

UNDERSTANDING EFFECTS OF BIOFOULING AND CORROSION ON UNDERWATER MUNITIONS:

IMPLICATIONS FOR RISK MANAGEMENT AND RESOURCE ALLOCATION

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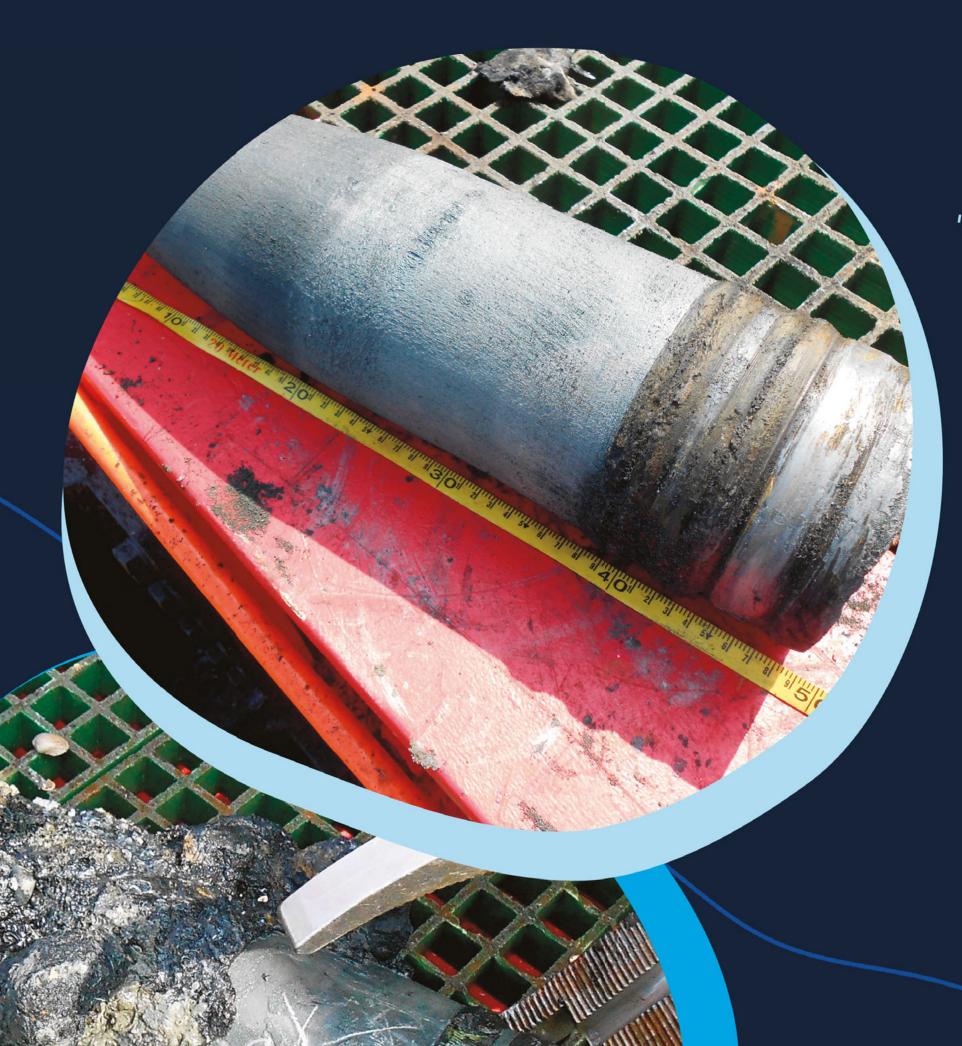
The problem

Current knowledge regarding the aging of munitions underwater is largely anecdotal, lacking formal insights into visual and structural changes resulting from these conditions. To address this multidimensional issue, we consider the following key aspects:

- Diverse Munitions Development. Ammunition of various types, spanning small cannon projectiles to large missiles, has been developed and tested around US territories for decades. These munitions incorporate a wide range of explosive types, fuzing combinations, and construction
- **High Dud Rates.** Even well-manufactured and tested ammunition can experience unexpectedly high dud rates upon water impact. This has led to the dispersal of significant quantities of unexploded explosive ordnance (UXO) across ranges and test areas, with a substantial proportion being underwater.
- Effects of Underwater Immersion. After prolonged immersion, UXO face the combined impact of water itself and various other influences present in the underwater environment. The condition of this ammunition, which has already failed for unknown reasons, is further complicated by the effects of aging.
- Assumption-Based Risk Assessment. Current risk assessments for aged munitions often rely on assumptions. Without an evidence-based understanding of changes in UXO underwater, forming a realistic assessment of the associated risks becomes almost impossible.

Project ObjectiveSuch as detecting, classifying, and remediating military munitions at underwater sites.
This includes assessing the feasibility and potential implications of these activities.

Beyond saving lives, the project will help to guide clearance prioritization, protect the aquatic environment, and inform decisions leading to cost, time, and resource savings in underwater clearance operations.



Concretion' is often a feature on submerged ammunition. This buildup can make identification and detection of the munition more difficult while also potentially providing a layer of protection for its contents

> Lifting an anti-tank mine in the Falkland Islands. The study of aging n land-based munitions formed an important foundation for this project

What we did

Based on our extensive previous research on the effects of aging on land-based munitions, we examined the visual and structural changes that have occurred to ordnance as a result of aging in an underwater environment. In trying to understand the interaction of the many effects and outcomes of underwater aging, we considered:

- Comparisons to existing data. Information from previous investigations into the effects of aging on may cause changes that have important previous investigations into the effects of aging on land-based munitions, and from recent underwater clearance operations.
- Predisposition to aging. The various reasons why a piece of ammunition may be more, or less, vulnerable to the effects of aging.
- Factors involved in aging. The primary known, and likely, causes of degradation, along with combinations of factors.
- implications for the functionality of key components, and the consequences for residual risk.
- Creation of new hazards. The potential for ammunition to become more dangerous, through unintended and often unexpected mechanisms, as a result of aging.

to the release of explosive fillings



• Existing research. Our literature review established that there has been surprisingly little research in this area, and that current risk assessment is often based on unfounded supposition.

The risk from fuzing systems that have failed to function remains an

area of great uncertainty

- Land-based comparisons. Data from landbased aging studies translate to a point, but some issues are specific to the underwater environment. These include concretion, explosive dissolution, effects of saltwater versus freshwater, and the impacts of climate change.
- Predisposition factors. Some influences are knowable, such as the design, materials, production, and casing thickness of a given munition. Others are less clear, such as their maintenance and storage conditions prior to use, how they were prepared and deployed, and what occurred upon impact.
- **Dumped vs fired munitions.** Abandoned or dumped ordnance typically carries a lower risk than ammunition that has failed to detonate, since the former would have entered the water in a safe condition while the latter is usually fuzed and armed.
- Warhead casings. Many munitions use iron or steel for the main casing. Clearly, this is prone to rusting once any surface protection is breached. In extreme cases, this may expose the explosive filling.

• Thin casings. The thin casings and seals protecting fuzing systems are prone to failure – particularly if damaged on/impact,/This tends to expose internal fuze components to the underwater environment.

Secondary explosives tend to remain

in good condition when protected by

thick casings. ...however, the

corrosion of thinner casings may lead

- Mechanisms. Most ammunition incorporates mechanical components, which are prone to degradation and blockage. This often inhibits their ability to function as designed.
- Initiating explosives. The sensitive explosives used to initiate ammunition are often key to the level of residual risk, but there is very little existing research into the effects of water on primer compositions. The project proposes the development of a predictive model, which could significantly enhance risk assessment.
- Explosive fillings. Most of the military explosives used for the main filling are resistant to the effects of aging; however, once exposed, they may get fully or partially released.
- Numerous influences. Many influences including environmental, chemical, physical and human – may interact. We are only beginning to understand the many permutations and potential for combined effects.

Huge quantities of unexploded and abandoned ordnance are present in US coastal and inland waters

Next steps

The study has identified a number of knowledge gaps that require further investigation. These should be addressed through a combination of academic study and practical field research.

- Initiating explosives. The predictive model suggested in the study needs laboratory testing and validation through the recovery and study of live unexploded ammunition.
- Fuzing mechanisms. If an explosive train is present, then the functionality of a fuze becomes important. The effect of prolonged immersion on various fuzing mechanisms requires further
- Material interactions. There is plenty of data on the aging of common materials underwater, but little about the possible long-term reactions between explosives and surrounding materials.
- Unforeseen hazards. Most risk assessment focuses on designed methods of initiation, but the potential for the formation of new and unexpected hazards should also be investigated.
- Relevance to the community. We are seeking feedback from SERDP researchers and practitioners undertaking UXO clearance to understand which aspects of this issue are most consequential for their research and operations.





