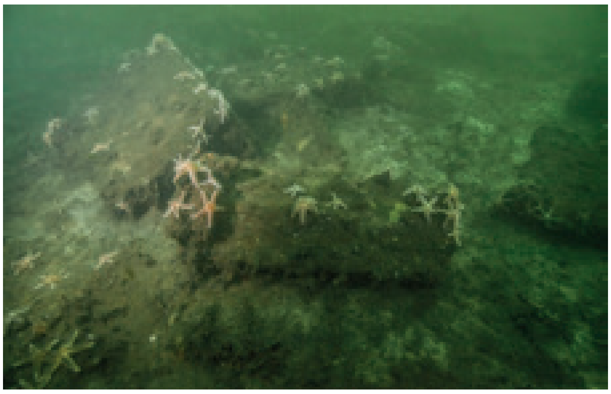
The following images show various types of ammunition and their status in underwater environments:

Rifle ammunition I (source: Christian Howe/Submaris, 2018)

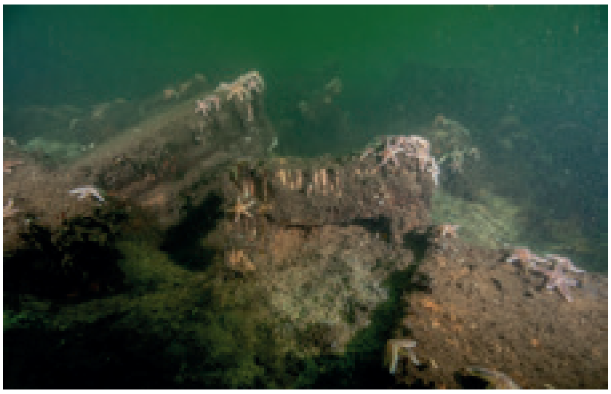


Rifle ammunition II (source: Christian Howe/Submaris, 2018)

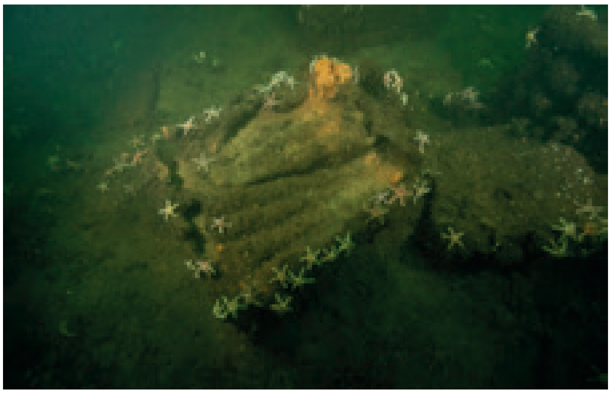
Loose explosives (source: Jana Ulrich, 2018)



Unknown ammunition boxes (source: Jana Ulrich, 2018)



Ammunition box with suspected 2.0 cm grenades and various other ammunition boxes (source: Jana Ulrich, 2018)



Ammunition box with suspected 3.7 cm grenades (source: Jana Ulrich, 2018)

2.2.2 Incendiary Munitions

Incendiary munitions are designed to cause fire and not destruction through explosions. The payload is a combination of a small charge to open the grenade and scatter the combustible mixture and the combustible mixture itself, which starts burning after release. Often, white phosphorus is used, which self-ignites when in contact with air. Large incendiary munitions like incendiary bombs are additionally filled with a highly flammable fluid using white phosphorus as initiator. White phosphorus can be easily confused with amber and has therefore a high risk potential if it is washed ashore.

2.2.3 Chemicals and Chemical Warfare Agents

While conventional munitions contain explosives or incendiary agents and their effect is characterised by detonation or burning, chemical munitions are distinguished by a payload of chemical warfare agents. Their purpose is not the physical destruction of infrastructure, but rather directly or indirectly, a temporary or permanent incapacitation of humans due to the respective toxic effects of the compounds used. In addition, a strong psychological component exists, associated with the type of external injuries and the delay before their appearance (e.g., blisters on the skin). In contrast to the substances contained in conventional munitions, the hazards posed by chemical warfare agents for people and the environment appear obvious. Hence, researching this kind of munitions has received special attention in the past.

The majority of chemical warfare munitions dumped are aircraft bombs. In terms of weight, more than half of the chemical munitions dumped were aircraft bombs containing mustard gas. However, not all chemical warfare agents were dumped as payload ammunition; a considerable amount was dumped in encasements and containers. In the Baltic Sea, chemical warfare agents occur in the form of vesicants (blister agents; sulphur mustard, nitrogen mustard, lewisite), irritants (nose and throat agents; Clark 1, Clark 2, Adamsite), lachrymators (tear gases; α-chloroacetophenone), lung agents (phosgene, diphosgene), nerve agents (Tabun) and blood agents (hydrogen cyanide).[1]

Chemical Warfare Agents

- Vesicants (blister agents): Sulfur mustard, nitrogen mustard, Lewisite
- Irritants (nose and throat agents): Clark I, Clark II, Adamsite
- Lacrimators (tear gases): α-chloroacetophenone
- Lung agents: phosgene, diphosgene
- Nerve agents: Tabun
- Blood agents: hydrogen cyanide

Effect-based classification of chemical warfare agents. [1]

It is likely for three of the chemical warfare agents (sulphur mustard, Adamsite, α-chloroacetophenone) and one compound of the conventional munitions (trinitrotoluene) are netted outside of the original containment vessel.[1] These chemical components might be encapsulated in arbitrary objects, for example, paint buckets or car tyres, or lie open on the sea floor, however, the most likely state is encapsulated within their original vessels, that means their respective munitions shells or containers. In either case, chemical components are possible to be netted during derelict fishing gear retrieval actions. In the following the chemicals and chemical warfare agents dumped within the Baltic Sea as a consequence of warfare are introduced within their respective category. For the two most common of those substances, sulphur mustard and trinitrotoluene.

2.2.3.1 Vesicants (Blister Agents)

A blister agent, or vesicant, is a chemical compound that causes severe skin, eye and mucosal pain and irritation.[4] Vesicants are chemical warfare agents designed to attack contact surfaces, the exposure routes are skin, eyes, lungs and ingestion.

Vesicants include sulphur mustard, nitrogen mustard and lewisite.

Sulphur Mustard

Sulphur mustard (also known as mustard gas, yperite, H or HD) is an oily liquid with bis(2-chloroethyl) sulfide as its main active component[1], which solidifies into insoluble lumps and can be netted.[1]

Sulphur mustard mixtures represent about 63 % of all materials dumped near Gotland and Bornholm. However, probably due to the formation of persistent lumps, this hazardous material is involved in 88 % of all reported fishing incidents.[1]

Nitrogen Mustard

Nitrogen mustard, tris(2-chloroethyl)amine (also known as HN-3), is a liquid vesicant quite similar in function and behaviour to sulphur mustard.[1]

Lewisite

Lewisite (dichloro(2-chlorovinyl)arsine, also designated Lewisite I), is a liquid organoarsenic versicant, which means it exhibits bonds of arsenic and carbon.[1]

Figure: Sulphur mustard lumps [1]

2.2.3.2 Irritants (Vomiting Agents)

Irritants belong to the class of chemicals classified as vomiting agents [4] and include Clark 1, Clark 2 and Adamsite.

Adamsite

Adamsite (diphenylaminechloroarsine, also known as DM), is an arsenic-containing irritant chemically classified as a nausea or vomiting agent, it occurs as a solid and can be netted.[1]

Clark 1, Arsine Oil, Clark 2

Diphenylchloroarsine (DA, Clark I) and diphenylcyanoarsine (DC, Clark II) are organo-arsenic irritant compounds and are classified as sneezing or vomiting agents. Arsine oil is the designation of technical-grade Clark I and consists of Clark I (35 %), phenyldichloroarsine (50 %, "Pfiffikus"), triphenylarsine (5 %) and trichloroarsine (5 %) (Franke, 1977).[1]

2.2.3.3 Lachrymators (Tear Gas)

Tear gas, formally known as a lachrymator agent or lachrymator (from the Latin lacrima, meaning "tear"), sometimes colloquially known as mace, is a chemical weapon that causes severe eye and respiratory pain, skin irritation, bleeding, and even blindness. [4]

Alpha-Chloroacetophenone

α-Chloroacetophenone (also known as CN or CAP) is a solid riot control agent or tear gas. In German artillery shells, CAP was used either as a mixture with explosive and wax or as solid material surrounded by an explosive, it occurs as solid and can be netted.[1]

2.2.3.4 Pulmonary Agents

A pulmonary or lung agent is a chemical weapon agent designed to impede a person‘s breathing ability, pulmonary agents include phosgene and diphosgene.

Phosgene, Diphosgene

Phosgene is a colourless gas with a boiling point of 8.3 °C, classified as a lung agent and was filled into munitions in liquefied form. Diphosgene (“Perstoff”) can be described as a “masked” phosgene consisting of two molecules of phosgene bound together.[1]

Phosgene degrades extremely fast when it comes into contact with water (its half-life was calculated to be 0.4–1.0 seconds at 2 °C.[11] The alkaline pH of seawater accelerates the decomposition by neutralizing and buffering the released hydrochloric acid and carbonic acid. While a short-term impact will certainly occur on the immediate environment upon release (due to the violent release of hydrochloric acid), the breakdown products are effectively non-toxic after dilution and neutralisation.[1]

2.2.3.5 Nerve Agents

Nerve agents are a class of organic chemicals that disrupt the mechanisms by which nerves transfer messages to organs. They include Tabun, which was the first nerve agent to be discovered and produced as a chemical warfare agent.

Tabun

Tabun (ethyl dimethylphosphoramidocyanidate, also known as GA), is a organophosphate – a functional group within organic chemistry – nerve agent. It is a liquid with a specific weight slightly higher than seawater (1,10 g/cm³) – even in oceanic salinity [1] – and hence will sink to the seafloor.

In the marine environment, Tabun is hydrolysed into phosphoric acid, dimethylamine and hydrogen cyanide. In seawater, at temperatures ranging from 7–15 °C, its half-life is approximately 5–8 hours. Thus, it poses a rather short-term threat to the marine environment, and only when it occurs in high concentrations (Bizzigotti et al., 2009).[1]

2.2.3.6 Blood Agents

Blood agents include hydrogen cyanide.

Hydrogen Cyanide

Hydrogen cyanide can be released upon degradation of Tabun or Clark II. Just like phosgene, the Organisation for the Prohibition of Chemical Weapons (OPCW) considers it as a potential dual-use toxic chemical (OPCW 2012).[1; 12]

It dissolves in the alkaline seawater as cyanide. While effects on the immediate environment are possible upon release, it is easily and quickly degraded and dissipates in the marine environment.[1]

2.2.3.7 Chemicals from Conventional Munitions

Chemicals from conventional munitions include trinitrotoluene and white phosphorus.

Trinitrotoluene

Trinitrotoluene is an explosive solid with primary hazards from effects of a blast. It was not designed to produce significant fragmentation or throw projectiles. It may explode under exposure to intense heat or fire [3; 6], as it occurs as solid, it can be netted. It can be absorbed through the skin. The vapours are toxic: when heated to decomposition it emits toxic fumes. It will detonate under strong shock or sudden heating. (NTP, 1992) [2]

White Phosphorus

White phosphorus is the most reactive modification of elemental phosphorus. Due to its property to spontaneously self-ignite when the solid is dry and in air, it has been used as an incendiary agent.[1]

2.3 Spatial Distribution

The knowledge of the spatial distribution of conventional and chemical ammunition plays an essential role in planning retrieval operations and the determination of risk mitigation measures. Because of the different modes of entry of ammunition into the Baltic Sea, the distribution patterns largely vary – from concentrated local dump sites to widespread munitions' contaminated areas – resulting from, for example, military exercises or post-war bottom trawling activities. Information about the spatial distribution of ammunition can be obtained in different ways and only the on-going interpretation and analysis of available historic and current datasets can help reduce risks related to ammunition.

Due to the dynamics of marine systems (e.g., currents, sedimentation) and human impact (e.g., bottom trawling) the following risk maps are just a starting point for caution during retrieval of derelict fishing gears. Continuous analysis of data, consideration of new information as well as an intensive exchange of experience is necessary to avoid risks in the most effective way.

The resulting spatial distribution maps are grouped into three categories depending on the probability of occurrence of different types of warfare materials:

- **Large conventional warfare materials:** This category includes, for instance, moored and ground mines from World War I and II.
- **Various kinds of warfare materials:** Includes all different kinds of warfare materials resulting from, for example, coastal anti-aircraft guns and dumping.
- **Chemical warfare materials:** This category includes information about dumped chemical ammunition and known accidents.

CAUTION

The spatial assessment provides only an aggregated overview about the risks of encountering warfare materials, but for most of the Baltic Sea the risk is always present.

2.3.1 Information Sources

The following paragraphs describe potential sources to obtain information about the spatial distribution that can be used for planning of retrieval operations.

2.3.1.1 Historic Documents

All circumstances and decisions from the military were documented in form of stored orders, reports, diaries and other specific documents that are partly accessible in several national military and non-military archives. Research and analysis of relevant documents prior to carrying out retrieval operations are an important part of preparation and can be considered as a mitigation measure on its own.

Archive work and interpretation of documents and their relationships is a complex and time-consuming task which can be underlined by the fact that the German Military Archive in Freiburg alone stores 51 km of files, requiring highly specific contextual knowledge and an interdisciplinary approach.

2.3.1.2 Geophysical and Hydrographic Datasets

Another information source for potential warfare material objects are geophysical and hydrographical high-resolution datasets. Different kinds of data sources exist, yet most of them restrict access to most actual measurements (e.g., pangaea.de) or do not include the area of interest (e.g., ngdc.noaa.gov).

2.3.1.3 Databases and Information Systems

A more structured and user-friendly access to information about ammunition and its distribution can be provided by databases or geo information systems. Due to the complex topic and the difficulty in obtaining, interpreting and analysing datasets, not many services are available. Due to either military or security considerations, only two database/information systems are discussed below, both that can be used and are free and/or commercially available.

HELCOM

The HELCOM Data and Map Service was established in 2010 by the work of the HELCOM "Development of HELCOM Data and Geographic Information System" project (User Manual HELCOM Data and Map Service 2015), and can be accessed under maps.helcom.fi. Besides a wide variety of different datasets related to the status of the Baltic Sea, the most informative dataset in terms of ammunition is the so-called "Reported encounters with chemical warfare materials 1961 to 2012". This dataset contains information about reported encounters of sea-dumped chemical ammunitions in the Baltic Sea from 1961 to 2012. For further details see Annex 7.2 of the HELCOM 2013 report: Chemical Munitions Dumped in the Baltic Sea – Report of the ad hoc Expert Group to Update and Review the Existing Information on Dumped Chemical Munitions in the Baltic Sea (HELCOM MUNI). The position of encounters is given in decimal degrees (WGS84) whenever this information is available (encounters lacking this geographic information are also included in the dataset, although they lack coordinates), see metadata.helcom.fi.

AMUCAD

The Ammunition Cadastre Sea (AMUCAD) is a project currently developed by EGEOS GmbH (Germany) that will be released in 2019. It deals with the acquisition, management and analysis of ammunition-related datasets for the North Sea and Baltic Sea. Therefore, an immense amount of historical and modern datasets is acquired and integrated into the system with new technologies like artificial intelligence/visual analytics used for analysing and connecting these datasets. EGEOS GmbH is part of several national **ERPAD** * and international **DAIMON** ** and **NSW** *** research projects, relevant for the topics about ammunition in the sea. AMUCAD is designed for economic, research and administrative purposes, and will be deployed Europe-wide, such as for use in marine spatial planning, development of offshore infrastructure projects and environmental questions. Licences for AMUCAD can be directly purchased via EGEOS. More information is available under amucad.org.

ERPAD – Extraction of Spatial Data from Historical Documents *

The goal of ERPAD is an intelligent handling of historical documents and written sources of information from different thematic contexts. In German and European archives large amounts of historical documents are present containing information with extremely high value. Connecting these historic documents is particularly difficult without understanding the historic context and only possible with expert knowledge.

As a result, within the project an automated method for the determination and connection of historic documents based on geographical, temporal and thematic relationships will be developed. To this aim, recent developments from the field of machine learning (deep learning) and object character recognition using neural networks and GPU-based calculations (CUDA/OpenCL) will be applied. The resulting datasets can afterwards be manipulated, combined and analysed by means of current technologies.

DAIMON – Decision Aid for Marine Munitions **

The goal of the project DAIMON is to analyse identified and localised objects with artificial intelligence incorporating large amounts of spatial and non-spatial datasets based on latest scientific research. For each detected munitions object, the software will formulate a risk assessment, incorporating information about the localisation and overall state of the ammunition, the surrounding environment and state of biological pollution/damage. Furthermore, it will recommend possible actions, such as recovery & destruction, aggregation, encapsulation, capping, blasting or non-action, including monitoring and costs thereof.

In this context AMUCAD plays an important role because it incorporates the research results and provides access to DAIMON via its interface. In addition, AMUCAD will provide extended functionalities to the basic DAIMON, like including additional datasets, managing private data, versioning/history of found objects, and many more.

NSW – North Sea Wrecks ***

The goal of NSW is the development and implementation of a common strategy for dealing with economical, ecological and safety challenges in the context of shipwrecks, lost cargo, disposed chemical waste and ammunition to enable a sustainable management of the ecosystem North Sea. In addition, the project will develop new methods and technologies to fight risks for humans, enable "blue growth", secure food supply and protect the environment. In this context the project will identify and evaluate the cultural and historical heritage in the North Sea. Together with partners of countries around the North Sea the locations of wrecks, cargo and dumps will be identified, mapped and assessed. Available knowledge and best practices will be adapted to the requirements and prerequisites of the North Sea region.

As a result of the implementation of the prototype of NORTH SEA WRECKS into AMUCAD, several newly developed approaches and technologies will also be applied to the Baltic Sea to develop a better understanding of the ammunition and wreck situation.

BOSB

The Baltic Ordnance Safety Board (BOSB) was established in 2006 exclusively for military use to assemble information on mines and other explosives in the Baltic Sea. In addition, it is used to prioritise areas for mine clearance and to coordinate multinational mine clearance efforts across the Baltic (Möller, 2011). The members of the BOSB initiative are Sweden, Germany, Denmark, Poland, Lithuania, Latvia, Estonia, Finland and NATO, who gather and share information about historic ordnance with a specific focus on future mine counter measures to enhance maritime safety. For this study, only aggregated datasets from the Baltic Ordnance Safety Board are taken into account.

2.3.2 Categories of likelihood of encounter

The spatial distribution assessment outputs three different kinds of risk categories. Resulting analysis includes both applied techniques (diving retrieval, area search with hooks) and reflects the risk to encounter ammunition-related objects.

- **Very high likelihood of encounter:** The probability of an encounter in these specific areas is very high, depending on the applied techniques. In these areas, derelict fishing gear retrieval should be avoided.
- **High likelihood of encounter:** The probability of an encounter in these specific areas is high, depending on the applied techniques. In general, derelict fishing gear retrieval is possible but an intensive planning of the operation and a preliminary examination of the area (e.g., side-scan sonar measurements) should take place beforehand.
- **Medium likelihood of encounter:** The probability of an encounter in these specific areas is medium depending on the applied techniques.
- **Unknown likelihood:** in areas marked as unknown in the spatial risk assessment no information about spatial distribution of warfare materials was available

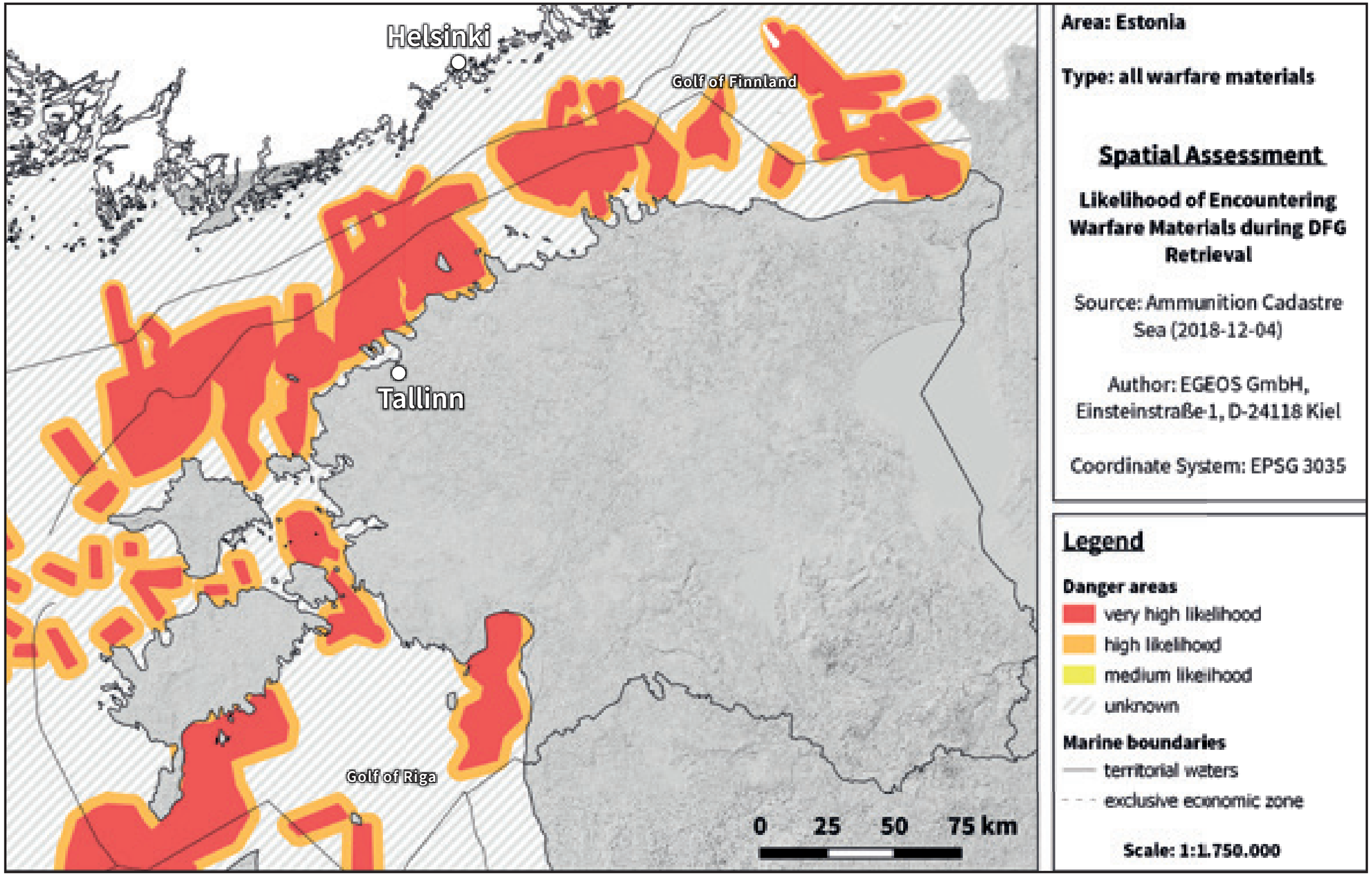
CAUTION

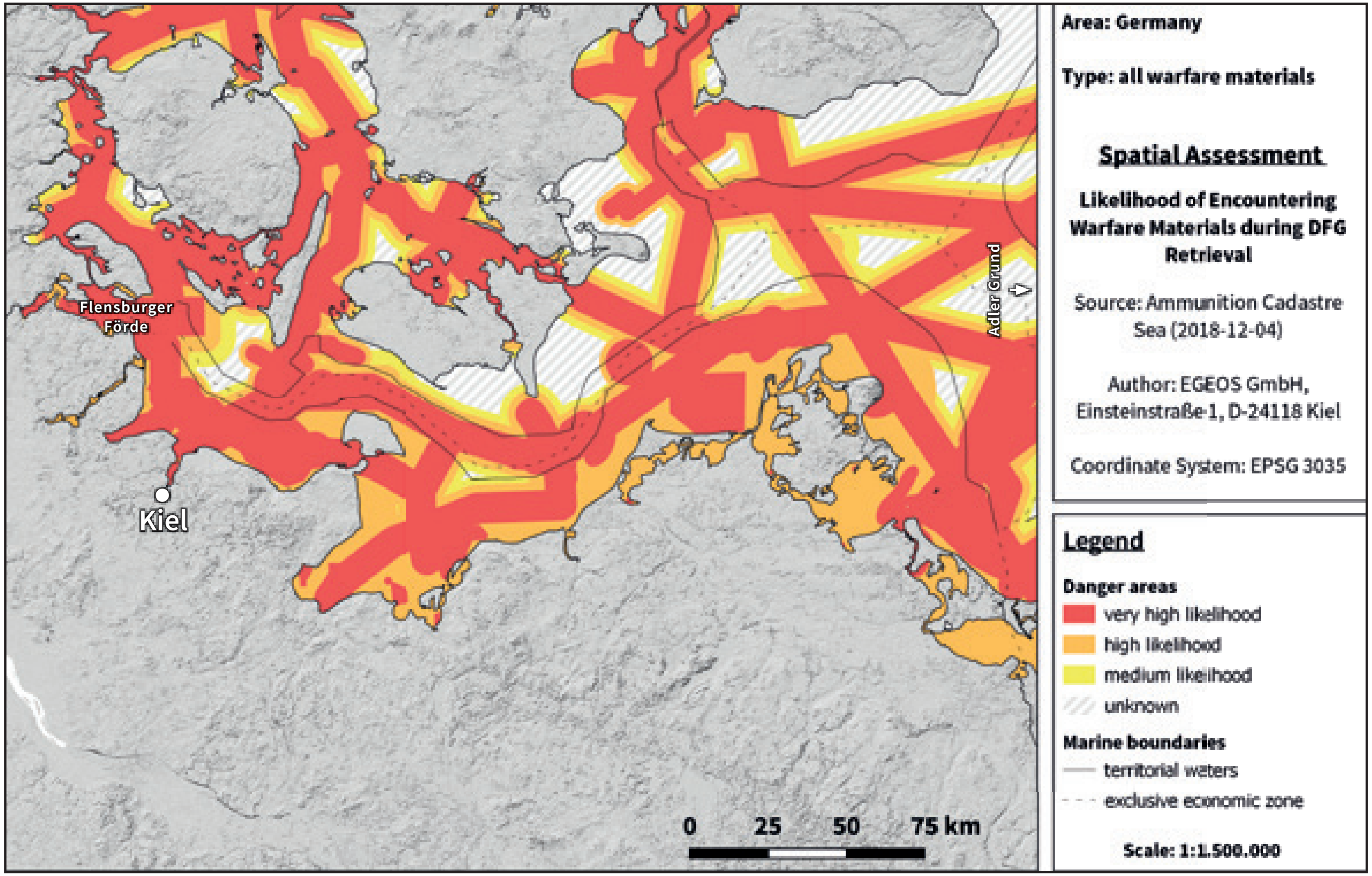
- The risk assessment reflects the present state of knowledge (2018.12.02) and is based on accessible datasets. A continuous refinement of these results should be carried out to provide current information and limit risks as effectively as possible.
- The risk maps include conventional and chemical dumping grounds, routes to dumping grounds, mine layings, military training areas, and potential risk areas regarding military use
- Low or even no likelihood areas are not specified, as those could imply a level of safety not present in the context of potentially lethal warfare materials in a highly dynamic, widely contaminated and sparsely monitored system like the Baltic Sea. Therefore, in order to discourage carelessness or negligence in regard to safety measures, neither low nor "no likelihood" areas can be defined.

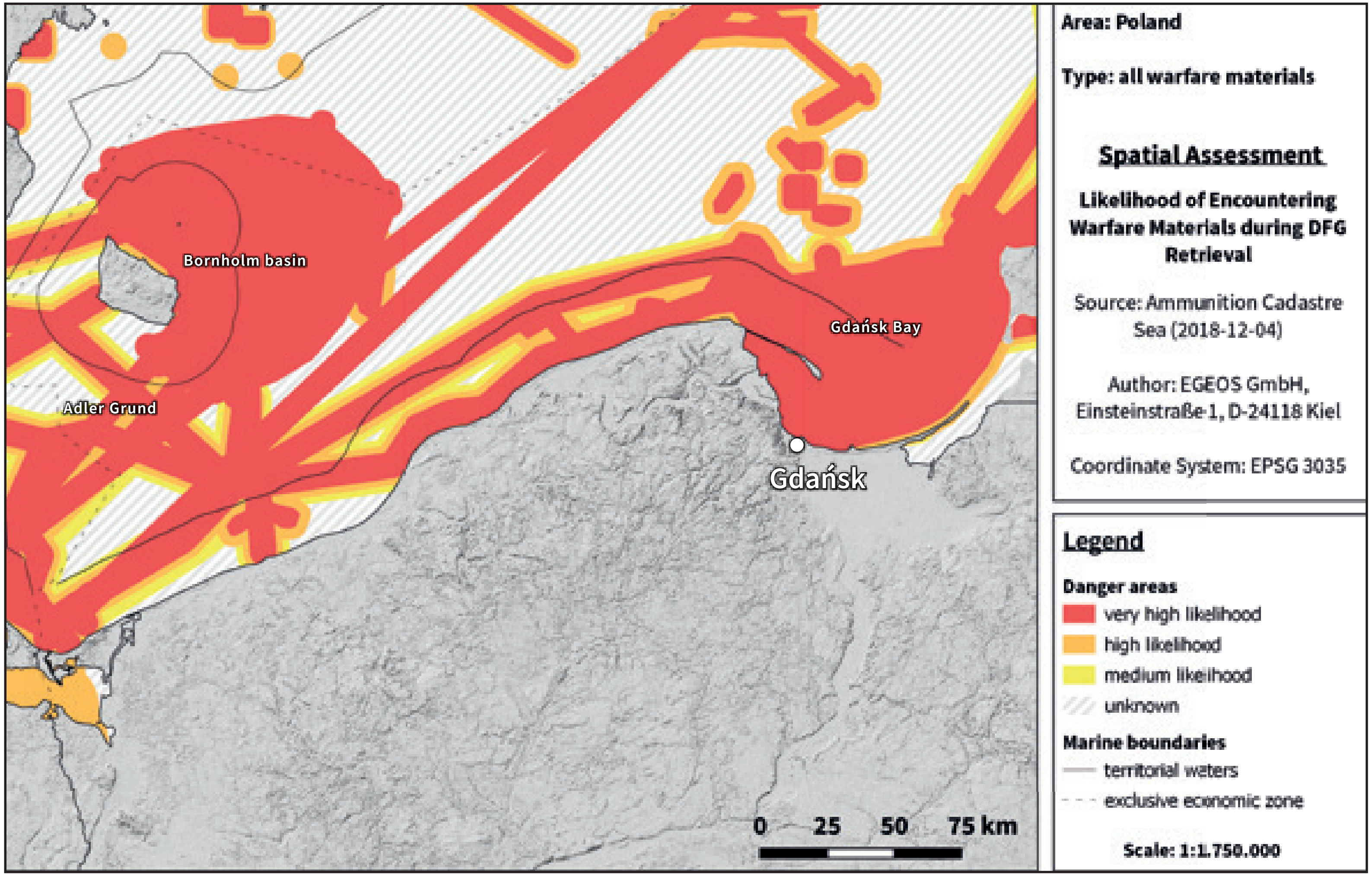
2.3.3 Likelihood of Encounter for all Warfare Materials

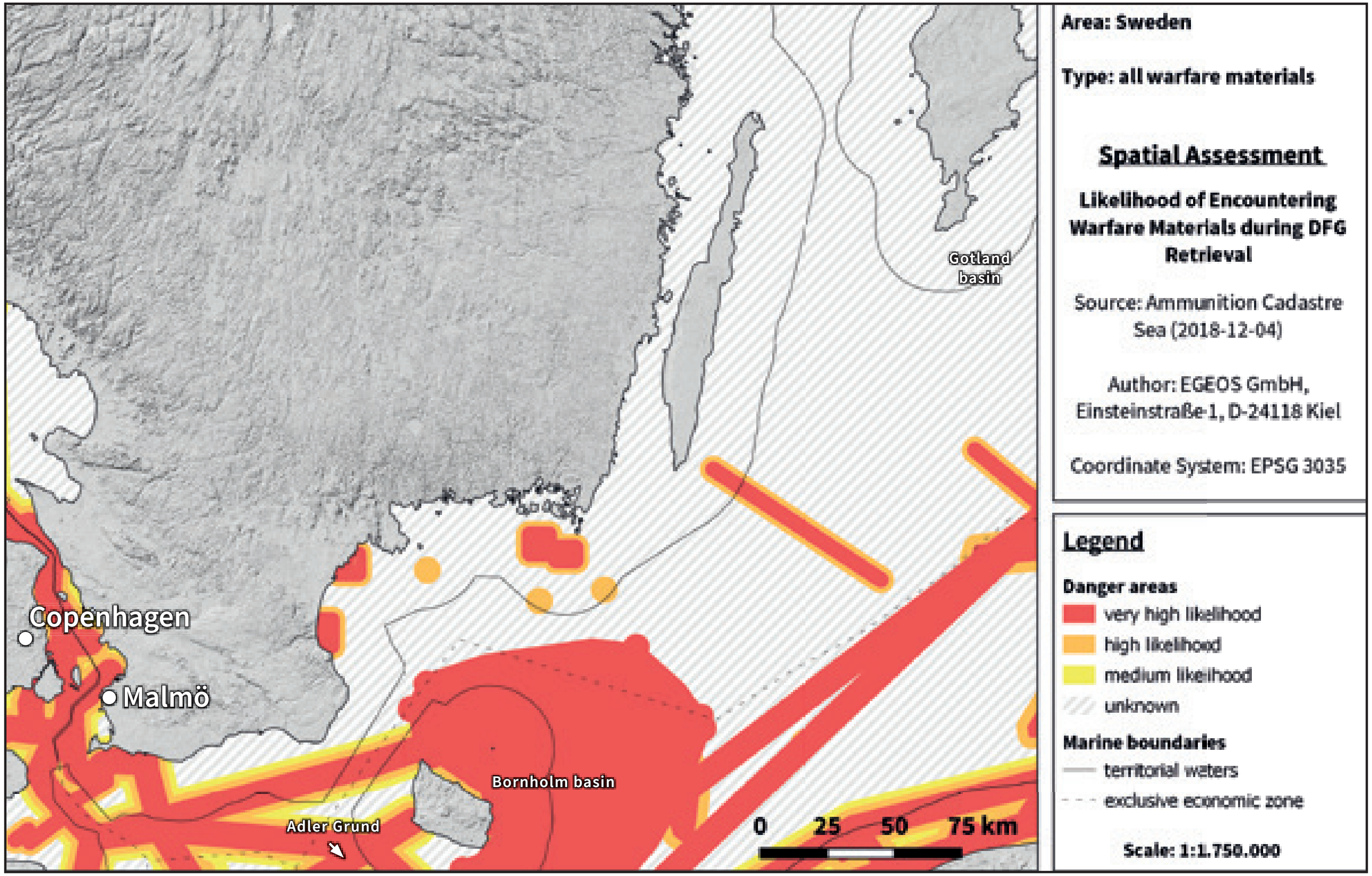
The following maps show all types of warfare materials from a single aggregated dataset. The classifications Chemical, Large and Various are shown in supplementation to All. The classifications represent contamination with chemical warfare materials, such as containers, artillery shells, reported incidents with large warfare materials like mines, large artillery shells, bombs: with various small calibre and unspecified warfare materials, including small artillery shells, grenades, ammunition, guns; the last category being a summary of the prior respectively.

MARELITT BALTIC RISKS: ESTONIA – ALL WARFARE MATERIALS




Flensburger Förde
Kiel
Adler Grund
0 25 50 75 km
Area: Germany
Type: all warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.500.000


Bornholm basin
Adler Grund
Gdańsk Bay
Gdańsk
0 25 50 75 km
Area: Poland
Type: all warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000


Gotland basin
Copenhagen
Malmö
Bornholm basin
Adler Grund
0 25 50 75 km
Area: Sweden
Type: all warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000

2.3.4 Likelihood of Encountering Chemical Warfare Materials

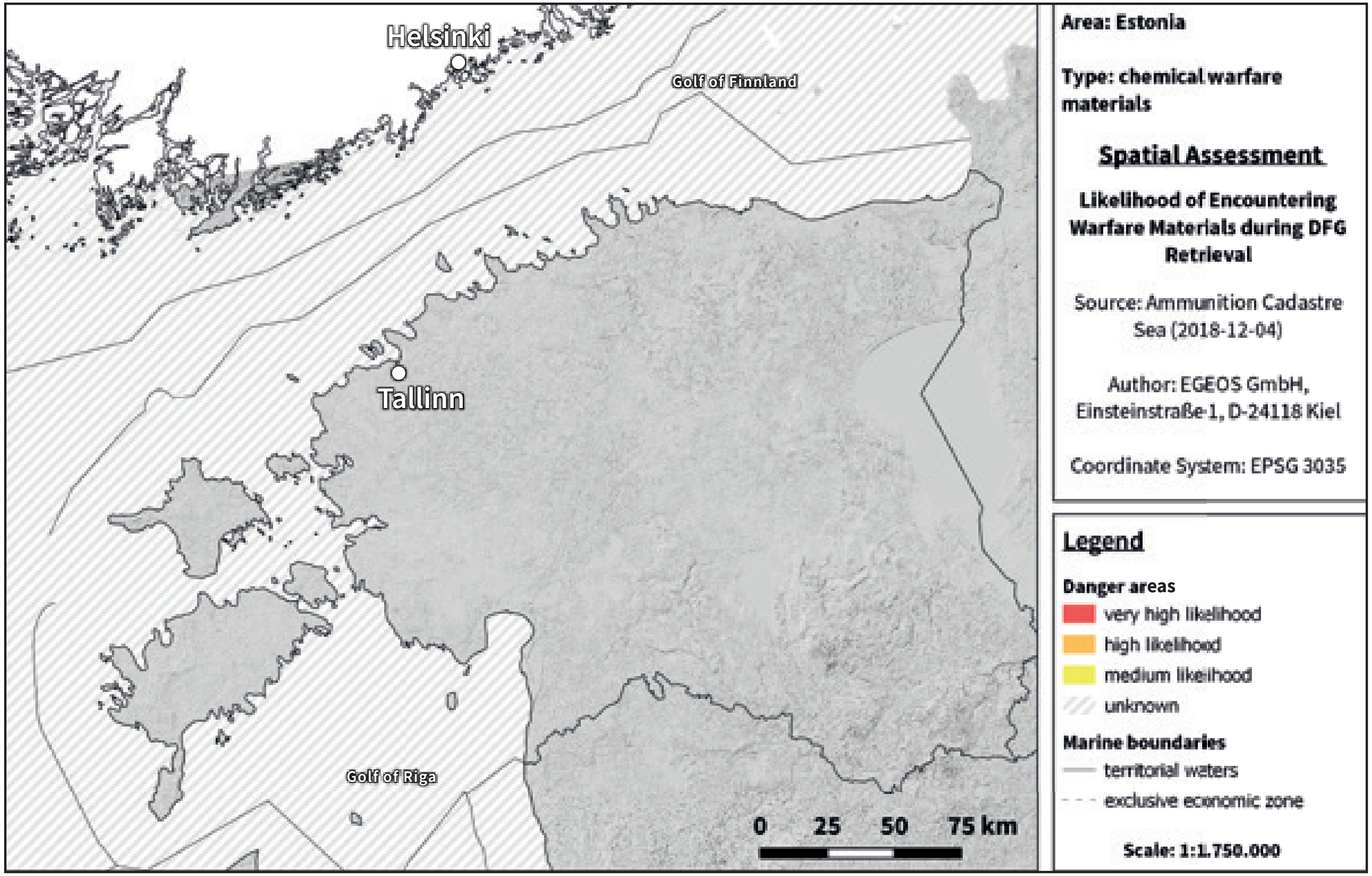
Chemical warfare agents were dumped into the Baltic Sea during and after the Second World War. The disposal of chemical warfare agents at sea was chosen based on strategic considerations during wartime, but mostly after the war as a cheap alternative to land-based neutralisation procedures. The dumping sites, as they are known today, have been chosen not only based on physical constraints, but mostly because of financial and political considerations, culminating into a diverse set of characteristics for those dumping sites. Designated dumping sites were chosen mostly based on depth and other physical parameters. However, so-called en route dumping also took place, causing a contamination of broad corridors with warfare materials along the routes. In other cases, chemical warfare agents were dumped into nearby depressions of larger harbours (e.g., Flensburg, Germany).

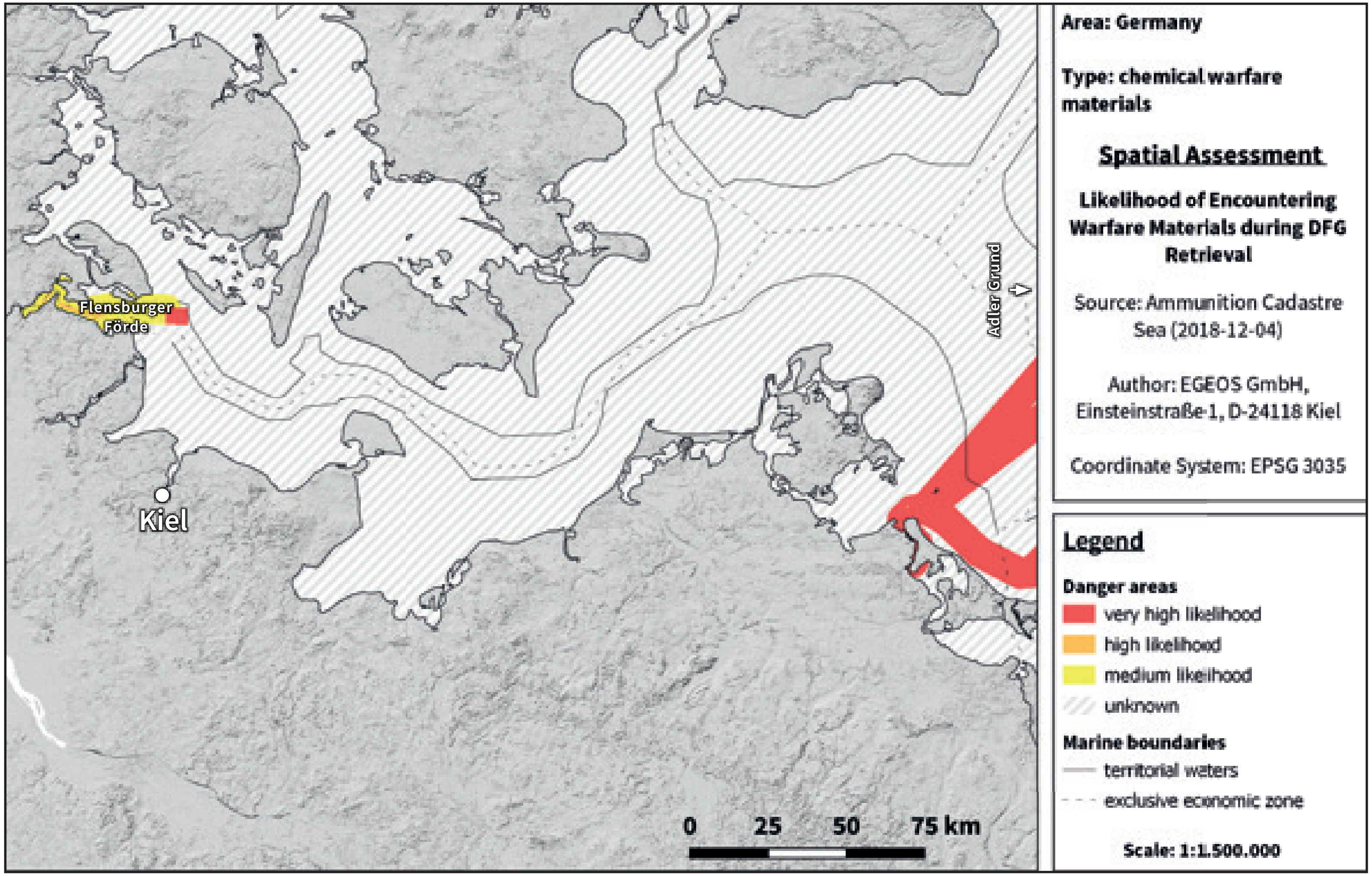
Dumpsites with chemical warfare agents known to date are within the Bornholm Basin, in the Gotland Deep, at the Adlergrund, in an area south of the Little Belt, and within the Gdansk Deep (p. 45 ff). Additionally, the official and unofficial routes to the previously mentioned dumping sites are likely to be polluted as a consequence of en route dumping. Of these dumping sites, the three major ones are the Bornholm Basin, the Gotland Deep and the dumping site south of the Little Belt. Considering all known dumping sites, the largest amounts of chemical warfare materials were dumped within the Bornholm Basin. At present, in the extended Bornholm Basin dumping site a total amount of warfare materials of over 32,000 tonnes is expected, with approximately 11,000 tonnes of chemical warfare agent payload and the depth ranges from 70 to 105m on an area of 67,260ha.[1]

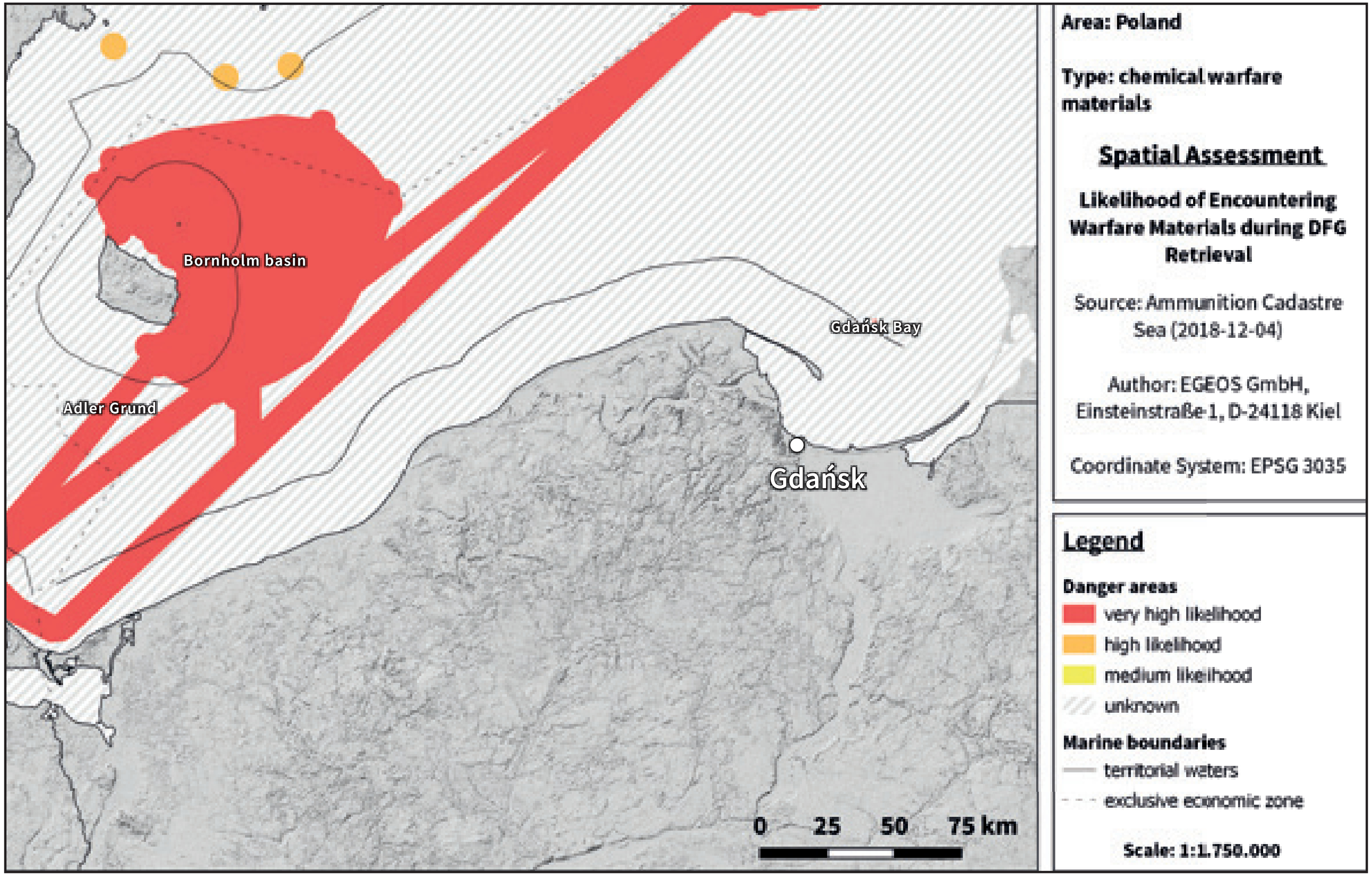
The second largest dumping site south of the Little Belt with depth of 25 to 31m, contains approximately 5,000 tonnes of warfare materials, including 2,000 tonnes of chemical warfare agent payload on an area of 4,180ha.[1] The next, the Gotland Deep with depths ranging from 93m to over 120m is the deepest dumping site, with approximately 2,000 tonnes of warfare material, including 1,000 tonnes of payload in the form of chemical warfare agents[1], although experts suspect that the total amount of dumped chemical warfare materials within the Gotland Deep is as high as 5,000 tonnes.[U. Wichert, personal communication] With an area of 141,610ha, the Gotland Deep is the largest but most sparsely contaminated area; nonetheless, the warfare materials are quite evenly distributed.[1] The remaining two dumping sites are considered minor, with approximately 60 tonnes scuttled on five to six ships in the Adlergrund – which has depths between 5 and 40m and no designated restricted area in sea charts – and 60 tonnes in the Gdansk Deep, within an explosives dumping ground of 100ha and depths from 80 to 110m.

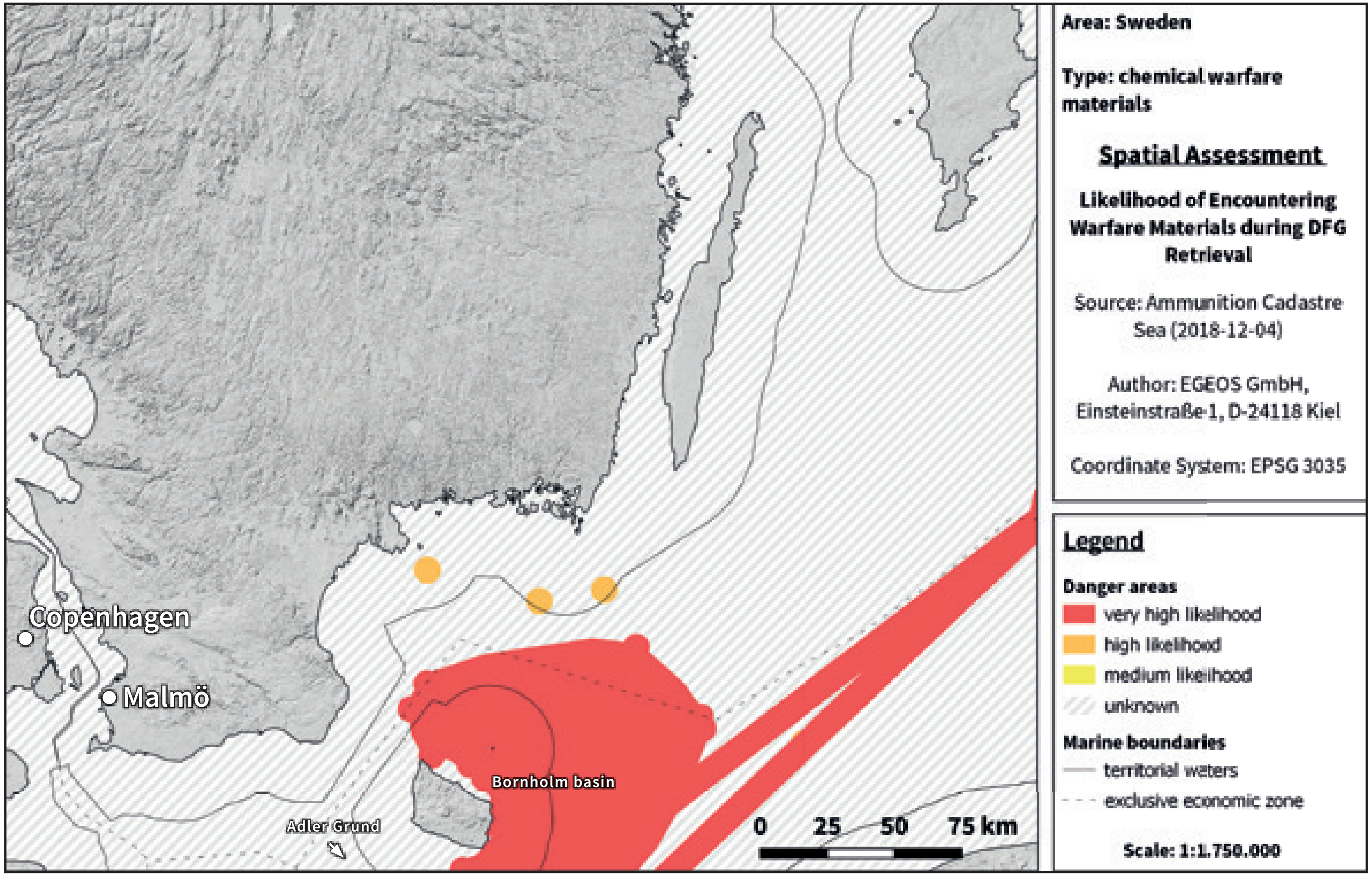
The practice of en route dumping further adds to the pollution with chemical warfare agents outside of the designated dumpsites. Areas likely to be polluted by en route dumping are the shipping routes between certain ports, mostly Wolgast and Flensburg, and the corresponding dumpsites.

Regardless of the areas marked on official sea charts, it is well established that human activities, mostly fishing with bottom-touching gear, and natural processes such as ocean currents, have already led to displacements, and will continue displacing warfare materials. Highest risk areas here are obviously adjacent to dumping sites; however, fishing activities are well capable of large distance displacements, resulting in extended risk areas surrounding restricted areas marked on sea charts, with the likely tendency to spread chemical warfare agents into adjacent fishing grounds.


Helsinki
Golf of Finnland
Tallinn
Golf of Riga
0 25 50 75 km
Area: Estonia
Type: chemical warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000

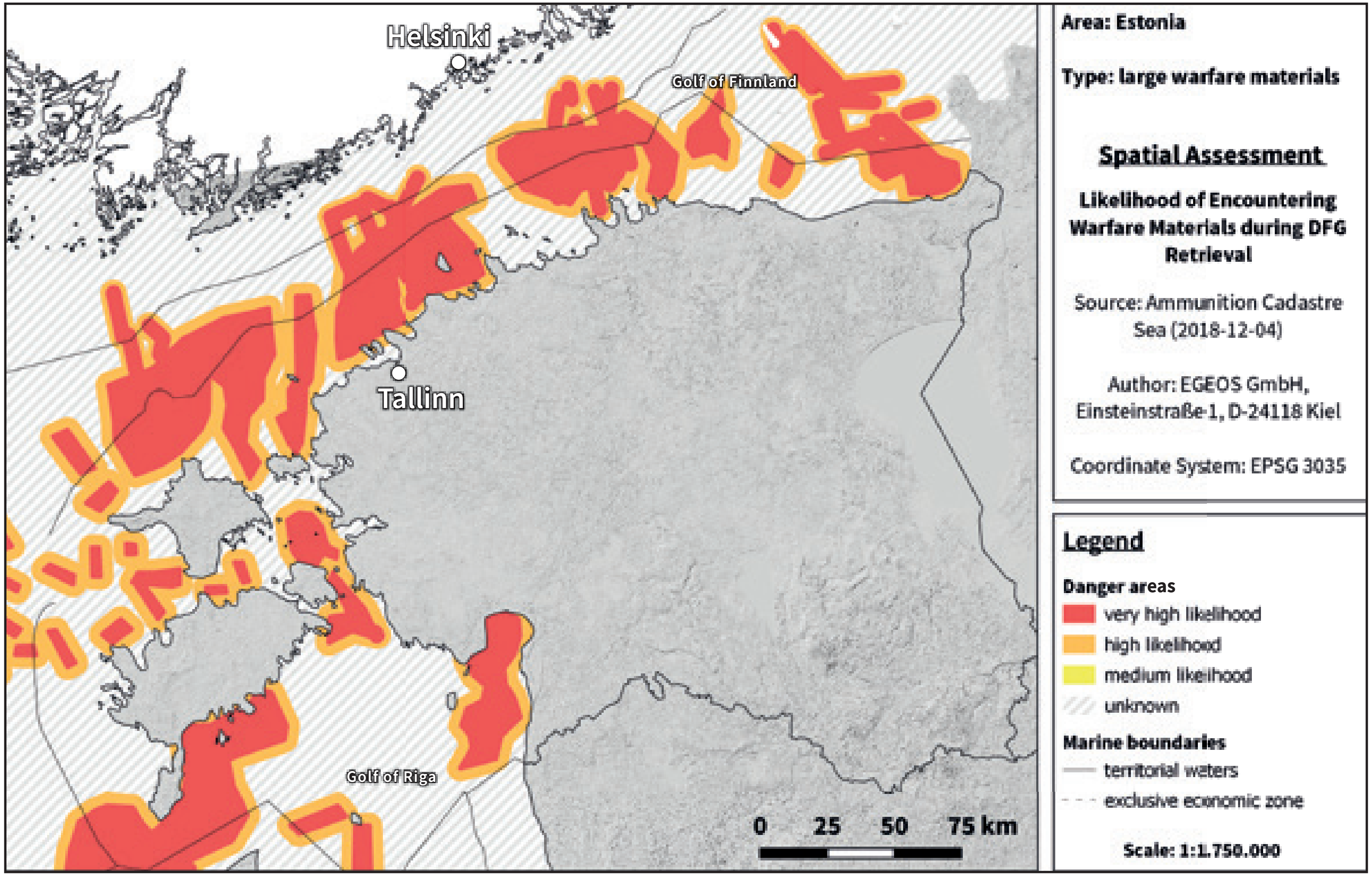

Flensburger Förde
Kiel
Adler Grund
0 25 50 75 km
Area: Germany
Type: chemical warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.500.000

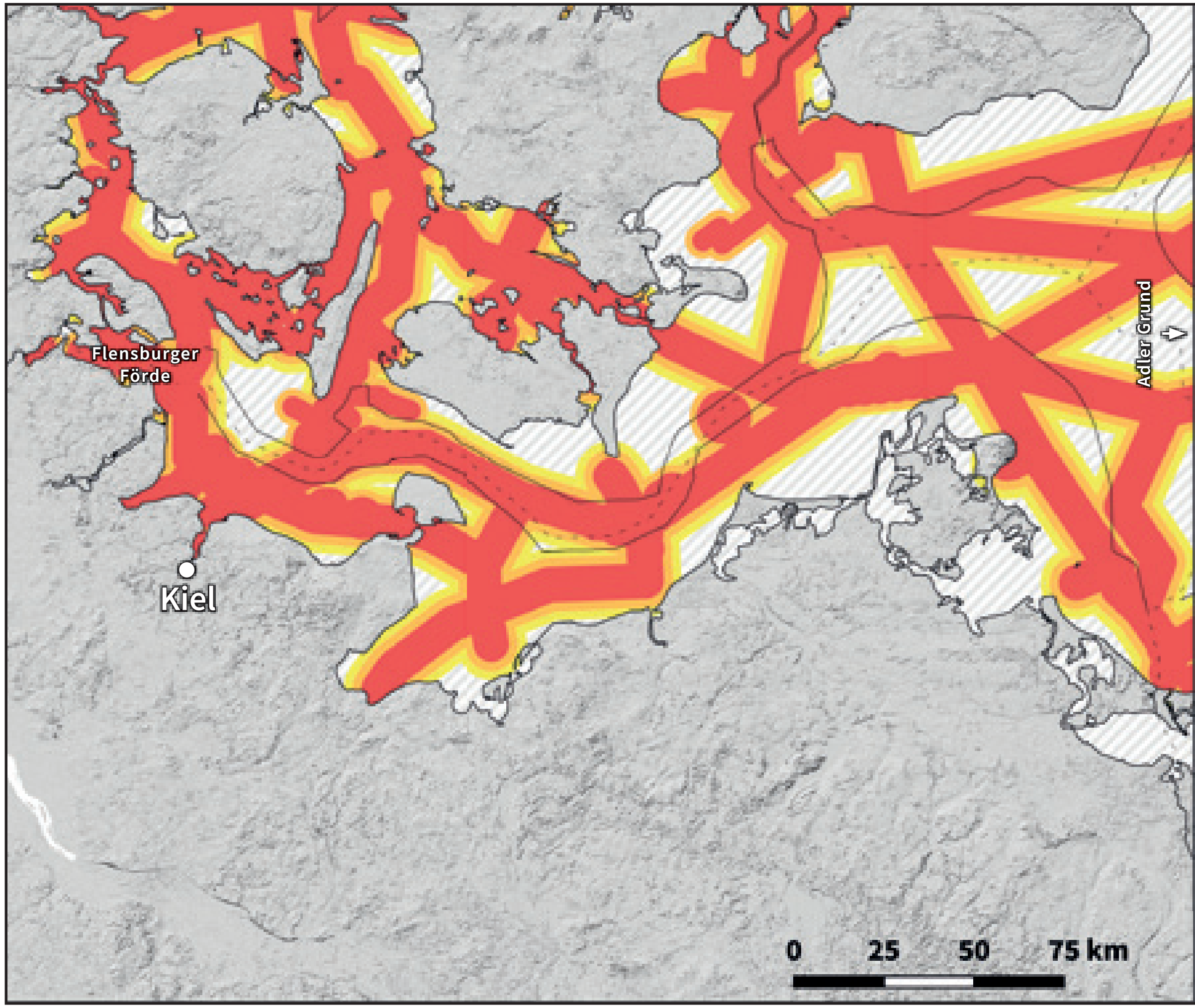

Bornholm basin
Adler Grund
Gdańsk Bay
Gdańsk
0 25 50 75 km
Area: Poland
Type: chemical warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000


Copenhagen
Malmö
Bornholm basin
Adler Grund
0 25 50 75 km
Area: Sweden
Type: chemical warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000

2.3.5 Likelihood of Encountering Large Conventional Warfare Materials

Risk areas of large conventional warfare materials are mostly related to information about mines (barriers and so-called gardenings) as well as bombings. These areas do not exclude other munitions types, but the probability to encounter larger conventional warfare materials is relatively high compared to other risk areas. Due to the size of objects high-resolution side-scan sonar measurements are the recommended way of minimising risks.


Helsinki
Golf of Finnland
Tallinn
Golf of Riga
0 25 50 75 km
Area: Estonia
Type: large warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000



Area: Germany

Type: large warfare materials

Spatial Assessment

Likelihood of Encountering Warfare Materials during DFG Retrieval

Source: Ammunition Cadastre Sea (2018-12-04)

Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel

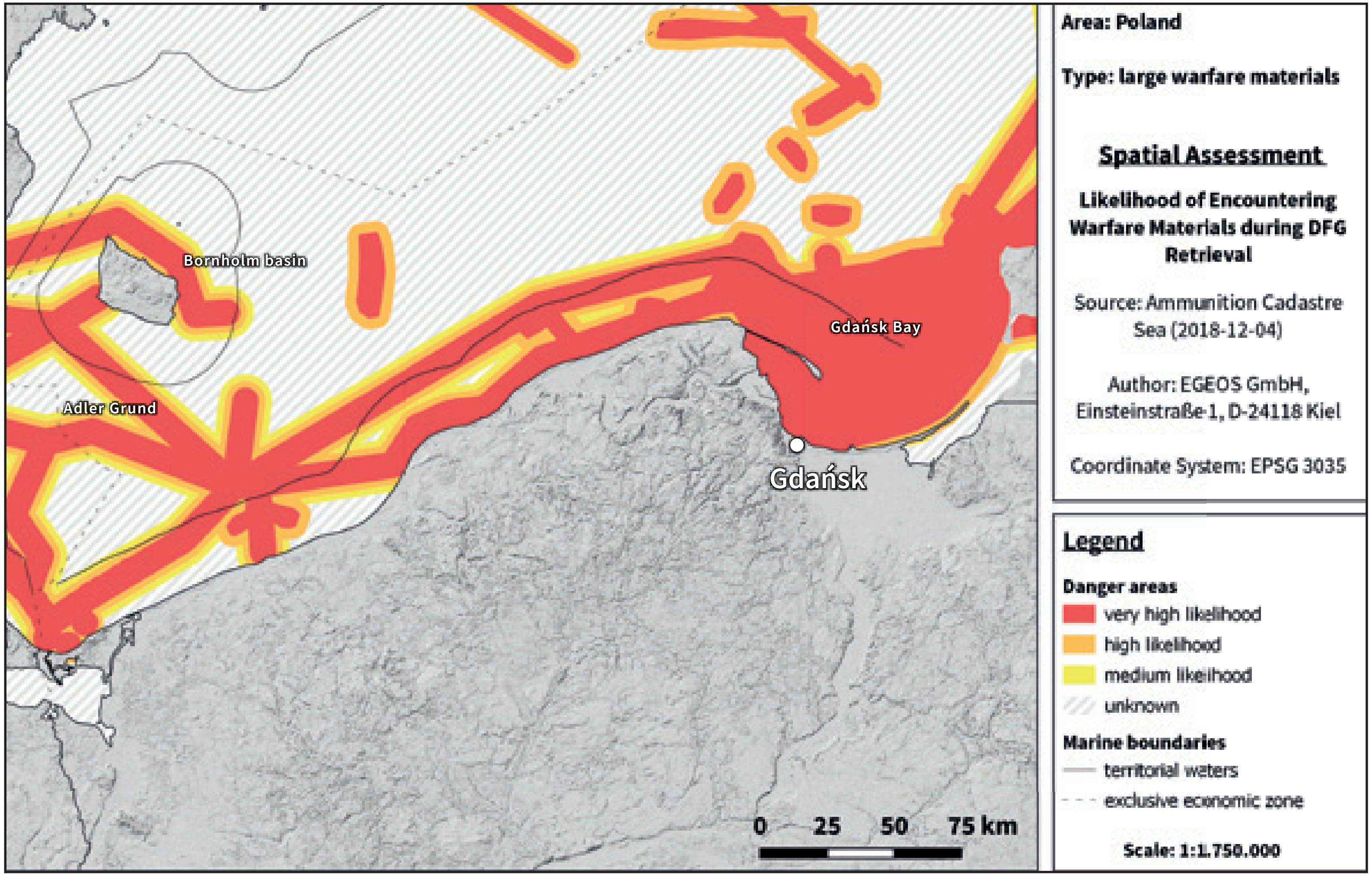
Coordinate System: EPSG 3035

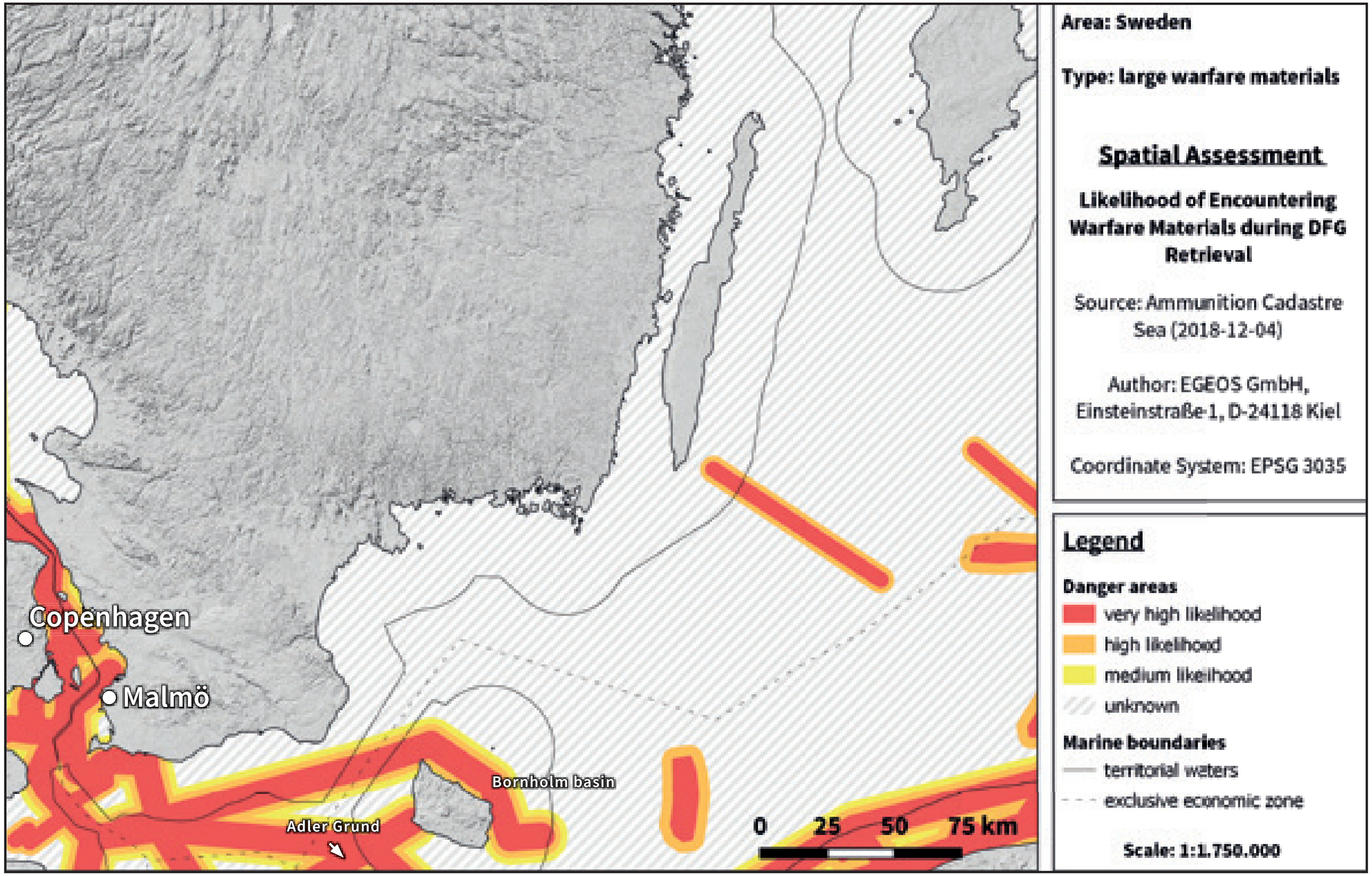
Legend

Danger areas
- very high likelihood
- high likelihood
- medium likelihood
- unknown

Marine boundaries
- territorial waters
- exclusive economic zone

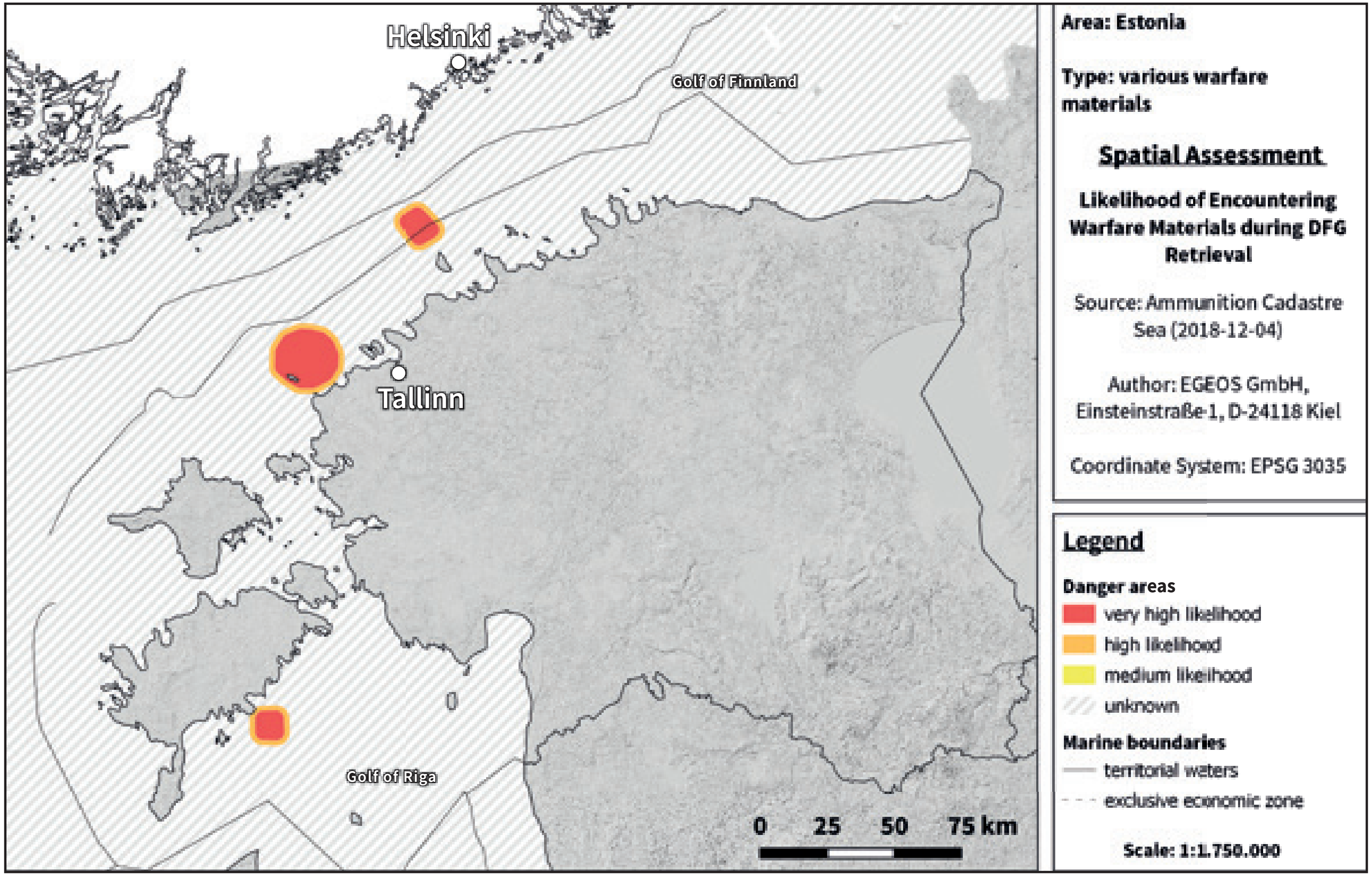
Scale: 1:1.500.000

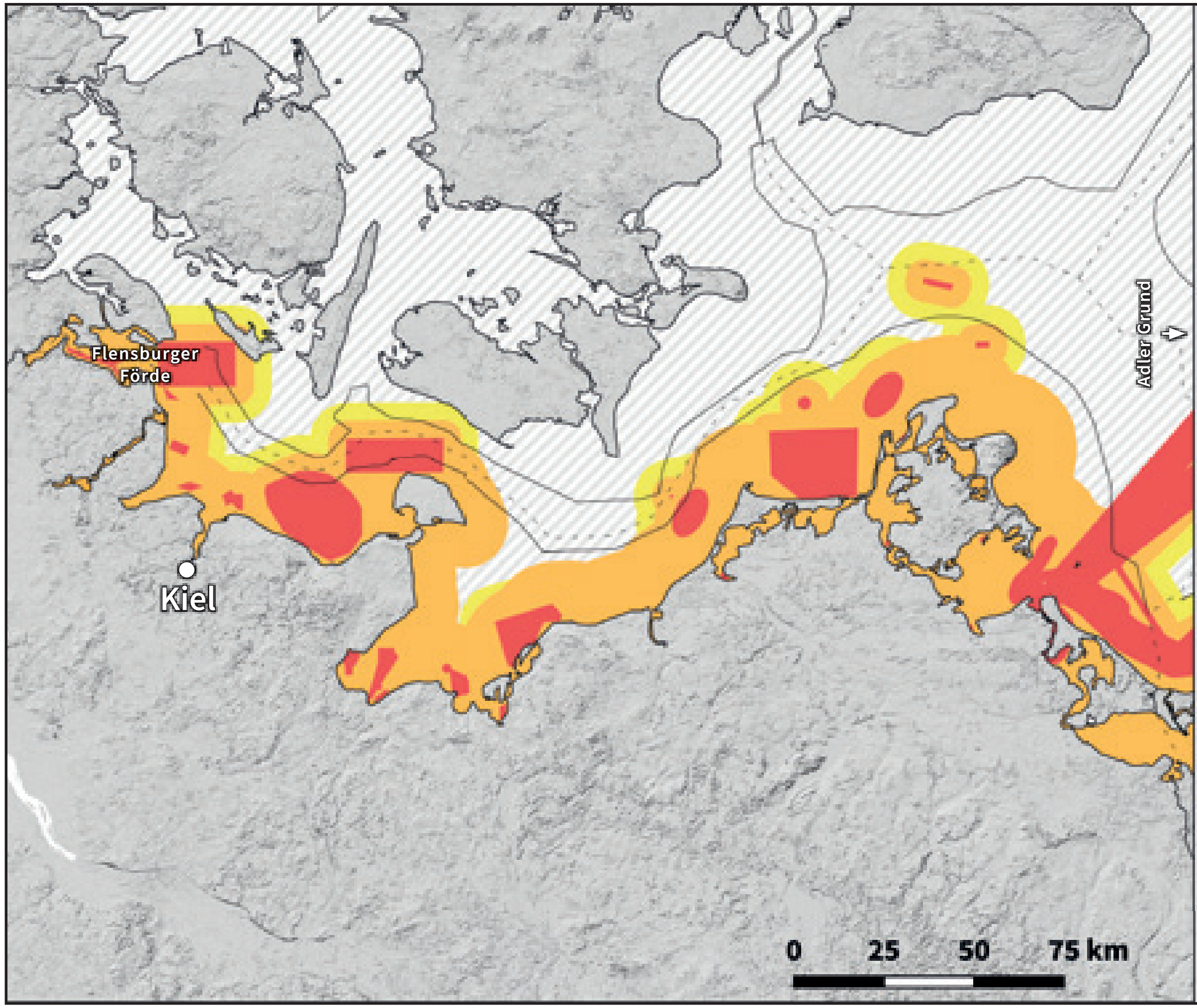

Bornholm basin
Adler Grund
Gdańsk Bay
Gdańsk
0 25 50 75 km
Area: Poland
Type: large warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000


Area: Sweden
Type: large warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000
Copenhagen
Malmö
Bornholm basin
Adler Grund
0 25 50 75 km

2.3.6 Likelihood of Encountering Various Conventional Warfare Materials

Risk areas of various conventional warfare materials are the result of different kinds of actions happened during and after WWI and WWII including e.g. dumping actions, mili-tary exercise areas and so on.


Helsinki
Golf of Finnland
Tallinn
Golf of Riga
0 25 50 75 km
Area: Estonia
Type: various warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000



Area: Germany

Type: various warfare materials

Spatial Assessment

Likelihood of Encountering Warfare Materials during DFG Retrieval

Source: Ammunition Cadastre Sea (2018-12-04)

Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel

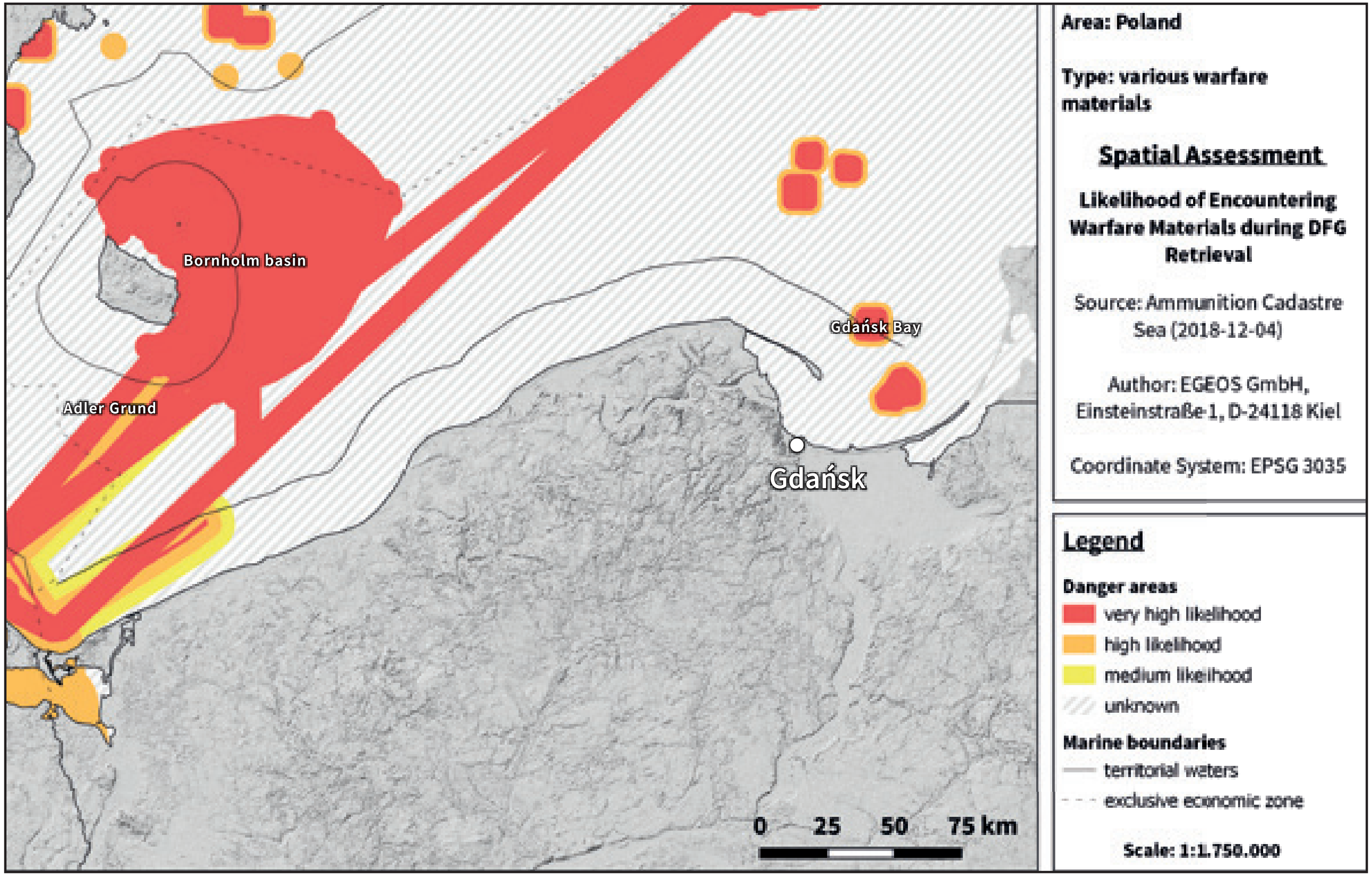
Coordinate System: EPSG 3035

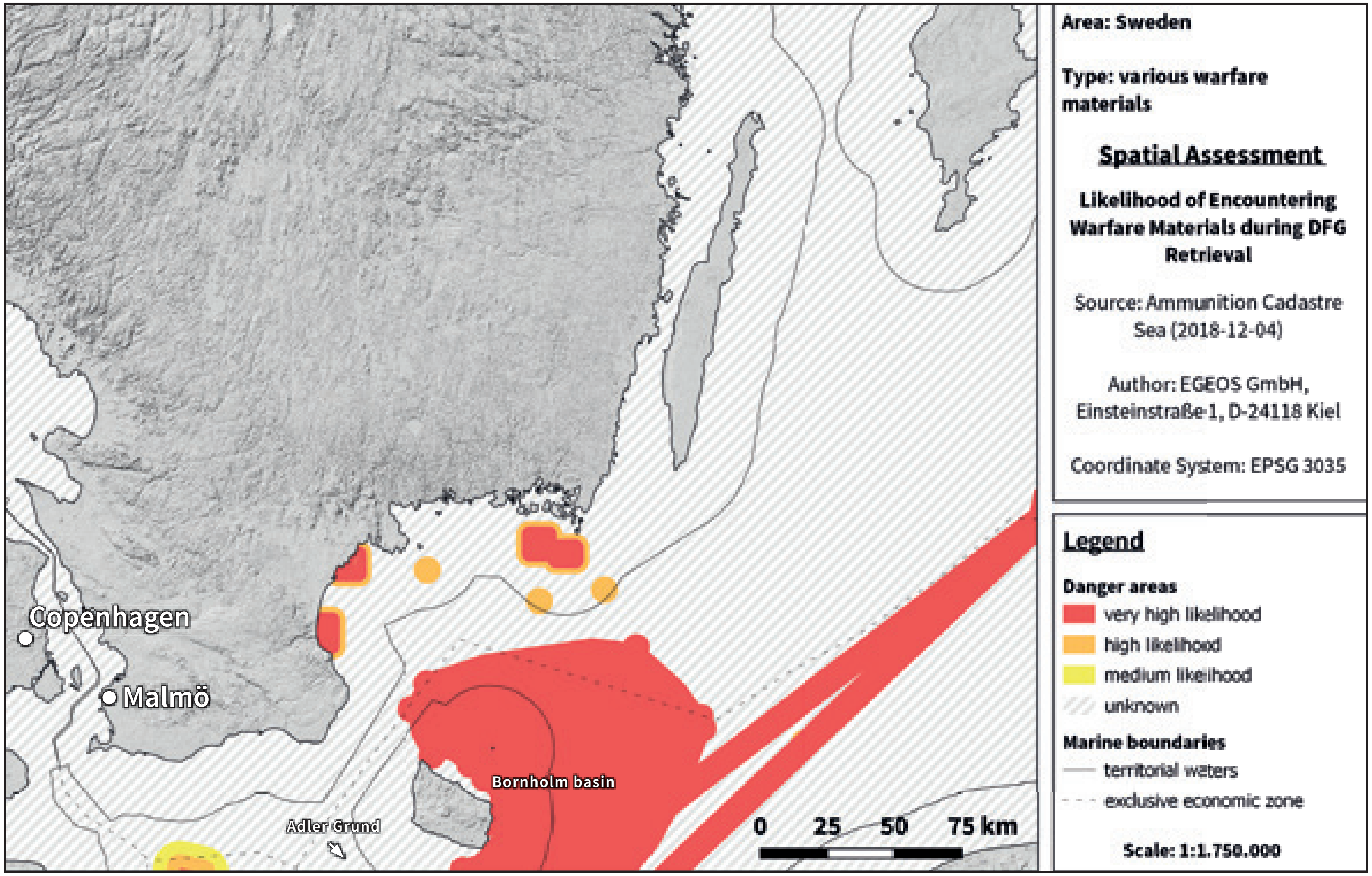
Legend

Danger areas
- very high likelihood
- high likelihood
- medium likelihood
- unknown

Marine boundaries
- territorial waters
- exclusive economic zone

Scale: 1:1.500.000


Bornholm basin
Adler Grund
Gdańsk Bay
Gdańsk
0 25 50 75 km
Area: Poland
Type: various warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000


Copenhagen
Malmö
Bornholm basin
Adler Grund
0 25 50 75 km
Area: Sweden
Type: various warfare materials
Spatial Assessment
Likelihood of Encountering Warfare Materials during DFG Retrieval
Source: Ammunition Cadastre Sea (2018-12-04)
Author: EGEOS GmbH, Einsteinstraße 1, D-24118 Kiel
Coordinate System: EPSG 3035
Legend
Danger areas
very high likelihood
high likelihood
medium likelihood
unknown
Marine boundaries
territorial waters
exclusive economic zone
Scale: 1:1.750.000

2.4 Recommendations and Risk Assessment

The Baltic Sea contains many areas known to be contaminated by some type of warfare material. Governments often restrict legal activities within those areas. The designation of the restricted areas and determination of their dimensions are usually defined depending on the severity of the contamination and regional or national legislation. Outside of officially restricted areas, there are many more areas known or presumed to be contaminated with unknown amounts of warfare materials that should not be assumed negligible, like shipping routes towards dumping sites of the post war period.

On international and national levels, many projects, such as for example the international cooperation HELCOM, attempt to aggregate as much information as possible to improve safety for maritime industries, off-shore infrastructure projects and leisure activities. Within the private sector, efforts are taken to support the national and international collaborations, as for example the Ammunition Cadastre Sea (amucad.org) project of EGEOS GmbH. The AmuCad project aims to combine information from various projects and databases to improve safety of citizens, support infrastructure projects and monitor environmental conditions.

Since health risks associated with warfare materials in general and explosives and chemical warfare agents in particular are extreme and death a likely outcome of an incident, avoiding warfare materials should be a priority during the retrieval of derelict fishing gear.

In the following, the overall likelihood to encounter warfare materials is summarised and recommendations are given towards mitigation measures. Then, individual risks for the different modes of derelict fishing gear retrieval are discussed. Finally, the inherent risk of derelict fishing gear to be entangled with warfare materials is examined on a hypothetical basis. This part of the risk assessment is concerned with the risk to encounter any type of warfare materials given their spatial distribution. However, within this section, the high danger of warfare materials to the human health is pre-empted and clear warnings regarding possible encounters are indcluded.

CAUTION

Depending on the expected types of hazardous materials in the target area, the recovery technique should be adapted to lower the possibility of encounters and to further minimise risks.

2.4.1 Risks of Handling Explosives on Board

Ordnance with an armed fuse or a sensitive main charge (e.g., picric acid) shall not be recovered aboard a manned vessel unless an appropriate containment system is used to mitigate the risk to personnel (UNMAS, 2014). A general problem of the surfacing of munitions from deeper water levels is the sudden change of ambient pressure, which may lead to spontaneous detonation, or, for heavily corroded shells, to mechanical failure and leakage (Pfeiffer, 2012). The transport containers mentioned above address this problem. Another risk posed by the surfacing and transportation on ship and land is the drying of unexploded ordnance. Pfeiffer (2012) describes that the complex and often unclear chemical constitution of old munitions can potentially react when dried, therefore arguing for deliberate wet arrangements (Pfeiffer, 2012).

CAUTION

Normally, special legal permissions are necessary to be allowed to handle ammunition

2.4.1.1 Sedimentation and Moving Sediments

Sedimentation can cover warfare materials from sight. In some parts of the Baltic Sea, sedimentation is significant enough to cover warfare material. However, in most of the Baltic Sea, sedimentation rates are too low to bury objects to a depth where resurfacing becomes unlikely. Many objects will only be covered by thin layers of sediments – if at all. As a result, warfare materials, in areas with low sedimentation rates but dynamic sediment movements that are covered with sediments are often part of a cyclic process in which they get covered and uncovered through the current and wave dynamics that drive the sediment movements. Therefore, even when remote sensing data is available within an area of interest, but the data is out of date, objects might have reappeared from the sediments, or alternatively moved laterally into the area of interest.

The Baltic Sea is a dynamic system and will keep on changing over time; this especially applies to such persistent processes as sedimentation. Therefore, while planning retrieval activities of derelict fishing gear, it must be considered that – depending on the relative age of data used during the decision-making process – changes at the seafloor might have occurred.

2.4.1.2 Corrosion and Environmental Threats

Effects of corroding munitions are subject of current research in several national and international projects (e.g., CHEMSEA, UDEMM, DAIMON). First results of these projects show the environmental threat resulting from corroding munitions and release of contaminants. Due to the applied techniques in derelict fishing gear retrieval operations, especially area searches with hooks, the environmental impact could be substantially higher than previous studies have shown. The physical destruction of corroding objects and the resulting acceleration of release and wider spreading of contaminants could result in severe, negative impact on the environment.

CAUTION

Area searches with hooks could cause severe environmental issues due to physical destruction of ammunition hulls and spreading of contaminants.

2.4.2 Contaminated Areas

Conventional Warfare Materials

The risk from conventional munitions in the Baltic See is assumed omnipresent and precautions must be taken at all times. The likelihood of encounters is higher in areas of former dumping activities, areas that were of interest for mine barriers and in areas representing offshore battles.

Retrieval of derelict fishing gears is therefore more likely to lead to encounters with warfare materials when contaminated areas are approached. Nevertheless, warfare materials can be mobile, and knowledge is insufficient to pinpoint every source of warfare material in the Baltic Sea. Therefore, it is important to stress that potential encounters with chemical warfare agents and with conventional munitions in particular, cannot be ruled out, even outside of restricted and marked areas.

Chemical Warfare Agents

Most of the chemical warfare agents located within the Baltic Sea are concentrated within areas which are often restricted by the respective government. In summary three modes of contamination with chemical warfare agents are likely:

1. Dumping activities resulting in dumpsites,
2. En route dumping on the way to designated dumpsites,
3. Displacement through natural processes like ocean currents, but mostly through human activities in the form of fishing with bottom touching gear.

The first mode, namely dumping of chemical warfare agents, was the primary mode of chemical warfare agent disposal. As the psychological and physical effects have been considered the worst of all the warfare materials, the chemical warfare agents are mostly found within their respective dumping sites, which often coincide with specific restricted areas. However, lack of concern and economic interests, but natural processes as well, lead to dispersion of chemical warfare materials into the surroundings of those restricted areas. In addition, due to time pressure and again some lack of concern, en route dumping resulted in contamination along the former shipping routes to those areas. Further, additional areas are suspected to host chemical warfare agents which are not marked in sea charts as restricted, these might be single wrecks containing chemical warfare agents or the result of problematic information policies with former regimes.

The risks from chemical warfare agents to an untrained crew are generally assumed to be very high, therefore any actions within areas that are known to host chemical warfare agents are strongly discouraged.

If missions are planned in areas known to host chemical warfare agents, it is recommended to use specially prepared vessels with decontamination areas, protection suits and specifically trained crew members. Sufficient protective measures must be discussed with local authorities, including general mission clearance.

For all practical purposes, the restricted areas as marked on sea charts in the Bornholm Basin, south of the Little Belt, the Gotland Basin, the Gdansk Deep and the unrestricted area in the Adlergrund should be avoided. Since assessing appropriate safety distances to risk areas is not possible from the present data basis, general alertness is advised when within several tenth of kilometres to contaminated areas. High likelihood areas as marked on the provided maps (p. 45 ff) should always be avoided.

2.4.3 Modes of derelict fishing gear Retrievals

The two most common modes for derelict fishing gear retrieval (area search and targeted search) are explained in the following paragraphs.

Area Search

Area search, also called blind area search, is a method for derelict fishing gear retrieval for which hooks in various forms are deployed behind a vessel and are then dragged along the seafloor. The term blind in this context refers to the lack of monitoring of the hook during the mission. For area searches the risk to encounter any type of munitions is considered high within restricted zones. Moreover, munitions are likely to have spread outside of the restricted zones, especially for areas which have been subject to fishing. In addition, the practice of en route dumping poses a higher risk to encounter munitions on the designated paths towards dumping sites. While the risk of encountering chemical warfare agents is mostly dealt with when avoiding the restricted areas together with their surroundings and approach pathways, the risk to encounter conventional munitions is not. Conventional munitions has diverse access routes into the Baltic Sea, including testing areas, combat areas, ship-based and airborne mine deployments, resulting in large numbers of scattered explosives.

Targeted Search

For the approach of targeted searches with probing of the operation site with remote sensing and analysis prior to the deployment of divers, the risks to encounter munitions or chemical warfare agents is as high as for the area search. However, due to remote sensing analysis a mission can be planned accordingly in order to minimise the likelihood of direct contacts with munitions.

Nevertheless, extreme caution must be taken when probing areas possibly containing chemical warfare agents or small calibre conventional ammunition as both types are difficult or even impossible to detect with commonly used remote sensing methods, such as side-scan sonar. Furthermore, side-scan sonar may yield “fluffy” imagery when examining derelict fishing gear, thereby further impeding early detection and risk minimisation efforts. Therefore, even after careful analysis of remote sensing data, the probability of encountering warfare materials in derelict fishing gears cannot be assumed to be negligible. Within the free water column, some chemical warfare agents are not dangerous for divers, as the chemicals degrade within the water and pose no threat afterwards. Some chemical warfare agents, however, form lumps that are hazardous when touched. Therefore, divers should not touch any lumps on the seafloor or in derelict fishing gears when inside or nearby a former chemical warfare agent dumping site or along the respective routes to those grounds. The area south of the Little Belt and the Adlergrund are accessible even for recreational divers; technical divers may reach all areas where chemical warfare agents where dumped, depending on their equipment.

2.4.4 Inherent Risk of Derelict Fishing Gear Contamination with Warfare Materials

The detailed travel paths and behaviour of derelict fishing gear are not established. The same is true for the analysis of the likelihood of derelict fishing gear becomming entangled with warfare materials at the sea floor compared to free floating, free resting or entanglement on non-hazardous objects.

In general, it could be assumed that derelict fishing gear is more likely to contain warfare materials than just by chance given its current location. This conclusion is based on assumptions regarding the behaviour of derelict fishing gear in water. As derelict fishing gear are uncontrolled traps for marine life, warfare materials could be unintentionally captured as well. Larger warfare materials as sunken ships are obvious possibilities for aggregations of derelict fishing gear; however, mines and other smaller warfare materials might be similarly likely snagging points for nets.

Moreover, under the assumption that fishers detached nets when they discovered that they contained warfare materials, the likelihood to find warfare materials in derelict fishing gear is further increased.

A comparison to ordinary fishing activities might also be problematic, given that the fishing grounds are often the same for long periods of time and warfare materials in those areas might have been retrieved or displaced during regular fishing activities. Ghost nets, however, shift and move across the sea floor, gathering warfare materials even in regions that have been unaffected by open sea activities, such as fishing or infrastructure projects.

In conclusion, the retrieval of derelict fishing gear could be assumed inherent riskier than ordinary fishing, although this is based on assumptions which need more research.

2.4.5 Summary

Warfare materials are spread throughout most of the Baltic Sea

Conventional warfare materials are more wide spread compared to chemical warfare agents

Restricted areas often mark the most heavily contaminated regions within the Baltic Sea

- However, warfare materials also occur outside of these areas

Land-based anti-aircraft and artillery fire polluted coastal zones up to 20 km offshore

Battles further polluted areas with munitions

Mines deployed from ships, submarines and airplanes can be found across the Baltic Sea

- Notably, compulsory shipping lanes established during the war have been targeted

Risk Assessment

The risk to encounter warfare materials is omnipresent within the Baltic Sea

Within the known dumpsites, the risk to encounter warfare materials is highest

Compulsory shipping lanes are assumed to be contaminated with higher numbers of mines

Higher concentrations of munitions has to be expected near as well as in dumping sites and battle fields.

Former and current areas used for military drills exhibit large numbers of especially ammunition

Coastal areas in the vicinity of air defence, artillery and other strategic positions exhibit a massively increased munitions risk.

- This includes most coastlines

continues on next page

Recommendations

Avoid:

- Restricted areas
- Dumpsites and their surroundings
- Compulsory shipping lanes
- Coastal areas where anti-aircraft or artillery fire took place
- Former mine barriers
- Waters surrounding land positions which were bombarded

Use remote sensing as often as possible to detect warfare materials before any direct contact occurred

- Assume objects to be dangerous rather than harmless

3 Health Risks and Mitigation Measures

With explosive and chemical warfare materials, the Baltic Sea exhibits two extreme health hazards likely to be encountered while searching for derelict fishing gear. The potential health risks, originating from the warfare materials found submerged in the Baltic Sea, range from direct blast and projectile injuries to the various, often lethal effects of chemical warfare agents. Knowledge and protection regarding those hazards is paramount for the safety of all involved personnel.

According to reported incidents, fishermen have been the main groups affected by munitions (both conventional and chemical) since dumping activities were concluded in the immediate post-WWII period. The risk of coming into contact with the dangerous materials was seen, by the respective authorities, to be highest when fishing inside or near to the former dumping areas. For this reason, these sites are marked on the official sea charts together with additional information on where fishing activities, anchoring and extracting seabed materials is not advisable. However, due to the former practice of en route dumping and the ensuing relocation of sea-dumped materials, there is also a risk when fishing is carried out outside the marked dumpsites.[1]

In this context, the former practice of en route dumping is of special interest, since these chemical warfare materials pose a considerable risk – one that is difficult to assess due to the unknown locations outside the assigned dumping areas and because they were disposed of and scattered item-by-item. While the probability of trawling one of these objects is low, any such incident might have severe consequences due to the unexpected event and improper preparation.[1]

As conventional munition, both with and without chemical compounds, is present in vast areas of the Baltic Sea, permanent alertness is required to avoid irreversible damage to the health of the crew and other personnel. The range of extremely dangerous objects, which are scattered across the Baltic Sea, is broad, for example 2 cm anti-aircraft ammunition is potentially lethal to a crew member when exploding in close proximity. Other objects are even more dangerous as they are capable of sinking entire ships and likely injuring the whole crew, examples for this are drifting mines and bottom mines.

The second major health hazard submerged in the Baltic Sea is posed by chemical warfare agents like sulphur mustard, tabun and arsenic-containing substances designed to trigger severe biological effects in very small doses. All the chemical warfare agents are extremely toxic to humans. In many cases, the degradation products also show some degree of toxicity. However, chemical warfare agents are mostly restricted to known dumping sites and the shipping routes to those locations. The risk of an encounter can therefore be minimised, although displacement of warfare materials through either natural processes (e.g., storms in shallow waters) or by human activities (e.g., bottom trawling), needs to be taken into account.

3.1 Health Risks for Divers and Retrieval Teams

In the Baltic Sea, it must be assumed that each object entangled in a derelict fishing gear or found on the sea floor is a serious threat to human health. Unless clearly identified as harmless, any contact should be avoided.

3.1.1 Small Ammunition

Ammunition ranges from 2 cm shells up to bomb-sized grenades. While the extreme danger of the large ammunition calibres is obvious to most people, the potentially lethal outcome of incidents with small ammunition is sometimes relativised when comparisons are made. However, small ammunition like the 2 cm anti-aircraft shell can be lethal for a person nearby if it explodes. The two major threats here are the explosion itself, capable of rupturing body parts, and, secondly, accelerated metal shrapnel, which easily penetrates the human body.

The utmost care must be taken to carefully handle small lump or stone-like objects which are found on board, since small ammunition is difficult to spot or identify, with remote sensing or even on-board. The difficulty in identifying small ammunition is based not only on its size but also on the effects of corrosion and biota growth on those objects; the latter two can render a potentially lethal warfare object visually unidentifiable.

3.1.2 Explosives

Fully functional explosives are spread throughout the Baltic Sea, ranging from anti-aircraft ammunition to drifting mines. For a human being every one of those can lead to extreme harm whilst the largest are capable of the destruction of ships, the smallest shells might still be lethal when exploding in relative proximity.

Explosions might cause injuries in multiple ways, there are the direct injuries through over-pressure, which are particularly problematic for air and fluid-filled organs. Injuries caused by projectiles accelerated through the explosion, including shrapnel of the exploding munitions, also cause severe, potentially lethal injuries.

In the water, the relative danger of shrapnel might be smaller; albeit, overpressure becomes a major threat. Therefore, for divers the risk of explosions is higher when underwater, as pressure waves from the explosions can lead to severe injuries up to death. The safe distance from a detonation, based on lethal or severe damage, is 4.3 km for divers and 1.7 km for swimmers.[10]

3.1.2.1 Classification of Blast Injuries

Blast injuries are subdivided into four categories: primary, secondary, tertiary and quaternary or miscellaneous blast-related injuries.

Primary Blast Injuries

Occur as a result of direct effect on the tissue of the blast overpressure

Organs that are particularly vulnerable to these kinds of injuries are air-filled organs, such as the lungs, ear, and gastrointestinal tract, and fluid-filled cavities, such as brain and spinal cord

Secondary Blast Injuries

Occur as a result of people getting hit by debris that is directly displaced by the waves of blast pressure

Causes combination of blunt and penetrating trauma injuries

Tertiary Blast Injuries

Occur as a result of high-energy explosions

Causes people to fly through the air and hit other objects

Quaternary or Miscellaneous Blast-Related Injuries

Injuries that are caused by explosions

Such as fire, building collapse, burns, exposure to toxic substances (e.g., carbon monoxide poisoning, cyanide poisoning, radiation), asphyxia and psychological trauma

[www.cprandaed.ca/first-aid-management-blast-injuries]

3.1.3 Chemicals from Conventional Munition

The shells and containers surrounding the explosive charges found in the Baltic Sea are corroding at various rates. Depending on the degree of corrosion, chemicals might have escaped their respective containers and are now found openly on the seafloor. Furthermore, mine and bomb clearance often means sinking or blasting the objects. Especially an incomplete blasting of bombs is likely to spread the contained explosive chemical component on the sea floor.

Typically, the flammable chemical "white phosphorus" was used for tracer ammunition as well as incendiary compound. The second main chemical of conventional munitions is the explosive trinitrotoluene, which is a toxic substance that might detonate under pressure or when heated. In general, trinitrotoluene is relatively stable; nevertheless, the effects of the extended times submerged are believed to cause relative instability, increasing the risk of non-typical combustion or explosion.

3.1.3.1 White Phosphorus

White phosphorus, used as an incendiary agent, is likely to self-ignite when dry and in contact with air. This can lead to fire on the mission vessel or, if kept by a crew member, to severe burns.

White phosphorus is a translucent waxy solid that quickly becomes yellow when exposed to light. For this reason, it is also called yellow phosphorus. It glows greenish in the dark (when exposed to oxygen) and is highly flammable and pyrophoric (self-igniting) upon contact with air.[4]

The smell of the fumes of white phosphorus is pungent and reminds of garlic. Furthermore, white phosphorus closely resembles amber in its appearance.[J. Euting, Bachelor thesis]

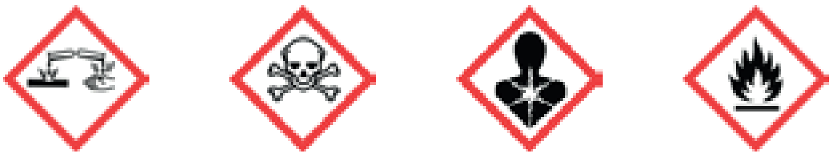


Figure from left to right: GHS labels for white phosphorus, GHS stands for Globally Harmonized System of Classification and Labelling of Chemicals: GHS05-Corrosives; GHS06-Acute Toxicity; GHS08-Health Hazard, carcinogen, mutagenicity, reproductive toxicity, target organ toxicity, aspiration hazard; GHS02-Flammables.

3.1.3.2 Trinitrotoluene

Trinitrotoluene, commonly known as TNT, is the most abundant explosive chemical in munitions found in the Baltic Sea.

Trinitrotoluene has many symptoms as it accumulates within the body. Symptoms of expo-sure to this compound may include headache, weakness, anemia, toxic hepatitis, cyanosis, dermatitis, jaundice, purpura, liver injury, conjunctivitis, irritation of the respiratory tract, constriction in the chest, lack of appetite, nausea, vomiting, diarrhea, petechial hemorrhages in the skin, oliguria, albuminuria, casts in urine, papular dermatitis, and yellow-orange discoloration of the hands, nails, face and hair.[5]

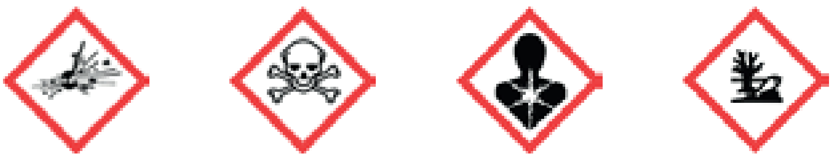


Figure from left to right: GHS labels for trinitrotoluene: GHS01-Explosives; GHS06-Acute Toxicity; GHS08-Health Hazard, carcinogen, mutagenicity, reproductive toxicity, target organ toxicity, aspiration hazard; GHS09-Environment, aquatic toxicity.

3.1.4 Chemical Warfare Agents

The chemical warfare agents in the Baltic Sea range from strong skin irritants to potent nerve agents, capable to cause rapid death.

The different types of chemical warfare agents dumped into the Baltic Sea are presented in section 2, in the following the health hazards of those chemical warfare agents, from the categories of vesicants (blister agents), irritants (nose and throat agents, vomiting agents), lachrymators (tear gases, riot control agents), lung agents, nerve agents and blood agents, are discussed.

Note that for lethal dosages the following measures are used: firstly, the median lethal dose in milligram of chemical per kilogram of body mass (mg/kg) and secondly, the median lethal dosage from exposure in milligram of chemical per cubic meter of exposed body volume times the time of exposure in minutes (mg min./m3). The median is the middle value of a sorted list of values and often represents a robust measure for a “typical” value. Moreover, in some cases only the amount of chemical is provided (mg) which must be seen relative to the body mass. For gases the concentration is given in parts per million (ppm) in the air and then related to the time of exposure.

3.1.4.1 Sulphur Mustard

Acute effects of sulphur mustard include severe blistering of the skin, the delayed effects after exposure include cancer.[1] In addition, sulphur mustard is extremely toxic and may damage the eyes, skin, and respiratory tract and suppress the immune system. Although sulphur mustard causes cellular changes within minutes of contact, the onset of pain and other symptoms is delayed. Thus, patients/victims arriving immediately from the scene of sulphur mustard exposure are not likely to have signs and symptoms. The sooner after exposure that symptoms occur, the more likely they are to progress and become severe.[2]

The smell of the fumes of sulphur mustard reminds of mustard or garlic. Furthermore, sulphur mustard is capable of penetrating rubber, leather and some plastic materials.[J. Euting, Bachelor thesis]

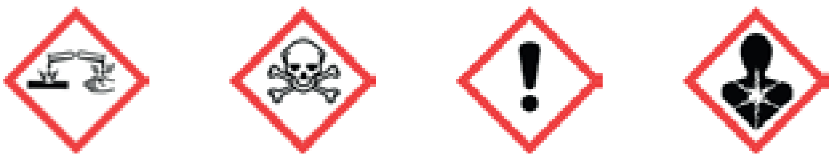


Figure from left to right: GHS labels for sulphur mustard: GHS05-Corrosives; GHS06-Acute Toxicity; GHS07-Irritant; GHS08-Health Hazard, carcinogen, mutagenicity, reproductive toxicity, target organ toxicity, aspiration hazard.

3.1.4.2 Nitrogen Mustard

Toxic doses as low as 400 mg/kg have been reported in humans. Blood clots may occur at site of intravenous injection and tissue damage if outside vein. Powerful vesicant (causes blisters) when it contacts skin, mucous membranes, or eyes. Delayed toxicity – missed menstrual periods, alopecia (hair loss), hearing loss, tinnitus (ringing in ears), jaundice, impaired spermatogenesis and germinal aplasia, swelling, and hypersensitivity. May damage foetus in pregnant women. (EPA, 1998) [2]

The smell of the fumes of nitrogen mustard reminds of mustard or garlic. Furthermore, nitrogen mustard is capable of penetrating rubber, leather and some plastic materials. [J. Euting, Bachelor thesis]

Figure from left to right: GHS labels for nitrogen mustard: GHS05-Corrosives; GHS06-Acute Toxicity; GHS08-Health Hazard, carcinogen, mutagenicity, reproductive toxicity, target organ toxicity, aspiration hazard.

3.1.4.3 Lewisite

Highly toxic by all routes of exposure. Lethal dose in humans is 6ppm (inhalation), 20 mg/kg (skin). Eye injury below 300 mg min./m3. It is a blister agent, cell irritant, and systemic poison. (EPA, 1998)

The smell of the fumes of lewisite reminds of geraniums. Furthermore, lewisite is capable of penetrating rubber, leather and some plastic materials.[J. Euting, Bachelor thesis]

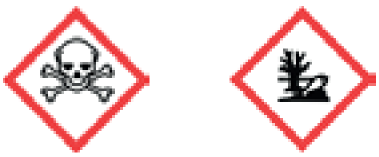


Figure from left to right: GHS labels for lewisite: GHS06-Acute Toxicity; GHS09-Environment, aquatic toxicity.

3.1.4.4 Adamsite

The effects of exposure to vomiting agents under usual outdoor conditions generally are self-limited, disappearing in 20 minutes to 2 hours, and require no specific therapy other than symptomatic relief. Exposure to large concentrations of Adamsite (also DM), or exposure to Adamsite within an enclosed space or under adverse weather conditions, may result in more severe adverse health effects, serious illness, or death and may require supportive measures for symptomatic complaints of eye, skin, and airway irritation.[2]

The smell of the fumes of Adamsite is pungent. [J. Euting, Bachelor thesis]

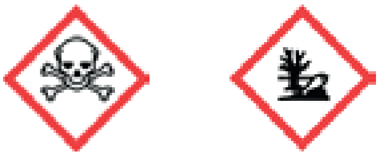


Figure from left to right: GHS labels for adamsite: GHS06-Acute Toxicity; GHS09-Environment, aquatic toxicity.

3.1.4.5 Clark I

Highly toxic, may be fatal if inhaled, swallowed or absorbed through skin. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution. (ERG, 2016) [2]

The smell of the fumes of Clark's may remind one of garlic; however, some are odor-less. [J. Euting, Bachelor thesis]

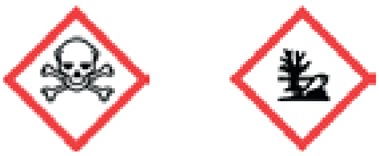


Figure from left to right: GHS labels for Clark 1: GHS06-Acute Toxicity; GHS09-Environment, aquatic toxicity.

3.1.4.6 *Clark II*

TOXIC, inhalation, ingestion or skin contact with material may cause severe injury or death. Contact with molten substance may cause severe burns to skin and eyes. Avoid any skin contact. Effects of contact or inhalation may be delayed. Fire may produce irritating, corrosive and/or toxic gases. Runoff from fire control or dilution water may be corrosive and/or toxic and cause pollution. (ERG, 2016) [2]

The smell of the fumes of Clark's may remind of garlic; however, some are odor-less. [J. Euting, Bachelor thesis]

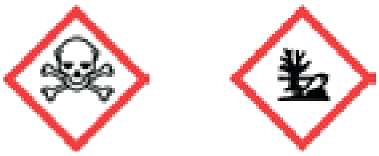


Figure from left to right: GHS labels for Clark 2: GHS06-Acute Toxicity; GHS09-Environment, aquatic toxicity.

3.1.4.7 *Phenyldichloroarsine*

Median lethal dosage 2,600 mg min./m3. Mean incapacitating dosage 16 mg min./m3 as a vomiting agent and 1,800 mg min./m3 as a blistering agent. 633 mg min./m3 produces eye injury. Poisonous, may be fatal if inhaled, swallowed, or absorbed through skin. Contact may cause burns to skin and eyes. Strong irritant to eyes, skin, and tissue. (EPA, 1998) [2]

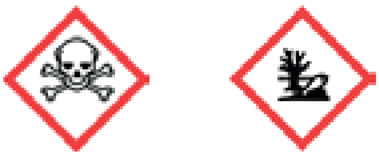


Figure from left to right: GHS labels for phenyldichloroarsine: GHS06-Acute Toxicity; GHS09-Environment, aquatic toxicity.

3.1.4.8 Triphenylarsine

Triphenylarsine is a organoarsenic compound, meaning it contains chemical bonds between arsenic and carbon, often abbreviated $AsPh_3$. It is a colorless crystalline solid. It is toxic if swallowed (acute toxicity, oral), toxic if inhaled (acute toxicity, inhalation), very toxic to aquatic life (hazardous to the aquatic environment, acute hazard), very toxic to aquatic life with long lasting effects (hazardous to the aquatic environment, long-term hazard).[2; 4]

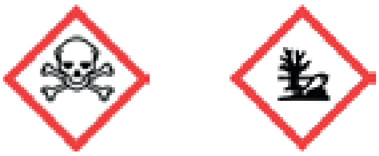


Figure from left to right: GHS labels for triphenylarsine: GHS06-Acute Toxicity; GHS09-Environment, aquatic toxicity.

3.1.4.9 Trichloroarsine

It can cause death. In acute exposures, it is extremely toxic and caustic, owing not only to the poisonous nature of arsenic, but also to the release of hydrochloric acid in the presence of water. Exposure to the skin causes local irritation and blisters. Inhalation or ingestion causes hemorrhagic gastroenteritis, resulting in loss of fluids and electrolytes, collapse, shock, and death. Chronic poisoning can lead to peripheral nerve damage, skin conditions, liver damage and has been implicated in the induction of skin and lung cancer. The fatal human dose is 70–180 mg depending on the weight of the exposed person. (EPA, 1998) [2]

Figure from left to right: GHS labels for trichloroarsine: GHS05-Corrosives; GHS06-Acute Toxicity; GHS07-Irritant; GHS08-Health Hazard, carcinogen, mutagenicity, reproductive toxicity, target organ toxicity, aspiration hazard; GHS09-Environment, aquatic toxicity.

3.1.4.10 Alpha-Chloroacetophenone

Initial treatment is primarily supportive. Most exposed persons require no medical attention and casualties are rare. In cases of inhalation, individuals with mild to moderate exposures generally improve rapidly following removal from the source of exposure and require no additional treatment. Persons with more severe exposures require hospital admission for observation of lung injury or accumulation of fluid in the lungs (pulmonary edema) and skin injury.[2]

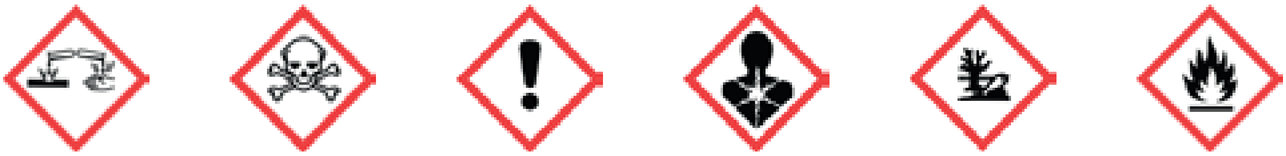


Figure from left to right: GHS labels for alpha-Chloroacetophenone: GHS05-Corrosives; GHS06-Acute Toxicity; GHS07-Irritant; GHS08-Health Hazard, carcinogen, mutagenicity, reproductive toxicity, target organ toxicity, aspiration hazard; GHS09-Environment, aquatic toxicity; GHS02-Flammables.

3.1.4.11 Phosgene

Phosgene is a lung toxicant that causes damage to the capillaries, bronchioles and alveoli of the lungs, by decomposition to hydrochloric acid. There is little immediate irritant effect upon the respiratory tract, and the warning properties of the gas are therefore very slight. Pulmonary edema, bronchopneumonia, and occasionally lung abscesses develop. Degenerative changes in the nerves have been reported as later developments. A concentration of 25ppm is dangerous for exposures lasting 30–60 minutes and 50ppm is rapidly fatal after even short exposure. (EPA, 1998) [2]

Figure from left to right: GHS labels for phosgene: GHS05-Corrosives; GHS06-Acute Toxicity; GHS04-Compressed Gases.

3.1.4.12 Diphosgene

Diphosgene is a chemical compount containing chlorine. It is related to phosgene and has comparable toxicity, but is more conveniently handled because it is a liquid, whereas phosgene is a gas. It is fatal if swallowed (acute toxicity, oral), causes severe skin burns and eye damage (skin corrosion/irritation), and fatal if inhaled (acute toxicity, inhalation).[2; 4]

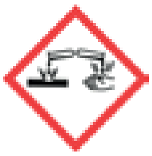



Figure from left to right: GHS labels for diphosgene: GHS05-Corrosives; GHS06-Acute Toxicity.

3.1.4.13 Tabun

This material is toxic by inhalation and by absorption through skin and eyes. The lethal dose for humans may be as low as 0.01 mg/kg. Tabun is a nerve agent, it acts as a cholinesterase inhibitor. The median lethal dosage (respiratory) is 400 mg min./m3 for humans, the median incapacitating dosage is 300 mg min./m3 respiratory lethal dosages kill in 1 to 10 minutes, liquid in the eye kills nearly as rapidly. Skin absorption great enough to cause death may occur in 1 to 2 minutes but may be delayed for 1 to 2 hours. (EPA, 1998) [2]


Figure from left to right: GHS labels for tabun: GHS06-Acute Toxicity; GHS08-Health Hazard, carcinogen, mutagenicity, reproductive toxicity, target organ toxicity, aspiration hazard.

3.1.4.14 *Hydrogen cyanide*

It is super toxic. Breathing in a small amount of the gas or swallowing a very small amount may be fatal. Average fatal dose is 50–60 mg. A few minutes of exposure to 300 ppm may result in death. Exposure to 150 ppm for 1/2 to 1 hour may endanger life. (EPA, 1998) [2]

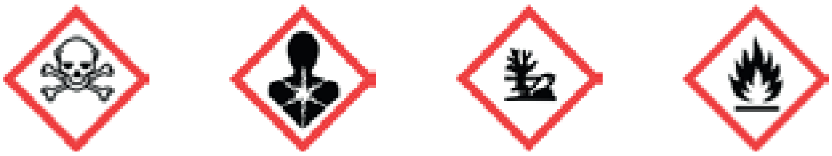


Figure from left to right: GHS labels for hydrogen cyanide: GHS06-Acute Toxicity; GHS08-Health Hazard, carcinogen, mutagenicity, reproductive toxicity, target organ toxicity, aspiration hazard; GHS09-Environment, aquatic toxicity; GHS02-Flammables.

3.2 Mitigation Measures for the Planning Phase

Effective measures to mitigate health risks are mainly avoidance of contaminated areas, hence knowledge of existing restricted areas and dumpsites as well as the routes taken to the dumpsites are of great value (p. 45 ff). Nevertheless, munitions from war activities are scattered across vast areas of the Baltic Sea and mapping attempts are both subject of current research as well as the digitalization efforts of the Ammunition Cadastre Sea (AMUCAD.org) project.

For area searches, preparation and training of the crew with regards to the ability to spot hazardous objects and substances is advised. Spotting a potentially dangerous object before it is brought onto the ship will decrease the potential health risks of the crew dramatically, as hazards can be released back into the sea, regardless of whether it would contaminate the ship and equipment or explode.

Similar training is advised for divers as well; however, when deploying divers, the local circumstances of the found net should be examined beforehand, for example, via acoustic mapping technology. For the analysis of footage of a potential derelict fishing gear the team should include a specialist for the identification of munitions. If an undefinable object is entangled into the net, local authorities should be contacted. Under no circumstances should a bomb, mine or container with chemical warfare agents be moved.

If a net is supposed to be removed from a potential explosive or is potentially contaminated, a specialist team with appropriate equipment and training is needed.

All participants have to be provided with printed and digital guidelines, protective gear and first aid equipment.

3.2.1 Planning Phase – Extended Guideline

Hire or train crew members in regard to first aid and warfare material detection

Distribute on-mission guidelines to all crew members, this means hard copies as well as digital versions

Provide sufficient amounts of protective clothing

Review map material with care to avoid unnecessary risks

- Use AMUCAD and help improving such projects by providing them with data and information about findings

3.2.1.1 First Aid Equipment for Chemical Warfare Agents

Excerpt from the HELCOM guidelines for fishermen. At least the following first aid equipment for such agents must be on board vessels fishing in the areas at risk:

One “gas box” for every three crew members. The “gas box” should contain the following:

- **Five** tongue spatulas
- **Four** packets of 10 g containing absorbent cotton
- **Three** 100 ml bottles containing either 5 % solution of dichloramine in dichloroethane or 5 % solution of 1,3 dichloro, 5,5-dimethylhydantoine in dichloroethane. The bottles should be marked clearly with “Gas-decontamination liquid” and the composition stated.
- **Three** powder sprays containing 50 g of fine pulverized compound of calcium of lime and magnesium oxide, adjusted to a content of 25 % active chlorine. The spray should be marked clearly with “Anti-gas powder” and the composition stated.
- **One** 75 ml bottle containing a solution of copper sulphate. The bottle should be marked “Anti-phosphorus liquid” and imprinted with instructions “approved by the appropriate authority”
- **One** copy of the National Leaflet on “Fisheries and Warfare Agents – Preventive measures and First Aid”.

Ten atropine/oxime automatic injectors for every three crew members on vessels fishing in the risk area C and using bottom tackle or tackle which is permanently fixed on the seabed.

Breathing masks (full-face mask with filter, speech membrane and panoramic screen) and spare filters should be available on board, e.g. one mask and one spare filter, for every crew member. Breathing masks and filters should be appropriately approved and maintained.

One pair of long isobutylene/isoprene rubber gloves per crew member.

Information about approved breathing masks and filters as well as on dealers who sell such equipment and isobutylene/isoprene rubber gloves can be obtained from the appropriate national authority.

3.3 Mitigation Measures During Retrieval Activities

Mitigation measures for the retrieval of derelict fishing gear mainly means avoiding the risk of warfare materials. In the following an extended guideline is given regarding mitigating health risk during retrieval activities.

3.3.1 Extended On-Mission Mitigation Guideline

Avoid bringing any kind of warfare material on board

- For area searches, this means off-board spotting warfare materials while the captured derelict fishing gear is pulled on board
- For targeted retrieval this includes pre-analysis of targeted derelict fishing gear, live assessment through divers and also off-board spotting of warfare materials while the captured derelict fishing gear is pulled on board
- If warfare materials are spotted in the captured or the target derelict fishing gear, abort retrieval immediately

If a suspicious object or substance is found on board

Do not move or touch the object or substance

Notify authorities immediately

If chemical warfare agent is suspected

Stay upwind, close all doors and orient the ship in order to have the wind blow off-board from the suspicious object

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Avoiding spreading of chemical warfare agents

- Search (each others) clothing for warfare materials, especially chemical warfare agents
- If necessary remove clothes normally or through cutting, in any case avoid contact
- Store contaminated clothes in an airtight packaging on deck
- Record contaminated gear and materials for later decontamination measures

Stop activities to the extent possible and send crew below deck

Close and seal airways leading into the ship

Examine crew regarding symptoms, remember time delay of some of the chemical warfare agents

Wear protective gear while carrying out necessary work on deck

Consider decontamination measures

Only pass other ships down-wind and keep a safety distance

If conventional warfare materials is suspected

Water-cool objects until local authorities arrive for disposal

Wait for instructions from authorities

Do not enter harbours without explicit permission

Call professional help in case of injuries and contamination

Minimize the possibility of munitions in targeted derelict fishing gear before moving it, for example by means of remote sensing analysis

Do not move a captured net while divers are in the water

On the off-chance that unexploded ordnance is unknowingly captured in the derelict fishing gear

3.4 Mitigation Measures for the Aftermath of an Incident

In the case of an explosion or exposure to chemical warfare agents the crew should take immediate action. Call professional help immediately then begin with first aid and in the case of chemical warfare agents with containment measures. Containment measures start with the protection of the first-aiders.

In the following, first aid measures in the case of explosions are given and a guideline for fishermen for encounters with chemical warfare agents as provided by the Danish Marine Authority and the HELCOM board.

3.4.1 Explosion

First Aid Management of Blast Injuries

It is necessary to administer first aid to all victims of blast injuries at all times. The proper first aid will depend on the type of injury sustained by an individual. Call for emergency local services immediately. The following is the general protocol in cases of blast injuries:

If the individual is unconscious, check his/ her airway, breathing and circulation. If necessary, initiate cardiopulmonary resuscitation immediately.

If there is bleeding, try to control it by compression. If compression is not sufficient or feasible apply a tourniquet in case of life-threatening blood loss.

Use a dressing or any clean absorbent cloth.

Begin measures to decrease heat loss and avoid hypothermia.

If there are signs and symptoms of shock careful treatment is necessary.

To learn how to give proper first aid to all victims of blast injuries, enroll in First Aid Training and CPR Courses.[13]

3.4.2 Contamination with Chemical Warfare Agent

3.4.2.1 Short Guide

Please follow the instructions from the Danish Marine Authority, original found at dma.dk/Documents/Publikationer/wargas.pdf.

First Aid in Case of War Gas Exposure

Stop the accident:

- The person in charge of first aid on board the ship puts on protective gear (butyl gloves and filter mask).
- Prepare the mobile resuscitation equipment if it is on board.
- Avoid touching equipment and captured objects or substances. Do not spread the contamination on board.
- Manoeuvre the ship into a position where the wind is able to lead any vapours of gas away from crew quarters. Close doors and hatchways.
- Prepare the ship. If this is not possible without contact with the contaminated area, the crew must wear protective gear (butyl gloves and filter mask).

Symptoms from the airways: shortness of breath, hoarseness, coughing, chest pains, choking sensation

First Aid

- Give oxygen if available, 9 litres via Hudson mask.
- The injured person must not smoke, eat or drink and must keep still.

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Symptoms from the Eyes: burning sensation, reddish, pain, closing, watery

First Aid

- Rinse the eyes immediately with generous amounts of water.
- Close the eyes and gently cleanse surrounding skin with soap and water.
- Give oxygen if available, 9 litres via Hudson mask.

Symptoms from the skin: reddish, itching, burning sensation, corrosive burn

First Aid

- Wash skin thoroughly with soap and water, dry skin gently with a clean towel and give oxygen if available, 9 litres via Hudson mask.
- Skin contaminated with vaseline-like gaseous substances: scraping with a wooden spatula or the back of a knife.
- Gently remove working clothes and leave on the site.

First Aid in case of Nerve Gas Exposure

Nerve gas symptoms: Headache, visual disturbance, pressure sensation in the chest, possibly cramps

First Aid

- Give an Atropine injection immediately through the working clothes into the thigh.
- Give oxygen if available, 9 litres via Hudson mask.
- If symptoms do not cease within 10 minutes, another Atropine injection must be given. No more than 3 injections may be given without medical consultation.

In all instances, contact Radio Medical

3.4.2.2 Extended Guide

EXCERPT FROM THE HELCOM GUIDELINES FOR FISHERMEN

First Aid is Emergency Aid

First aid must be given quickly and correctly in order to limit the extent of damage and injuries. It is therefore necessary for everyone on board to know where the first aid equipment is kept.

Medical help is necessary at the latest when the vessel arrives in port, and in some cases it may be expedient to contact a doctor on the radio or, in serious cases, to get medical assistance via helicopter as soon as possible.

In Case of Mustard Gas Poisoning

WARNING
Mustard gas penetrates very easily into the body via the skin, mucous membranes and respiratory tract.

An unusual property is that the symptoms do not appear immediately!

Often the injuries do not appear until several hours after exposure!

It is therefore of uttermost importance that decontamination starts immediately after contact with mustard gas!

WARNING
Do not rub your eyes, even if they are stinging. If there is the least sign of a contamination, the following precautions must be taken:

Avoid touching tackle and haul. Do not spread the contaminants on board.

Eye cleaning

WARNING
Eyes should only be cleaned if they are stinging. If there is no stinging in the eyes, the skin should be cleansed immediately.

- Wash the eye out with plenty of water (e.g., from flushing hose) for at least 15 minutes. Washing out should be done from the root of the nose outwards.
- Close the eye and carefully clean the surrounding skin area with soap and water.
- Never rub your eyes – even if they sting or itch. Do not use eye ointment and do not dress the eye.

WARNING
Gas cleaning liquid and anti-gas powder must not be used on the eyes.

Skin cleaning where the skin is contaminated by grease-like substance

- Carefully remove work clothing and leave it where it is.
- Remove the grease-like substance from the skin immediately by scraping with a knife or similar instrument. Be careful not to rub the substances into the skin or spread it.
- Clean the contaminated skin using cotton wool moistened with gas-cleaning liquid.
- Rub anti-gas powder into the affected skin area as soon as possible.
- Wash the skin thoroughly with soap and water.
- Carefully dry the skin with a clean towel and rub gas powder into the affected skin area again.

Skin cleaning in other cases

- Quickly rub anti-gas powder onto hands, arms and face.
- Remove work clothing and leave where it is.
- Once again, rub anti-gas powder onto the affected areas and wash it off once more after half an hour. Be careful not to spread the contamination, like when you go to the toilet.

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Any blisters must not be punctured. They should only be covered with a clean dressing.

Move the vessel into a position which allows the wind to carry any gas fumes away from the affected people on board. Close doors and hatches to the contaminated area.

Contact the national contact point via the coastal radio station to get information on what to do next. Medical assistance may be required.

Make the vessel ready for departure or boarding. If this cannot be done without coming into contact with the contaminated area, the crew must use safety equipment.

In Case of Nerve Agent Poisoning

Nerve agent poisoning has not yet occurred during fishing in the Baltic Sea, but it needs to be treated very quickly if it does occur.

If nerve agent poisoning is suspected or in case of severe difficulty in breathing and/or cramps, atropine/oxime should be injected into the thigh immediately – through the person‘s work clothing, if necessary.

When going to the aid of an injured person, you must wear a protective breathing mask and gloves. Otherwise follow the same procedure as described for mustard gas.

Unless the symptoms of poisoning disappear within 10 minutes, another injection of atropine/oxime in the thigh should be given. No more than three injections may be given without medical advice. A good sign of the atropine having worked is dryness in the mouth.

If atropine/oxime is taken without the person being poisoned by nerve agent, it can cause blurred vision and palpitations. Instructions for use of atropine/oxime can be found on the injector itself.

In Case of Suffocating Agent Poisoning

Suffocating agents affect the respiratory system. In case of suffocating-agent poisoning, the poisoned person must not smoke, eat or drink, and must stay calm.

In Case of Phosphorus Poisoning

CAUTION

PHOSPHORUS is not a warfare agent and can thus also be found outside the dumping sites. Extinguish any burning phosphorus particles by keeping the affected area under water. Scrape off the particles using a knife. Then keep the affected area covered with a wet cloth until it can be bathed in anti-phosphorus liquid. Finish by applying a dry dressing.

3.5 Recommendations and Risk Assessment

Ordnance with an armed fuse or a sensitive main charge (e.g., picric acid) shall not be recovered aboard a manned vessel unless an appropriate containment system is used to mitigate the risk to personnel (UNMAS, 2014).

Warfare materials off all sizes are lethal, especially small explosives that are more likely to be brought on board, must be handled with utmost care.

3.5.1 Mission Planning

Always have first aid materials on board

Always have protective gear against toxic fumes and chemicals on board

Plan the mission outside of areas that are known to host any type of warfare objects, this is especially true for areas with chemical warfare agents

3.5.2 Crew Training

Always have multiple members of the crew trained in first aid for explosions and if possible, for chemical contamination

Always have at least one crew member trained in the identification of both munitions and chemical warfare agents

Have divers trained on their behaviour regarding munitions and chemical warfare agents (do not handle munitions and chemical warfare agents unless trained for bomb disposal and with sufficient professional equipment and crew)

3.5.3 Behaviour

Carefully look for hazards in the catch

Never move or bring munitions or objects of unclear status onto the ship

Never move nets that are potentially entangled with munition, especially not when divers are in the water

Call a specialist team for clearance if an object or chemical is found on board

3.5.4 Post Mission

Handle bottom touching gear carefully as contamination with chemical warfare agents is possible

- Wear (at least minimal) protective gear
- Examine bottom touching gear carefully
- Clean bottom touching gear thoroughly
- Keep bottom touching gear well ventilated and locked away

Consider screenings for divers if deployed in potentially polluted waters

Perform regular urine tests if exposure to trinitrotoluene is likely

4 Damage Risks to Equipment

Equipment for the retrieval of derelict fishing gear includes vessels of various types, creepers and anchors for area searches and diving gear. The direct physical impact on the sea bottom caused by some of the mentioned equipment pose an immediate danger. The different types of warfare materials found in the Baltic Sea have different risk associated with regards to the equipment. Equipment might be subject to contamination from chemical warfare agents or direct damage through explosions.

For the subject matter of chemical warfare agents and conventional munitions the risk of an encounter is highly disproportional to the potential harm done to humans and equipment. It might be unlikely to trigger an explosion or catch a chemical warfare agent outside of a dumping site, however, it is the human life that is at risk if such an event occurs. Act accordingly.

In the following, it will be distinguished between the potential damage risks from the various warfare materials and the risk of an encounter.

4.1 Host Vessel

For the host vessel, explosives of larger calibres are major threats – like mines, for example. An exploding mine is capable of inflicting major damage up to the destruction of a ship. Smaller explosives will still be able to damage the deck or hull and all smaller components of a ship if they explode within relative proximity, relative to the size of the explosive. Fragments of exploding ordnance and objects accelerated by the explosion might destroy what they hit.

Chemical warfare agents will usually do only minor damage to the material of a vessel. However, decontaminating a vessel which got in contact with chemical warfare agents will be difficult. Removal of chemical warfare agents could result in partial deconstruction of the ship, unless the chemical warfare agent is isolated on an even and resistant surface which is trivial to clean, resistant with regards to the chemical warfare agent. Decontamination must be done by experts.

4.2 Seafloor Touching Equipment

Seafloor touching equipment can physically effect munitions which is lying on top of the seabed or which is covered with a thin layer of sediments. In case of high impact grenades, mines and rockets with fuses could potentially detonate. Particularly dangerous in this context are grenades with impact fuses which are usually found in form of all different kinds of anti-aircraft shells. Even heavily corroded munitions could cause severe danger due to a over time growing sensitivity to shocks of the explosive compounds over time. Regarding chemical warfare agents, the situation depends on the material of the bottom touching gear as this determines whether decontamination costs are reasonable relative to the equipment cost, not taking into account health issues discussed in section 3.

4.3 Diver Equipment

The equipment of divers is not designed to protect against explosions or chemical warfare agents. Explosions are likely to rip the fabric apart and destroy tubes and oxygen tanks. It is possible that the diver is temporarily protected against chemical warfare agents; however, the contamination of diver equipment equals destruction of the equipment. Contaminated diver equipment should be shed and discarded as soon as possible.

Note, if conventional munitions or chemical warfare agents are spotted, local authorities must be notified immediately.

5 Summary

5.1 Conclusions

The Baltic Sea contains immense amounts of warfare materials, some in well-defined areas, others spread out over loosely defined regions and a portion where it is not known where they are likely to appear.

Secrecy of military organisations to this day, hesitation of fishermen to report encounters, and the financial costs of large-scale surveys hamper the efforts of national and international interest groups to accumulate information with the goal to improve security for workers and citizens of the states of the Baltic Sea region.

Chemical warfare agents, one of the hazards in the Baltic Sea, are found in for the most part dedicated dumping sites, where the majority of the material was either sunk within their ships or thrown overboard. Chemical warfare agents might, however, be found outside of those dumping sites as the practice of en route dumping as well as natural displacement processes and fishing activities have either spread the materials in neighbouring regions or resulted in chemical warfare agents distribution along the path from the harbour where they were loaded.

5.1.1 Chemical Warfare Agents

Chemical warfare agents in the Baltic Sea include vesicants (blister agents), where sulphur mustard is the most frequent, given that it forms lumps and will not dissolve over time, it is one of the most likely to be found in nets. The next group consists of irritants (nose and throat agents) which include Clark I and II, lachrymators (tear gases), lung agents, nerve agents and blood agents.

5.1.2 Conventional Munitions

Conventional munitions consists of a large variability of types and sizes. Located in dumping sites are mostly grenades and shells. In contrast, mines were both dropped from airplanes and deployed by ships and are often impossible to pinpoint to this day.

Chemicals from conventional ammunition and munition, including white phosphorus and trinitrotoluene, are found outside of their shells more frequently due to corrosion and incomplete detonations during bomb disposal operations.

While white phosphorus is highly inflammable, it is not known to form larger lumps found in fishing nets. Trinitrotoluene could be found in larger lumps but is not as reactive. That being said, accumulation of trinitrotoluene in the human body has substantial health risks, including increased risk of cancer.

5.1.3 Risks

Warfare materials in the Baltic Sea are potentially life-threatening. Whether conventional munitions explode, or a person comes in contact with a chemical warfare agent, the risk of a lethal encounter is extremely high.

First aid in this context is emergency help, especially regarding chemical warfare agents where quick action is necessary even when the affected person shows no symptoms right away. Furthermore, containment of chemical warfare agent contamination is paramount, and first aiders must protect themselves first before attending the affected person, as the risk to spread chemical warfare agents is extremely high since the concentrations needed to inflict severe injuries are usually low. Minimising the risks of warfare material encounters in the Baltic Sea is only possible when areas known to have warfare materials are avoided. This can be done with careful mission planning using national restrictions and recommendations for fishermen, as those are the group with the highest associated risks. Furthermore, modern digitalisation efforts such as the AMUCAD.org project have the goal supplying decision-makers with exactly this information and, moreover, including historical data and data from international projects.

Despite careful planning, the risk to encounter warfare material in the Baltic Sea is never negligible for activities like searching for and recovering of derelict fishing gear.

5.2 Recommendations

Three parts of the mission should be considered: the planning phase, the execution of the mission, and a follow-up.

The planning phase is crucial, as most hazard mitigation has to be incorporated into the mission at this stage.

Personnel: Training

- Workshop and qualification
- Divers and ship crew need training regarding recognition and detection of conventional as well as chemical warfare materials
- Crews need behavioural training to prepare for encounters with warfare materials
- Spotting is key when it comes to crew safety
- First aid training for blast and contamination injuries
- Detection and understanding of chemical warfare agent contamination

Operation Area: Avoid Contaminated Areas

- Archive research for operation planning
- Existing data portals (AMUCAD)
- Governmental recommendations

Precautionary Equipment

- Bring recommended equipment
- First aid equipment for blast and contamination injuries
- Protective equipment regarding chemical warfare agents

Guidelines

- Provide personnel with guidelines

During operations the crew must be alert at all times. Munitions and chemical warfare agents could be entangled within derelict fishing gear, and the only effective protection is avoidance or at the least minimising interaction of any form.

Do not under any circumstances bring warfare materials onto the vessel

If warfare material is found on the ship, follow the guidelines closely and call the local authorities

After returning from operations some measures might be appropriate, this has to be decided on a case by case basis.

Have divers been deployed in trinitrotoluene polluted waters or was trinitrotoluene brought onto the ship and not handled with safety protection?

- Take urine samples and visit a medical doctor

Was the mission located within or close to areas contaminated with chemical warfare agents?

- Take extra care of bottom touching gear, make sure that no contamination took place

A general and final remark:

The threat of munitions and chemical warfare agents is high and should be dealt with by professional bomb disposal organizations. Therefore, encounters should be avoided and in case of encounters local authorities should be contacted immediately.

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APPENDIX A – Contact Points

Germany

Örtlich zuständige Verkehrszentrale
(EN: VTC – Vessel Traffic Center)
Radio frequencies: VHF 16

In addition, an ammunition encounter should be reported to:

Maritimes Sicherheitszentrum Cuxhaven
Phone: +49 30 185420 1609
E-Mail: wsp@msz-cushaven.de
Radio frequencies: VHF 16

Poland

Depending on the area

Maritime Office – Szczecin
Phone: +48 91 4403400

Maritime Office – Gdynia
Phone: +48 58 3553333

Maritime Office – Słupsk
Phone: +48 59 8474256

Sweden

Joint Rescue Coordination Center – Sjöfartsverket
Phone: +46 10 4927900, SOS alarm: 112
E-Mail: jrcc@sjofartsverket.se
Radio frequencies: VHF 16

Estonia

Joint Rescue Coordination Center – Merevalvekeskus
Phone: +372 6191224, SOS alarm: 112
E-Mail: jrcc@politsei.ee
Radio frequencies: VHF 16, VHF 69

APPENDIX B – Interview with Fisherman

Brief excerpt of an interview with a fisherman from the area of Flensborg Fjord

- Guidelines are not reaching fishermen if they exist
- Encounters with sulphur mustard are not known to the fishermen
- Fishermen will identify empty munitions and just throw them back into the water or sell the metal (mostly in the past)
- Fishermen will call bomb disposal agency if a mine is in the net
- Fishermen in interview think no sulphur mustard in Flensburg fjord
- Fishermen mostly fish in shallow water (deep areas of Baltic Sea have few fish because of low oxygen concentration)
- Fishermen often find grenades and 2 cm munition
- Fishermen would throw a bomb back into the water
- Call “Wasserschutzpolizei” as the number of bomb disposal agencies are usually not known and the “Wasserschutzpolizei” will act accordingly to the situation

MARELITT Baltic

Interreg Baltic Sea Region

EUROPEAN UNION

EUROPEAN REGIONAL DEVELOPMENT FUND

The MARELITT Baltic project

Derelict fishing gear (DFG) is addressed worldwide as a source of marine litter with extensive hazardous effects on the marine ecosystem. From 5.500 to 10.000 gillnets and trawl nets are lost every year and despite intense media focus – the problem is poorly known in the fisheries industry and among politicians.

The MARELITT Baltic project is one of the first transnational initiatives in the world to provide an operation oriented all-in-one solution for how to approach DFG. It will turn a diffuse problem into a clear and apprehensible topic that can contribute to an enhanced international readiness to act.

The project is divided into five work packages (WP), where package 2, 3 and 4 are the major parts concerning the cleaning, prevention and recycling of lost fishing gear.

Cleaning the sea and planning future action at sea
The aim of WP 2 is to plan and execute DFG retrievals in Sweden, Estonia, Poland and Germany both on the seafloor and wrecks. The activities will be based on methodologies and techniques tested in earlier national projects. These experiences will contribute to a common methodology which is crucial given the extreme hydrographic and morphological variation in the Baltic Sea. The new operation platform will make cleaning operations both transparent and demonstrate if the task is physically possible.

Responsible fisheries prevention scheme
The aim of WP 3 is to develop an overall approach to mitigate the problem of lost fishing gear in the future. It can roughly be divided into three types of actions. Firstly, the project will increase knowledge on fishing technological and strategic changes over time and how these changes have influenced the evolution of gear loss. In the second step, the project will focus on the potential causes to why fishing gears are lost. The third category of action includes development of preventive methods such as gear marking technologies helping to track irresponsible fishermen or assisting responsible fishermen to locate lost gears.

Marine litter reception facilities and recycling
The aim of WP 4 is to identify the options for a safe and fully sustainable handling and recycling of the lost fishing gear in a circular approach. Within this work package the phase from reaching the harbour through cleaning, sorting, transport until processing of recycling of the nets will be dealt with. The work encloses a variety of approaches such as creating a knowledge baseline about the transnational status and capacities of harbours, waste handling systems and industries in the Baltic Sea countries.

Projectpartners

Sweden
Municipality of Simrishamn, Lead partner
Keep Sweden Tidy

Germany
WWF Germany

Poland
WWF Poland Foundation
Maritime University of Szczecin
Kolobrzeg Fish Producers Group
Institute of Logistics and Warehousing

Estonia
Keep the Estonian Sea Tidy
Estonian Divers Association

More information

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