No Time to Waste:
Tackling Submerged Munitions in European Seas

11 June 2025 at 18:00
Research Vessel METEOR, Port of Nice, UNOC 3

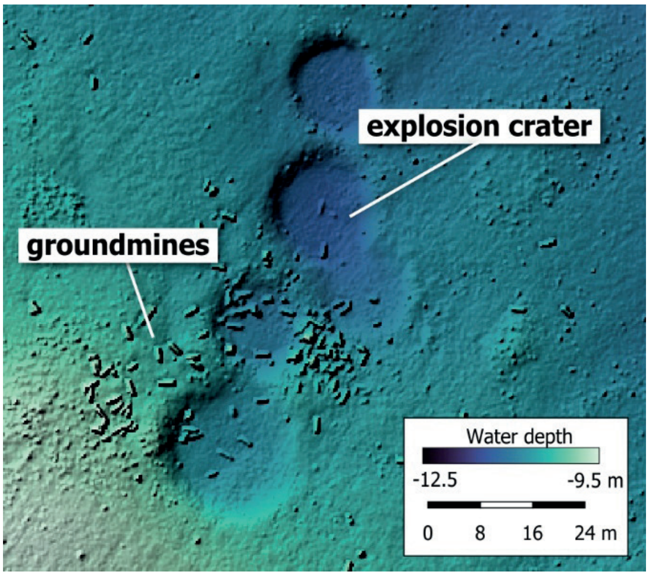
Factsheet #2
Detection of Marine Dumped Munition and Clearance Options

#2

Background – Marine Munition Surveys

Historical documents and reports highlight significant quantities of marine-dumped munitions in European seas. While the approximate locations of dumpsites are generally known, their exact contents and the conditions of the munitions are often not fully understood. Technical surveys are therefore essential – both to detect and identify objects and to develop clearance strategies that include prioritization and the selection of appropriate remediation methods.

The suitability of survey methods depends on oceanographic and seafloor properties, as well as on whether the munition is buried or not. For instance, highly dynamic current regimes may result in object burial and migration, necessitating ground-penetrating and non-optical survey methods.



Bathymetric map of explosion craters and ground mines. (Image: GEOMAR)

Hydroacoustic Surveys

Hydroacoustic methods are a type of non-optical geophysical method that enables seafloor mapping based on sound propagation through the water. These methods differ in terms of deployment and therefore have different operational spectra.

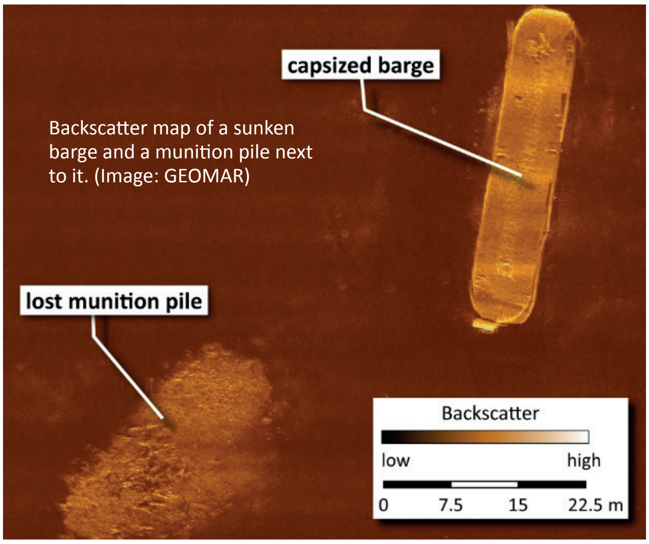
Multibeam Echosounder (MBES): MBES are state-of-the-art hydroacoustic sensors used for precise seafloor mapping. They emit multiple sound beams across a wide swath beneath a survey vessel, enabling detailed capture of the seafloor's topography and the detection of objects. MBES is particularly effective in identifying underwater obstructions and variations in sediment composition thanks to its high resolution and accuracy. The results are georeferenced maps. These can be analysed and correlated with other spatial data. The munition detection capability is linked to data resolution, which depends on the water depth and the technical properties of the hardware.

Advantages: High-resolution seafloor bathymetry and object detection with high positional precision.

Limitations: Only objects on the surface can be detected. The detection capability depends on the size of the object and the data resolution. The footprint (and therefore survey efficiency) decreases with water depth.

Sidescan Sonar: Sidescan Sonar is a hydroacoustic survey method that also uses sound waves but to create detailed backscatter images of the seafloor. It emits sound pulses to the side and captures the return signals reflected from seafloor objects. The resulting high-resolution data can reveal the texture and composition of the seafloor, aiding comprehensive undersea exploration. It is typically operated either by being towed from a vessel or by being based on an

ORGANISERS:
GEOMAR
HELCOM
Federal Ministry of Research, Technology and Space
Federal Ministry for the Environment, Climate Action, Nature Conservation and Nuclear Safety
SUPPORTING PARTNERS:
JPI Oceans
Umwelt Bundesamt



Backscatter map of a sunken barge and a munition pile next to it. (Image: GEOMAR)

AUV, in order to achieve high data resolution due to the low altitude and very narrow beam opening angle.

Advantages: High-resolution seafloor backscatter imagery for object detection. Constant altitude ensures consistent data resolution.

Limitations: Only surface-level objects are detectable. The detection capability depends on the size of the object. Towed systems may be affected by weather conditions, and precise data positioning may be difficult.

AUV with attached magnetometer. (Photo: Marc Seidel / GEOMAR)

Magnetic Surveys

Magnetic surveys are essential for detecting ferrous objects underwater, including munitions. These instruments measure variations in the Earth's magnetic field caused by ferromagnetic objects, enabling potential hazards to be located precisely. Magnetometers are sensitive enough to detect buried munitions. Magnetometers or magnetic gradiometer arrays can be towed from a vessel or operated by an AUV.

Advantages: Enables the distinction between stones and munitions. Buried objects can be detected.

Limitations: Further information is required for object identification. The small footprint makes surveys time-consuming. Precise data positioning can be an issue.


Photomosaic of Fi-103 warheads in the Baltic Sea. (Image: GEOMAR)

Optical Validation

In order to identify suspicious contacts, optical ground truth is essential. It also gives important information about corrosion conditions, fouling and the degree of burial. Data quality depends on the underwater visibility. Apart from divers, two main methods exist: Remotely operated and autonomous operations.

Remotely Operated Vehicle (ROV): due to their maneuverability and ability to capture high-resolution images, Remotely Operated Vehicles (ROVs) are highly effective for underwater object identification. They can be equipped with cameras and sensors to provide real-time visual data and detailed inspections, even in challenging underwater environments.

Advantages: High-resolution underwater footage and detailed observation of target objects.

Limits: Only surface-level objects are detectable. Detection capability depends on visibility. High-quality positioning is required.

AUV for high-resolution photo surveys. (Photo: Köser, et al. 2024)

Autonomous Underwater Vehicles (AUVs) equipped with advanced imaging systems are invaluable for underwater photo mapping. These vehicles can autonomously navigate pre-defined areas, capturing high-resolution images of the seabed and submerged objects. Their ability to operate independently allows for efficient and comparable mapping, which is crucial for identifying, documenting and monitoring underwater munitions.

Advantages: High-resolution underwater images and georeferenced photo mosaics for munition identification and monitoring. AUVs can be equipped with magnetic sensors as well.

Limitations: Only surface-level objects are detectable unless magnetic sensors or sediment penetrating hydroacoustic sensors are used.

Data Analysis

Hydroacoustic data forms the basis for optical confirmation operations. Magnetic methods can be used for contact detection and validation. In order to identify suspicious targets, the hydroacoustic data must first be annotated to determine locations for follow up investigations. Annotation can be done manually by experts or via automated detection using trained machine learning models . Bathymetric data allow the generation of morphological derivatives like slope or surface area, which improve the visibility of objects within the dataset and assist with annotation. Annotation software such as Validity (https://validity-project.eu/) or various GIS (Geographic Information System) tools can streamline the annotation process further. All datasets can be integrated into GIS software to assess the number and condition of munitions and to facilitate further spatial planning, monitoring and clearance actions.

Methods of Marine Munition Clearance

Options for underwater munition clearance include retrieval by divers, who can locate and secure items manually for removal, and the use of ROVs or crawlers – remotely operated vehicles that manoeuvre on the seabed – to recover objects. Another option is to neutralise the munitions by detonating them on site (Blast in Place), which is often the preferred method when clearance is too dangerous. Each method has its own specific challenges and advantages, depending on the conditions and the type of munitions involved.

Clearance Options at a Glance

	Advantages	Drawbacks
Diver recovery	+ Targeted operation + Expert identification on site + controlled handling	- Limited bottom time - Highest risk to humans
ROV / crawler recovery	+ Targeted operation + Low risk to humans + Cost- and time-efficient	- High technical effort
In-situ detonation	+ Works for almost any object + No transport required	- Costly and time-consuming - Environmental stress due to noise and contamination

Future Clearance Vision

Marine munition dumpsites pose a significant threat of toxic contamination and security risk in national waters. Existing clearance methods are tailored to small areas and individual unexploded ordnance (UXOs) rather than large and complex munition dumpsites. On-site detonation requires extensive infrastructure – such as bubble curtains – to protect the environment from noise and contamination. Manual or remote munitions retrieval still involves transporting munitions to land-based disposal facilities, which are already operating at full capacity. The goal is to develop secure, efficient, and scalable solutions. Ideally, delaboration and disposal will take place near the dumpsites on a remotely operated platform at sea.

In 2024, Germany launched its first clearance trials in the Baltic Sea targeting complex munition piles and initiated the development of a mobile clearance platform

https://www.bundesumweltministerium.de/themen/meeresschutz/munitionsaltlasten-im-meer