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Safeguarding the Blue Economy

*Legal Framework and War-Related
Marine Contaminants in the Black Sea Area*

Black Sea Sierra Project · Romanian Coastal Research Initiative

2026

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CONSTANȚA · ROMANIA · BLACK SEA REGION



COURSE OVERVIEW

50 minutes

01

Black Sea Context

02

Legal Framework

03

War Contaminants

04

Monitoring & Bioindicators

05

Conclusions & Discussion

Learning Objectives

Understand the unique environmental vulnerability of the Black Sea and the geopolitical threats posed by the Russo-Ukrainian war

Identify and apply the key international conventions, EU directives, and Romanian national legislation protecting the Black Sea marine environment

Recognise and classify war-related marine contaminants: heavy metals, explosives (TNT/RDX), oil spills, and other types of chemical munitions

Describe monitoring programmes, bioindicator species, and sampling strategies used in the Black Sea Sierra Project

Evaluate the role of EU environmental policy within the Blue Economy strategy for sustainable maritime development



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01

The Black Sea Context

Vulnerability, geopolitics, and environmental stakes in the north-western Pontic Basin



The Black Sea: A Uniquely Vulnerable Marine Ecosystem



Low Salinity

Varies from 3‰ to 21‰ — far below typical ocean levels. Unique brackish environment highly sensitive to chemical inputs.

Counter-Clockwise Currents

Surface currents circulate anti-clockwise on the western side, spreading pollutants toward Romanian coastal areas.

Anoxic Deep Waters

Lack of oxygen below ~150 m favours H_2S deposits due to anaerobic bacteria — a 'closed' basin with no deep-water renewal.

Enclosed Basin

~80% of pollutant input comes from land-based activities, the Danube River, and maritime economic zones under continuous conflict pressure.

Geopolitical Pressure

War in the north of the Pontic Basin since 2022 generates acoustic pollution, chemical contamination, and naval mine hazards.

Industrial Coastline

Petrochemical plants (Rompetrol/Midia), Midia shipyard, and NATO military polygon at Cap Midia compound pollution risks.

The Russo-Ukrainian War: Environmental Consequences for the Black Sea

Key Environmental Threats

Naval Mines

Drifting mines carried by Black Sea currents endanger the entire western Pontic Basin, including Romanian waters.

Chemical Munitions

Explosives containing heavy metals (Pb, Cd, Hg, As, Sb, Cu, Zn) and TNT/RDX compounds dissolve into sediments and water columns.

Infrastructure Damage

Destruction of oil & gas infrastructure, refineries, and port facilities releases hydrocarbons and industrial chemicals.

Acoustic Pollution

Military operations generate significant noise pollution affecting marine mammals, fish migration, and ecosystem structure.

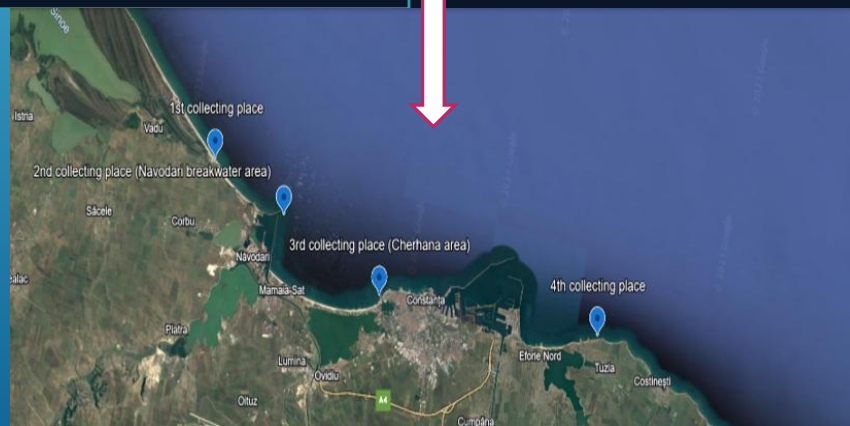
"The Ukraine war has not only affected the civilian population but has caused environmental damage that will be felt by future generations."

~80%

of pollutants from land-based
& shipping activities

4

key sampling zones identified
along Romanian coast





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02

Legal Framework

International conventions, EU directives & Romanian national legislation



International Conventions Governing Marine Pollution in Armed Conflicts

UNCLOS 1982

UN Convention on the Law of the Sea

Arts. 192–237 mandate states to prevent, reduce and control marine pollution from all sources including armed conflict. Provides the overarching legal architecture for Black Sea protection.

MARPOL

International Convention for Prevention of Pollution from Ships (IMO)

Sets binding standards for oil, noxious chemicals, sewage, garbage, and air pollutant discharges from ships. Romania is signatory. Applies even in conflict scenarios.

Barcelona Conv. 1976

Barcelona Convention (UNEP — Mediterranean/Black Sea Region)

Regional agreement addressing marine pollution including from armed conflicts. Creates a framework for transboundary cooperation applicable to the Black Sea sub-region.

Geneva Conv. 1949

Geneva Conventions & Additional Protocols (1977)

Although focused on humanitarian law, Additional Protocol I (Art. 55) explicitly prohibits methods of warfare causing widespread, long-term, and severe damage to the natural environment.

Hague Conv. 1907

Hague Convention IV — Laws & Customs of War

Foundational treaty minimising environmental damage during armed conflict. Principles continue to influence customary international humanitarian law in marine contexts.

ILC Principles 2022

ILC Principles on the Protection of the Environment in Relation to Armed Conflicts (2022-ILC PERAC Principles (2022))

Principle 13: prohibits methods of warfare causing widespread, long-term & severe environmental damage. **Principle 14:** IHL principles (distinction, proportionality, precaution) apply to the environment.

European Union Directives: The Core Legal Framework

WFD — Directive 2000/60/EC

Water Framework Directive (2000)

- ▶ Objective: "good ecological and chemical status" for all water bodies
- ▶ Establishes unified monitoring & pollution prevention at source
- ▶ Foundation for all EU water quality standards applicable to coastal zones
- ▶ Directly links to the Blue Economy strategy for sustainable marine development
- ▶ Romania transposed WFD into national law upon EU accession

MSFD — Directive 2008/56/EC

Marine Strategy Framework Directive (2008)

- ▶ Target: seas to be "productive", "healthy" and "clean"
- ▶ Links marine environmental goals to the EU Blue Economy agenda
- ▶ Requires ecosystem-based approach to marine management
- ▶ Zero Pollution Action Plan (2022) extends MSFD ambitions to 2050
- ▶ Romania: transposed by Law 6/2011 — strategy for good environmental status

Interconnected

Romanian National Legislation & International Commitments

Law 17/1990

1990

Law 17/1990

Marine Environment Protection

Establishes the legal regime for inland maritime waters, territorial sea, contiguous and exclusive economic zone. Prevention and control of pollution from all sources.

Law 36/2002

2002

Law 36/2002

Amendment to Law 17/1990

Strengthens the regulatory framework on the legal regime of internal maritime waters and territorial sea, aligning with UNCLOS obligations.

Law 6/2011

2011

Law 6/2011

Marine Strategy Transposition

Transposes the EU Marine Strategy Framework Directive (2008/56/EC) into Romanian law, establishing targets for good environmental status of marine waters.

2030 Agenda

2015

2030 Agenda

UN Sustainable Development Goals

Romania committed to SDG 14 (Life Below Water) at the UN Development Summit, integrating marine conservation into national sustainable development strategy.

Zero Pollution

2022

Zero Pollution

EU Zero Pollution Action Plan

Romania as EU Member State committed to this ambitious plan to reduce air, water and soil pollution to levels no longer harmful to human health or ecosystems.

Correlation: IMO Conventions ↔ EU Directives ↔ Romanian Legislation

IMO Convention	Subject Matter	EU Directive(s)	Romanian Law
MARPOL 73/78	Prevention of Pollution from Ships	Dir. 2008/56/EC Dir. 2005/35/EC	Law 17/1990 HG 530/2023
UNCLOS 1982	Law of the Sea — Art. 192–237	Dir. 2000/60/EC MSFD 2008/56/EC	Law 17/1990 Law 6/2011
SOLAS 1974	Safety of Life at Sea / Ship Structural Safety	Dir. 2009/45/EC	OGRN Ordinance 15/2001
London Conv. 1972/1996	Dumping of Wastes at Sea	Dir. 2008/56/EC	Law 17/1990 Law 6/2011
OPRC 1990	Preparedness, Response, Cooperation — Oil Pollution	Dir. 2013/30/EU	Emergency Plans MAR Authority
CLC/FUND 1992	Civil Liability for Oil Pollution Damage	Dir. 2008/56/EC	Law 17/1990 HG decisions



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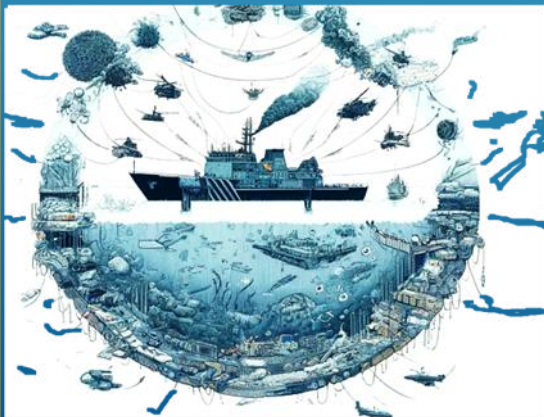
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SECTION

03

War-Related Marine Contaminants

Heavy metals, explosives, hydrocarbons & chemical hazards from military operations



afeguarding



Heavy Metal Contamination from Military Operations

Sources of Heavy Metal Release

- Bullets & Projectiles**
Pb, Cu, Zn, Sb in bullet cores and mantles
- Naval Mines**
Mine body, internal components, explosive primers (Pb, Cd, Hg)
- Artillery & Rockets**
Tracer materials, propellants contain As, Sr, W, Cr
- Chemical Munitions**
Fuel, safety and explosive primers — cadmium, mercury compounds
- Shipwrecks**
Corroding hulls and weapons release metals into sediment columns
- Military Exercises**
Cap Midia NATO training area — repeated firing impacts coastal sediments

Key Heavy Metals of Concern

Pb	Lead	Cd	Cadmium	Hg	Mercury	As	Arsenic
Cu	Copper	Zn	Zinc	Sb	Antimony	Sr	Strontium
W	Tungsten	Cr	Chromium	Ni	Nickel	Fe	Iron

Environmental Fate & Transport

- Heavy metals from bullet casings and mine corrosion settle into marine sediments, remaining bioavailable for decades
- Counterclockwise Black Sea currents carry contaminated sediment plumes toward Romanian coast from Ukrainian war zones
- Bioaccumulation occurs in *Mytilus galloprovincialis* mussels, *Rapana venosa*, and *Pontogammarus maeoticus* (key bioindicators)
- Levels in training areas (Pb, Cu, Zn) significantly exceed background concentrations (Hong & Hyun, 2014)

Explosive Ordnance Contamination: TNT, RDX & Related Compounds

TNT — 2,4,6-Trinitrotoluene

& 2,4-Dinitrotoluene (DNT)

- ◆ Nitrobenzene-based organic compound — tends to BIND to organic matter in sediment
- ◆ Less mobile in water than RDX when organic matter is present
- ◆ Risk increases dramatically in sandy, low-organic soils (e.g., Black Sea coastal sands)
- ◆ Dissolution rate linked to temperature — warmer Black Sea waters accelerate release
- ◆ Toxic to marine organisms at low concentrations; persistent in sediment for decades
- ◆ Present in naval mines, torpedoes, artillery shells, and depth charges

RDX — 1,3,5-Trinitro-1,3,5-Triazine

(Royal Demolition Explosive / Cyclonite)

- ◆ Organic nitramine compound — HIGH water solubility and groundwater/surface water mobility
- ◆ Does NOT bind readily to sediment → disperses more widely through water column
- ◆ Greater threat as a dissolved pollutant than TNT in aquatic environments
- ◆ Highly toxic to marine invertebrates, fish, and benthic organisms
- ◆ Adsorption mechanism: contaminant adheres to soil/sediment particles (immobilised)
- ◆ Degradation: breaks down into toxic metabolites — all with potential environmental impact

Chemical reactions and their impact during the detonation of a naval mine



The primary detonation reaction:



Secondary reactions:



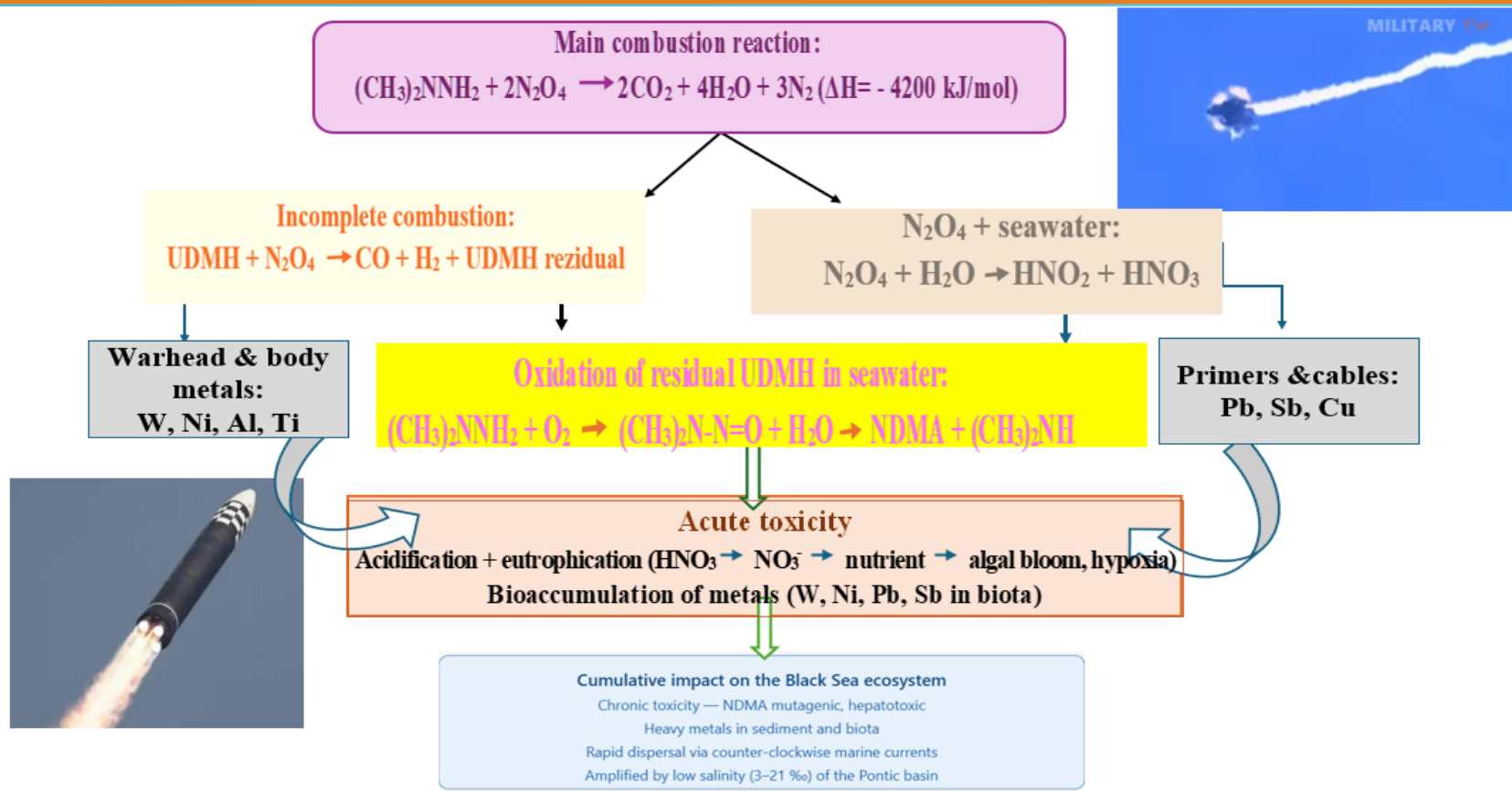
Heavy metals released from the primer and the mine body:
Pb (body, primer); Fe (casing); Cu (wiring); Sb, Sr (fuse); Zn, Ni (coatings)

Incomplete detonation:
 $\text{TNT residual} \rightarrow 2\text{-ADNT} + 4\text{-ADNT} + 2,4\text{-DANT}$
(anoxic reduction in sediment)

Local acidification
Bioaccumulation of metals
Chronic toxicity (mutagenic TNT/NTDA, carcinogenic in biota)



Chemical reactions and their impact during the detonation of a ballistic rocket



Additional War-Related Contaminants & Environmental Pathways

Hydrocarbons & Oil

- Fuel spills from damaged naval vessels and oil infrastructure
- Rompetrol (Midia) refinery at heightened risk from conflict-related incidents
- PAHs (Polycyclic Aromatic Hydrocarbons) — carcinogenic, persist in sediments
- Mineral resource exploitation from Black Sea continental shelf at risk

Acoustic Pollution

- Naval exercises, submarine activity, and explosions generate intense noise
- Proven impacts on cetacean navigation, fish schooling, and larval settlement
- NATO Cap Midia polygon — regular exercises in Romanian coastal zone
- Monitoring requires dedicated annual acoustic campaigns (CTD + hydrophones)

Emerging Pollutants

- Pharmaceuticals, hormones, and surfactants from displaced civilian populations
- Pesticides from destroyed agricultural infrastructure entering river systems
- PCBs from damaged electrical and military infrastructure
- Dioxins from fires and industrial destruction — highly persistent and toxic

Microplastics & Debris

- Destruction of coastal infrastructure releases plastic materials into sea
- Military packaging, equipment, and uniforms fragment into microplastics
- Accumulate in surface waters, sediments and within bioindicator tissues
- Black Sea is already one of the most microplastic-polluted enclosed seas globally



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SECTION

04

Monitoring & Bioindicators

Sampling design, bioindicator species, and quality assessment methodology



Black Sea Sierra Project: Monitoring Programme Design

ISO Standards Applied

- ✓ ISO 5667-1:2020 — Sampling programme design
- ✓ ISO 5667-3:2018 — Preservation & handling
- ✓ ISO 5667-19:2004 — Marine sediment guidance

Campaign Schedule

2
campaigns/year

water, sediment
& bioindicators

+ 1 acoustic campaign/year

Sampling Locations

1. Corbu-Poligon trageri
2. Cap Midia Beach
3. Pescarie Constanta
4. Tuzla area

CTD Sensor Package — In-Situ Monitoring Parameters

Conductivity

Temperature

Depth/Pressure

Dissolved O₂

pH

Salinity

Turbidity

Microplastics

Heavy Metals

PAHs/PCBs

Emerging Pollutants

Pesticides

Black Sea Sierra Project: Monitoring Programme Design



Summer campaign

Winter campaign



Marine Bioindicator Species: Sentinels of Black Sea Health

Mediterranean Mussel

Accumulation Bioindicator

Mytilus galloprovincialis

- Filter feeder — accumulates microplastics, heavy metals, PAHs, PCBs, pesticides, dioxins
- Sessile: reflects local pollution levels without migration bias
- Widely studied in Black Sea — extensive baseline data available
- High stress response sensitivity — ideal for molecular & physiological studies
- Present year-round in Romanian coastal zones



Veined Rapa Whelk (Gastropod)

Reaction Bioindicator

Rapana venosa

- Tolerates low salinity, extreme temperatures, pollution, and low oxygen
- Bioaccumulates heavy metals — reflects toxic effects at tissue level
- High fertility & fast development rate — population dynamics measurable
- Key tool for assessing chemical pollutant toxicity in coastal areas
- Studies confirm heavy metal accumulation: Pb, Cd, Hg, As, Cu (Bat et al., 2022)



Ponto-Caspian Amphipod Crustacean

Novel Bioindicator (Black Sea Sierra)

Pontogammarus maeoticus

- Native species — occupies shallow sandy habitat (0–1.5 m depth)
- Collected easily along northern Romanian coast year-round
- Tolerates 0–20‰ salinity and temperatures as low as 2–3°C
- Detritivorous: absorbs heavy metals & hydrocarbons from sediment
- Under-studied — novel research potential for Black Sea Sierra Project



Seawater Quality: Assessment, Monitoring & Management Cycle

MONITORING

1

Systematic data collection at regular intervals:

- Physical: temp, colour, turbidity, salinity
- Chemical: pH, dissolved O₂, nutrients, metals
- Biological: species composition, biomarkers
- Technology: CTD sensors, satellite imaging, automated buoys

ASSESSMENT

2

Analysis of collected data to understand implications:

- Trend analysis — detecting environmental stress signals
- Impact analysis of human activities (ports, war, industry)
- Algal bloom prediction from nutrient loading data
- Future scenario modelling under different impact

MANAGEMENT

3

Policy & enforcement to preserve seawater quality:

- Marine Protected Areas (MPAs) for vital habitats
- Waste disposal regulations at sea (MARPOL aligned)
- Sustainable fishing guidelines — Blue Economy link
- Romania: Law 17/1990, Law 6/2011, SDG 14 commitments

FEEDBACK LOOP

4

Continuous re-evaluation adapting to new data:

- If data shows deterioration → stricter regulations triggered
- If quality improves → policy adjusted to enhance resilience
- Compliance monitoring enforces regulatory requirements

Continuous Adaptive Loop — informed by MSFD, WFD, and national enforcement mechanisms

Research Gaps, Future Directions & Discussion Questions

Key Research Gaps

- ⚠ Lack of pre-conflict baseline data for many Black Sea contamination parameters
- ⚠ *P. maeoticus* as bioindicator: near-absent literature — novel research opportunity
- ⚠ Limited data on acoustic pollution impacts on Black Sea fish and mammal populations
- ⚠ No standardised war-contaminant monitoring protocols endorsed by EU/IMO
- ⚠ Insufficient cross-border data sharing between Black Sea riparian states during conflict

Future Directions

- Develop specific EU legislative proposals for conflict-zone marine contamination
- Establish post-war Black Sea remediation fund (similar to Gulf War precedent)
- Implement real-time autonomous buoy network along Romanian coast
- Validate *P. maeoticus* as novel bioindicator — publish first standard reference
- Coordinate Black Sea riparian states monitoring under UN Environment Programme

Discussion: Should the EU adopt a specific Directive for marine environmental protection in armed conflict zones? What would it look like, and how would it interact with MARPOL and UNCLOS?



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SECTION

Conclusions & Discussion

05

Policy recommendations, research gaps, and the Blue Economy imperative



Key Takeaways & Policy Recommendations

01

Legal Framework is Robust — Enforcement is the Challenge

UNCLOS, MARPOL, Geneva Conventions, WFD, MSFD, and Romanian national laws provide a comprehensive legal architecture. The critical gap is in enforcement capacity during active armed conflict, where IMO and EU mechanisms face jurisdictional constraints.

02

War Contaminants Require Specialised Monitoring

Standard environmental monitoring was not designed for conflict-related contamination. Heavy metals (Pb, Cd, Hg, As), explosives (TNT, RDX), and hydrocarbon spills demand tailored sampling protocols, bioindicator networks, and the application of advanced ISO sampling standards.

03

Bioindicators Are the Most Powerful Early-Warning Tools

M. galloprovincialis, *R. venosa*, and *P. maeoticus* (novel) provide cumulative, cost-effective, and ecologically meaningful data on contamination levels — surpassing one-off water sampling for detecting persistent war-related pollutants.

04

Blue Economy Depends on a Healthy Black Sea

Fishing, tourism, maritime transport, offshore energy, and aquaculture — Romania's coastal economy — are directly threatened by unaddressed war contamination. Protecting marine ecosystems is not just an environmental obligation but an economic imperative.

05

Transboundary Cooperation is Non-Negotiable

The Black Sea's counterclockwise current system means Ukrainian war contaminants reach Romanian, Bulgarian, and Turkish waters. Regional coordination mechanisms (BSC, EU, UN) must be activated to establish post-conflict environmental remediation programmes.

Thank You

Safeguarding the Blue Economy: Legal Framework and War-Related Marine Contaminants in the Black Sea Area

Key References & Standards

- EU WFD — Directive 2000/60/EC | EU MSFD — Directive 2008/56/EC
- UNCLOS 1982 | MARPOL (IMO) | Geneva Conventions 1949 + Protocols 1977
- UN ILC Draft Principles on Environment in Armed Conflicts (2022)
- Romanian Law 17/1990, Law 6/2011 | ISO 5667 Series (2004–2020)
- Black Sea Sierra Project (2024)

