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Ukraine Case Study – Environmental and Economic Impact from Sea Mines and underwater unexploded ordnance (UXO) in the Black Sea

Disclaimer:

This document was independently prepared by Victor Romanenkov, founder of RFM Solutions LLC, a maritime expert and international relations professional. A U.S. Navy veteran with over 20 years of service, Romanenkov is not affiliated with, or endorsed by, or coordinated with the Government of Ukraine. All assessments are based on publicly available information, open-source information, and professional expertise in maritime security, humanitarian and regional stability operations. The objective is to support informed discussions and policy formulation regarding partners and alias engagement in humanitarian sea mines clearance action in Ukraine.

1. Executive Summary

The full-scale invasion of Ukraine by the Russian Federation in 2022 has resulted in a substantial maritime security and environmental crisis. The extensive deployment of sea mines and the presence of underwater UXO in the Black Sea, coupled with persistent strikes and the degradation of port infrastructure, have disrupted over 40% of Ukraine's GDP, which was previously linked to pre-war maritime trade. Consequently, there has been significant damage to port infrastructure and sea lanes, and the long-term environmental contamination from explosives and sunken vessels poses persistent threats to biodiversity, seafood safety, and ecological stability.

Currently, the existing demining institutions in Ukraine, such as the National Mine Action Center (NMAC), State Emergency Service of Ukraine (SESU), and the Ukrainian Naval Forces (UPN), are facing challenges due to a lack of coordinated authority, underwater clearance capabilities, and regulatory clarity. This paper presents an evidence-based analysis of these impacts and identifies critical institutional shortcomings in Ukraine's existing mine action framework, which primarily focuses on land-based hazards.

This paper argues that Ukraine's extant land-centric mine action system is fundamentally inadequate for the magnitude and intricacy of maritime explosive hazards. Consequently, it advocates for the immediate establishment of a **National Maritime Mine Action Center (NMMAC)** to oversee underwater clearance, diver certification, and environmental safety measures.

2. Introduction

Since the commencement of the Russian Federation's invasion in 2022, Ukraine's maritime domain has undergone a profound transformation, evolving from a conduit for commercial exchange into a war zone plagued by sea mines and underwater UXO. These modern tools of conventional and asymmetric warfare pose a grave threat to civilian lives, coastal economies, and marine biodiversity. The Black Sea, once a vital component of Ukraine's global trade, now harbors uncharted minefields and sunken vessels, obstructing shipping and hindering humanitarian access. While initiatives such as the Black Sea Grain Initiative have endeavored

to mitigate some of the impact (Enclosure 2), a comprehensive clearance of mines remains an elusive goal.

The inability of marine scientists, divers, and emergency responders to safely access contaminated waters further exacerbates the humanitarian and ecological toll. A conservative estimate based on publicly available information suggests that over 26,000 km² of Ukraine's maritime and internal waterways areas may necessitate sea-mine clearance and/or technical surveys. This encompasses approximately 5,000 to 6,000 km² of high-priority port access shipping lanes, which are essential for safe navigation and trade. (Enclosure 1) Specific clearance requirements still require validation by Ukrainian authorities, yet this estimate aligns with similar efforts undertaken in other post-conflict maritime regions.

Addressing these challenges demands more than tactical responses; it necessitates strategic institutional reform. This paper delves into the environmental and economic consequences of sea mining in Ukraine's waters, assesses the current legal and organizational framework, and proposes viable solutions. In essence, without dedicated underwater demining capabilities, cleared and focused legal authority, and effective international coordination mechanisms, which are crucial for long-term stabilization and recovery, the task of successfully clearing and recovering the estimated 26,000 km² of contaminated waters remains insurmountable.

3. Economic Impact of Sea Mining on Ukraine's Maritime Sector

Prior to the full-scale invasion in 2022, Ukraine's Black Sea ports, including Odesa, Chornomorsk, Pivdennyi, Mykolaiv, and others, were pivotal economic drivers, contributing over 70% of the nation's foreign trade (Policy and Management Consulting Group, 2022, 2023). Maritime trade accounted for approximately 40% of Ukraine's national GDP, primarily driven by exports of agricultural commodities, steel, fertilizers, and containerized goods. Notably, Ukraine emerged as the world's largest sunflower oil exporter and ranked among the top five global wheat exporters. The Black Sea served as a crucial artery, facilitating connectivity between Ukraine and markets across Europe, the Middle East, Africa, and Asia.

The active mine warfare and Russian naval operations against Ukraine in 2022 resulted in the abrupt closure of Ukraine's major seaports. According to the Georgetown Security Studies Review (2024), Ukraine's export volumes experienced a decline of over 50% during the initial year of the conflict, with maritime transport being the most severely impacted sector. Port infrastructure endured direct missile strikes, while shipping companies and insurers deemed Ukrainian waters excessively hazardous for commercial navigation. Although the Black Sea Grain Initiative provided temporary relief, its impact was limited, and merchant ships sailing through Ukrainian waters continued to face constant threats from sea mines and missile strikes (CBS News, 2022).

The deployment of various types of sea mines and the presence of unmarked minefields in coastal waters introduced significant uncertainty into shipping schedules and insurance premiums. Several merchant vessels presumably were damaged by sea mines or were abandoned by their crews due to sea mines alerts. This eroded the confidence of global shipping operators, leading many to reroute their vessels through Romania ports or halt their operations altogether.

The persistent presence of underwater explosives severely hinders economic recovery. As of early 2025, no national certification mechanism exists to ascertain the absence of sea mines

threats in port approaches and shipping lanes. Investors in port reconstruction, logistics corridors, and agro-industrial export infrastructure remain apprehensive in the absence of well-defined risk-reduction protocols. (CBS News, 2022; Reuters, 2022, 2025)

Additionally, Ukrainian ports are deficient in the specialized underwater clearance capabilities required for systematic surveys and certification of safe waters. These capabilities include remotely operated vehicles (ROVs), sonar systems, and trained divers. The economic cost of delayed clearance extends beyond trade losses to encompass reputational risk and missed opportunities for post-war redevelopment.

4. Environmental Impact of Sea-Mines and UXO Contamination

Explosives such as TNT (2,4,6-trinitrotoluene), RDX (cyclotrimethylenetrinitramine), and HMX degrade slowly in saltwater but release toxic byproducts into marine ecosystems over time. Research conducted in the Baltic Sea, where World War II-era munitions were dumped, has revealed significant contamination of seabed sediment and marine organisms near munition sites (Kammann et al., 2025). Mussels and fish residing in proximity to submerged explosives exhibit elevated levels of these compounds, which accumulate through the food chain.

In Ukraine's Black Sea Exclusive Economic Zone (EEZ), numerous sea mines have been deployed in shallow, ecologically sensitive waters, including estuaries and fish spawning grounds. The absence of baseline environmental monitoring hinders the quantification of contamination, but the risks are comparable to those observed in the Baltic and Adriatic Seas.

Sea mines and underwater UXO pose a severe threat to marine biodiversity. Explosive shocks can cause the death or injury of marine mammals, fish, and benthic species within a wide radius. For instance, detonations generate pressure waves that rupture swim bladders in fish and damage soft tissue in dolphins and seals. Coral reefs and seagrass beds, although less prevalent in the Black Sea, are also susceptible to habitat destruction from bottom-placed mines.

Fishing communities face both ecological and economic challenges. Contaminated seafood poses health risks, while fishing gear may inadvertently trigger mines or become entangled with UXO, resulting in injury or vessel damage. The apprehension of unexploded devices discourages artisanal and commercial fishing in high-risk zones, depriving coastal communities of income.

Of utmost importance, the presence of sea mines has severely hindered Ukraine's ability to respond effectively to maritime ecological emergencies. Oil spills, chemical leaks, and sunken shipwrecks are unable to be surveyed, assessed, or remediated due to the inherent explosive threat posed by these mines. A notable incident occurred in March 2022 when the MV Helt, a cargo vessel, sank after colliding with an explosive device off the coast of Odesa. Consequently, access to the wreckage for rescue and recovery operations was delayed for over a year due to ongoing UXO and sea mines clearance operations.

Similarly, the wreckage of the Moskva, a Russian guided missile cruiser, which sank in April 2022 by UPN missile strike, has never been comprehensively assessed for potential fuel or ordnance leakage. In late 2024 and early 2025, oil slicks from the Volgoneft-class tankers (212 and 239) washed ashore on Ukrainian beaches without proper containment due to the proximity of a sea-minefield. (Enclosure 3)

The absence of safe access to these sites has rendered Ukraine's Ministry of Environmental Protection and research institutions incapable of collecting the necessary data for assessing the extent of ecological damage. This oversight hinders both remediation efforts and accountability under international environmental law.

The environmental repercussions of maritime mine warfare are profound, cumulative, and often remain imperceptible to the general public. Without immediate clearance and substantial investment in underwater ecological monitoring, Ukraine may confront a long-term marine contamination crisis that will have regional implications for biodiversity, food security, and public health.

5. Legal, Strategic, and Institutional Landscape of Maritime Mine Action

5.1 Current Institutional Framework in Ukraine

Ukraine's mine action architecture is currently governed by Law No. 2642-VIII "On Mine Action in Ukraine," enacted by the Verkhovna Rada on December 6, 2018 (Verkhovna Rada of Ukraine, 2018). This legislation establishes the National Mine Action Authority (NMAA), which oversees the NMAC as the coordinating entity for mine action activities. However, the legal provisions primarily focus on land-based demining and explosive ordnance risk, omitting explicit mention of maritime explosive threats or underwater clearance operations. This legislative oversight significantly limits the national framework's applicability to the Black Sea and Ukraine's inland waterways.

The responsibility for underwater mine action across Ukraine's territorial waters and EEZ is divided among various civilian and military actors. The SESU assumes the primary role in humanitarian demining and possesses limited capabilities for shallow-water mine clearance, typically restricted to depths of up to 10 meters. In contrast, the UPN, under the command of the Ministry of Defense (MoD), are responsible for military mine warfare (MW) and mine countermeasure (MCM) operations in deeper maritime zones. However, their operations are primarily defensive in nature, and the Navy does not possess a formal mandate for civilian clearance, certification, or interagency coordination.

The NMAC serves as the designated authority for registering and certifying land-based mine action operators and serves as the central hub for national demining policy. Nevertheless, it lacks the legal mandate, specialized personnel, and technical infrastructure necessary to address underwater explosive ordnance disposal (EOD) tasks. Additional stakeholders, including the Ministry of Environmental Protection and Natural Resources and the Ministry of Infrastructure, hold statutory oversight of marine ecosystems and port operations, respectively. However, neither institution possesses the clearance capability nor the authority to conduct underwater EOD operations.

In contrast to landmine clearance, where an area is surveyed and cleared, it is typically certified as safe, aquatic mine action presents ongoing and dynamic risks. Shifting seabed and riverbed sediments, tidal currents, and storm surges can reintroduce or dislodge explosive hazards into previously cleared areas. Moored mines may drift into shipping lanes, while bottom mines can be exposed or reburied by sediment movement, necessitating continuous surveillance and repeated analysis of sonar and survey data against earlier baselines (Beck et al., 2025; Scharsack, Steinhagen, & Maser, 2021). This fundamental distinction underscores why institutions such as the NMAC, primarily designed to manage static, land-based hazards, lack

the expertise, mandate, and operational model to address maritime explosive threats. These unique challenges bolster the case for a specialized body with continuous monitoring, hydrographic expertise, and advanced underwater EOD capabilities.

The international partners, such as the United Nations Development Programme (UNDP), North Atlantic Treaty Organization (NATO), and the Organization for Security and Co-operation in Europe (OSCE), provide project-based support, including technical training, advisory services, and equipment donations. While these efforts are valuable, they often prioritize capacity building over establishing permanent, state-led demining capabilities, especially in aquatic environments.

5.2 Identified Gaps and Strategic Barriers

Several legal and institutional gaps hinder Ukraine's effective and comprehensive management of aquatic/maritime mine action. Firstly, there is no legally designated national authority for coordinating aquatic/maritime mine clearance operations. The division of responsibility between the SESU and the United Nations Office for the Coordination of Humanitarian Affairs (UNOCHA) remains informal and lacks clear legal delineation based on depth, function, or geographic area. This institutional ambiguity impedes operational planning, accountability, and international cooperation.

Secondly, the mandate of the NMAC does not encompass underwater threats. It lacks the legal foundation and operational capacity to regulate or support training, quality assurance (QA), quality control (QC), or clearance activities involving sea mines or underwater UXO. Furthermore, there is no national framework to train, certify, and validate divers or technicians involved in underwater EOD operations, whether in maritime or riverine (fluvial) environments.

Thirdly, environmental protection agencies encounter significant access and safety limitations. Although responsible for monitoring Ukraine's aquatic ecosystems, they lack clearance capabilities and rely on military or SESU escorts to access contaminated maritime zones. This restriction delays environmental response, pollution assessment, and incident investigation.

Finally, interagency coordination remains fragmented. Currently, there is no permanent mechanism to facilitate joint planning and execution between civilian, military, and donor stakeholders. This lack of coordination leads to duplication of effort, inconsistent funding streams, and diminished effectiveness of Ukraine's aquatic/maritime mine action response.

Key Gaps:

- Lack of legally mandated aquatic/maritime mine action authority
- NMAC's lack of jurisdiction or capacity for underwater clearance
- Absence of a national certification system for underwater EOD personnel
- Environmental agencies' limited access and clearance capability
- Interagency coordination is hindered by inconsistent mandates and support mechanisms.

6. Recommendations for Institutional and Legal Provisions Updates

To effectively address the legal and operational deficiencies in Ukraine's aquatic/maritime mine action framework, several institutional and legislative reforms could be recommended. Firstly,

Ukraine could establish a NMMAC, a dedicated authority responsible for overseeing all aspects of aquatic/maritime mine action. This governing body would coordinate clearance operations in Ukraine's territorial waters, EEZ and internal waterways, manage the certification of clearance operators and EOD divers, and serve as the central hub for liaison with the UPN, environmental agencies, and international donors.

Secondly, it is imperative to legally define jurisdictional boundaries between relevant institutions. Settle the separation of area of responsibility (AOR) and assign SESU responsibility for shallow waters (e.g., up to 10 meters depth) and the UPN for deeper maritime zones (starting at 10 meters depth). Formalizing this operational boundary in law would eliminate the current ambiguity and reduce overlaps or delays in mine clearance missions.

Furthermore, the mandate for underwater mine action should be formally transferred from the NMAC to the dedicated governing body such as proposed NMMAC. This would ensure that a aquatic/maritime-specialized institution manages underwater EOD, operator accreditation, environmental safety protocols, and quality control for underwater operations. NMAC would remain the central authority for land-based operations, while NMMAC would assume exclusive responsibility for maritime and riverine contexts.

A fourth recommendation is the establishment of a Joint Maritime Mine Action Council as a part of NMMAC or an additional independent council, which would function as an interagency coordinating body. This council should comprise representatives from the SESU, UPN, the MoD, the Ministry of Internal Affairs (MoI), the Ministry of Environmental Protection and Natural Resources, and key international observers such as the UNDP, NATO, or the OSCE. Its primary objective would be to harmonize national policies, mobilize donor assistance, and oversee cross-sectoral planning and response mechanisms.

Moreover, Ukraine's Law on Mine Action (Law No. 2642-VIII) and the Civil Protection Code should undergo amendments to incorporate specific provisions pertaining to maritime explosive threats. These revisions would establish the requisite legal framework for the establishment of the NMMAC and the formalization of interagency underwater mine action capabilities. Collectively, these reforms would substantially enhance Ukraine's institutional preparedness to mitigate the long-term environmental, economic, and security risks associated with sea mines and underwater UXO within its sovereign waters.

7. Conclusion

Ukraine's Black Sea territorial waters, EEZ, and internal waterways are heavily contaminated by sea mines and underwater UXO, posing a dual crisis: severe disruption of maritime trade, which once contributed up to 40% of national GDP, and escalating environmental threats, including long-term contamination and restricted access to ecological disaster sites. The current responsible agencies lack the mandates, technical capabilities, and coordination necessary to effectively manage these maritime-specific threats.

To address this issue, for Ukraine it is logical to promptly establish a NMMAC with the authority to oversee underwater EOD, diver certification, environmental safety measures, and interagency coordination. Legal provisions updates should clarify jurisdictional responsibilities between the SESU and the UPN and amend existing legal authorities to incorporate the aquatic/maritime dimension of explosive threats.

In the absence of dedicated aquatic/maritime demining capacity, Ukraine's recovery, trade reintegration, and environmental protection efforts will remain severely constrained. A coordinated national response with assistance from international donors is imperative to prevent long-term ecological and economic damage in the Black Sea region.

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Enclosures

1. Estimated Sea-Mine Threat Area of Ukraine Territorial Waters and EEZ in Northwest Part of Black Sea

Area mark in orange – estimated sea mines/underwater UXO threat area

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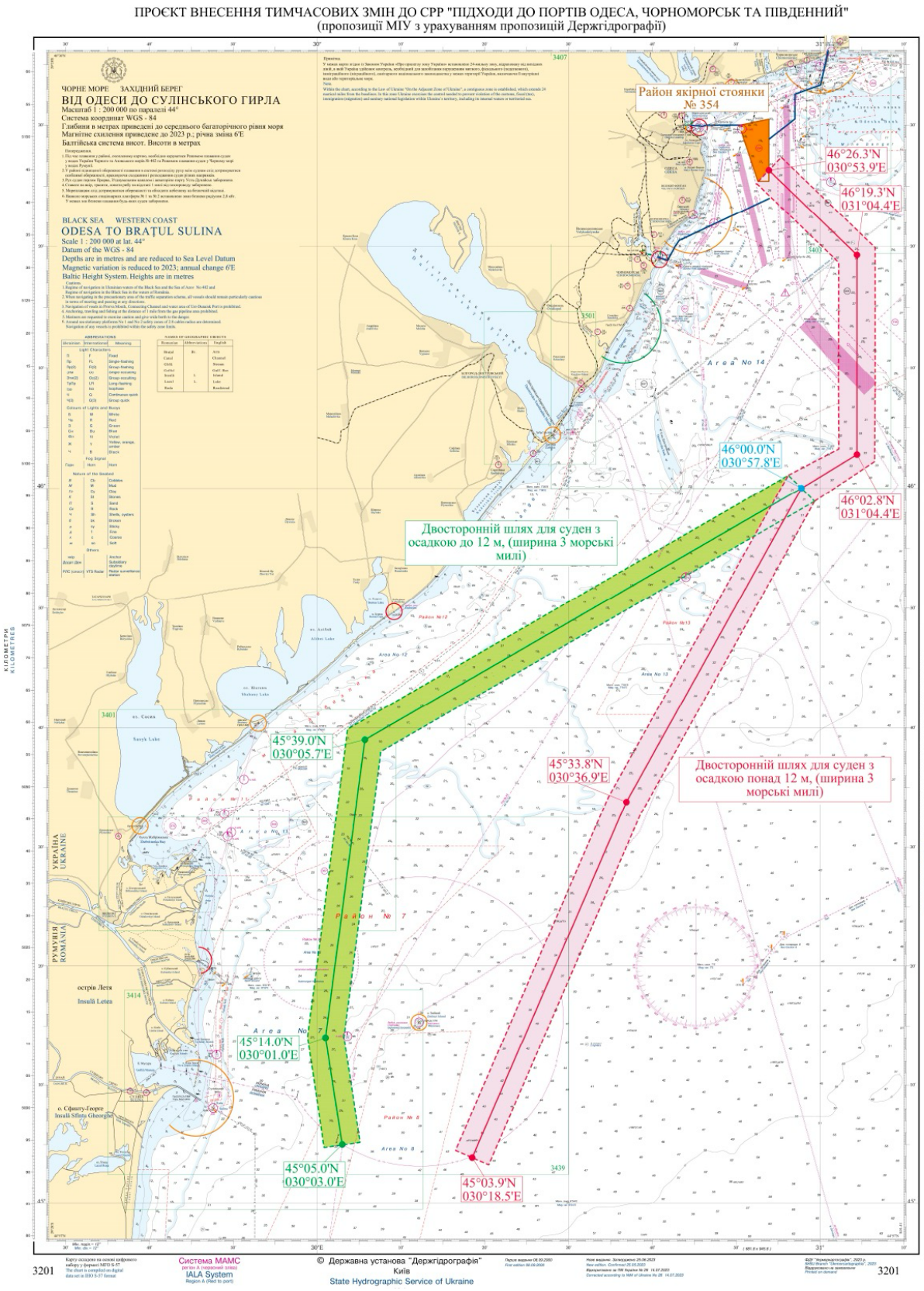
2. Ukraine Approved Approaches to the ports of Chornomorsk, Odesa and Pivdennyi as of July 19, 2023



3. Timeline of Key Incidents Related to Maritime Mine Threats in the Black Sea

Date	Incident	Description
Feb 24, 2022	Full-Scale Invasion	Russia launches full-scale invasion of Ukraine, including naval activity in Black Sea.
Mar 2, 2022	MV Helt Sinking	Estonian-owned cargo ship *MV Helt* sinks after striking a suspected mine near Odesa.
Apr 14, 2022	Moskva Sinking	Russian cruiser *Moskva* sinks after missile strike; wreck remains unassessed due to mines.
Jul 22, 2022	Black Sea Grain Initiative	UN/Türkiye-brokered deal enables grain exports; operations constrained by sea-mines risks.
Oct 2022–Dec 2023	Floating Mine Reports	Dozens of drifting sea mines reported by NATO, Romania, Bulgaria, and Turkey.
Jan 15, 2024	Fishing Vessel Incident	Ukrainian fishing boat damaged by a sea-mine near Mykolaiv; minor injuries to crew.
May 2024	Volgoneft-239 Oil Spill	Oil spill near Kerch Strait; response to cleanup Ukrainian shores hindered by nearby minefields.
Aug 2024	BSGI Collapse	Russia withdraws from Grain Deal; sea-mines threats escalate.
Q1 2025	Drafting of Clearance Plan	Ukraine proposes UN-backed sea-mine clearance strategy.

4. Table of Legal Provisions and Identified Gaps in Aquatic/Maritime Mine Action

Legal Instrument / Regulation	Current Scope	Gap / Limitation Identified
Law of Ukraine "On Mine Action" (No. 2642-VIII, 2018)	Regulates land-based humanitarian demining	No specific provisions for maritime explosive hazards or underwater clearance
Civil Protection Code of Ukraine	Addresses disaster response and emergency management	No clear assignment of underwater mine response roles or integration with MoD naval capabilities
Ministry of Defence Directives on Naval Operations	Covers military mine countermeasure (MCM) procedures	Not applicable to civilian humanitarian mine action, lacks environmental coordination
SESU Mandate under Cabinet Resolutions	Covers EOD and public safety response in land and coastal zones	Lacks authority for operations below 10 meters or offshore
NMAC Regulations	Governs operator accreditation and QA/QC for land demining	No underwater EOD certification mechanism, no diver accreditation framework
Environmental Protection Laws (MinEco, 2022 updates)	Provides standards for EIAs, marine pollution, biodiversity	No coordination mechanism with mine clearance entities for joint underwater hazard mitigation
Maritime Code of Ukraine (2004, as amended)	Regulates navigation, shipping, and marine infrastructure	No clauses addressing restoration of navigation following explosive contamination

Note: A comprehensive legal and regulatory update is essential to institutionalize a NMMAC, assign operational jurisdictions by depth and geography, and codify diver/EOD certifications, clearance standards, and environmental safeguards.