



Black Sea SIERRA – Project 101124670

Training Courses



Co-funded by
the European Union

Piloting session: UkrSCES (Ukraine)

Marine Macrolitter and Military-Related Debris in the Black Sea (Ukrainian sector)

Monitoring Methods, Citizen Science and Environmental Data Analysis

Date: 15th July 2026

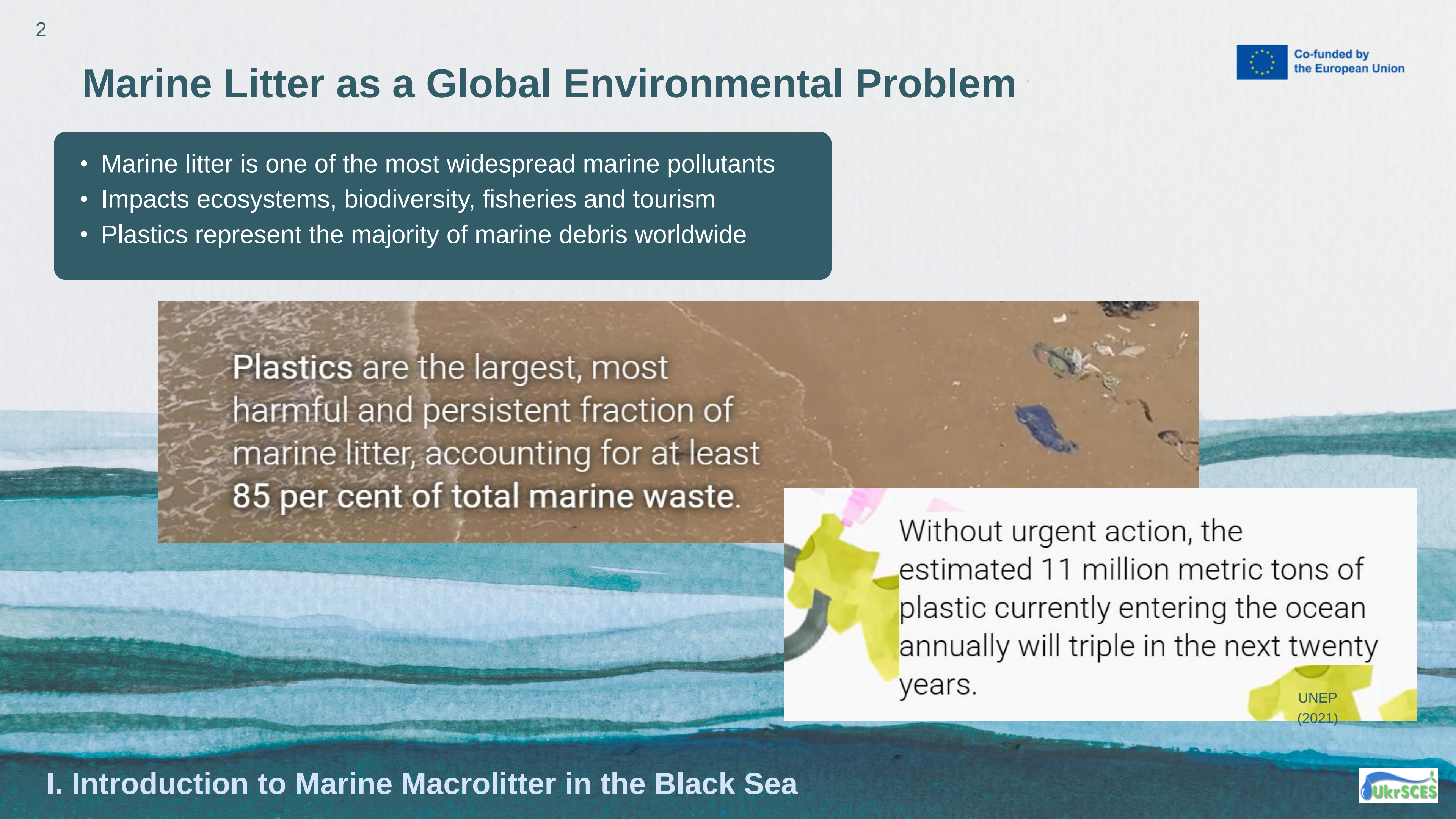
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Ukrainian Scientific Centre of Ecology of the Sea (UkrSCES)



Marine Litter as a Global Environmental Problem

- Marine litter is one of the most widespread marine pollutants
- Impacts ecosystems, biodiversity, fisheries and tourism
- Plastics represent the majority of marine debris worldwide



Plastics are the largest, most harmful and persistent fraction of marine litter, accounting for at least 85 per cent of total marine waste.

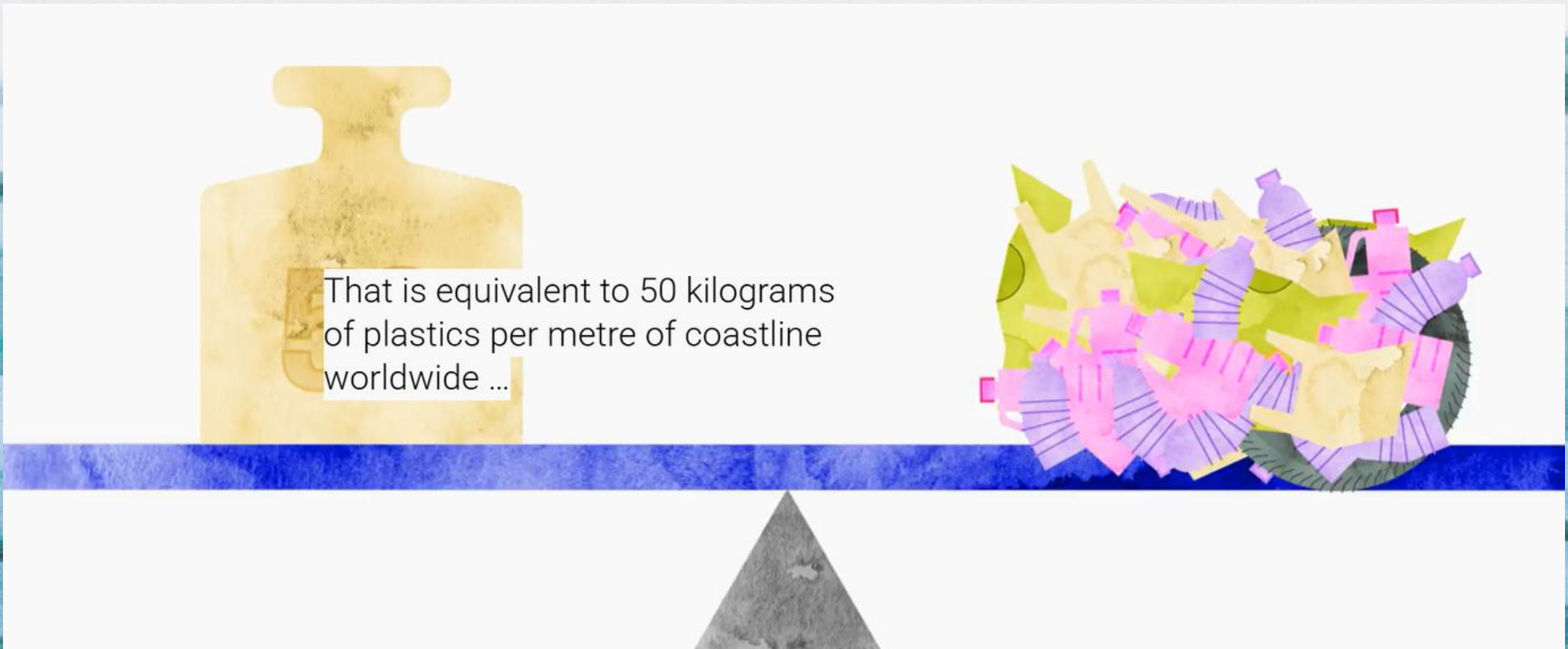
Without urgent action, the estimated 11 million metric tons of plastic currently entering the ocean annually will triple in the next twenty years.

UNEP
(2021)

Marine Litter as a Global Environmental Problem

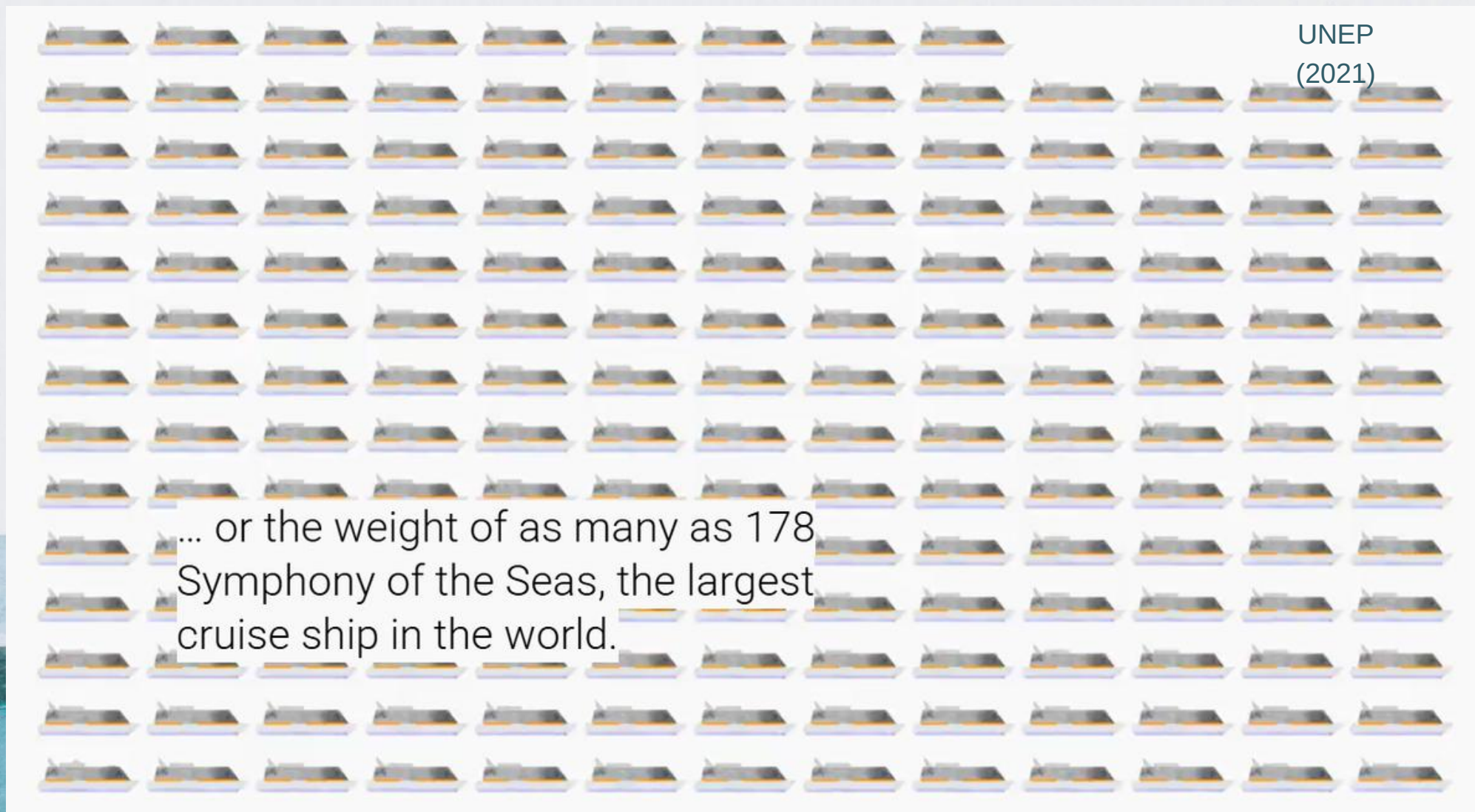
This would mean between 23 and 37 million metric tons of plastic flowing into the ocean every year by 2040.

UNEP (2021)

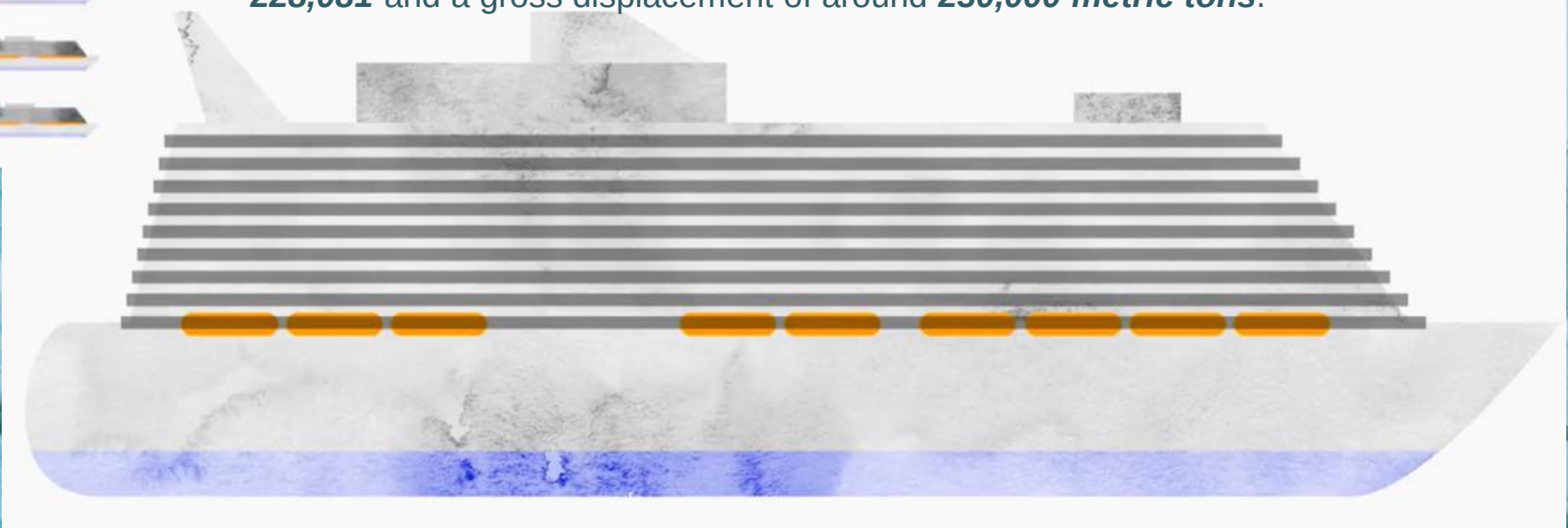


That is equivalent to 50 kilograms of plastics per metre of coastline worldwide ...

Marine Litter as a Global Environmental Problem



The cruise ship “***Symphony of the Seas***” has a gross tonnage of approximately **228,081** and a gross displacement of around **230,000 metric tons**.



Marine Litter as a Global Environmental Problem

Seabirds peck at plastics because it smells and looks like food.



UNEP (2021)

Marine mammals, sea turtles and other animals often drown after becoming trapped in lost or discarded plastics including packaging or fishing gear.



A leading cause of death for North Atlantic right whales, one of the world's most critically endangered whales, is being ensnared in ghost fishing gear.



What is Marine Macrolitter?

Marine macrolitter refers to human-made items larger than 25 mm found in marine and coastal environments.



Distinction:

- **Macrolitter** (>25 mm)
- **Mesolitter** (5–25 mm)
- **Microplastics** (<5 mm)

Standardized classification allows comparison of monitoring results between regions.

Definition and Classification

Material Classification - items are categorized into specific groups based on the **Joint List of Categories of Marine Litter**, which includes:



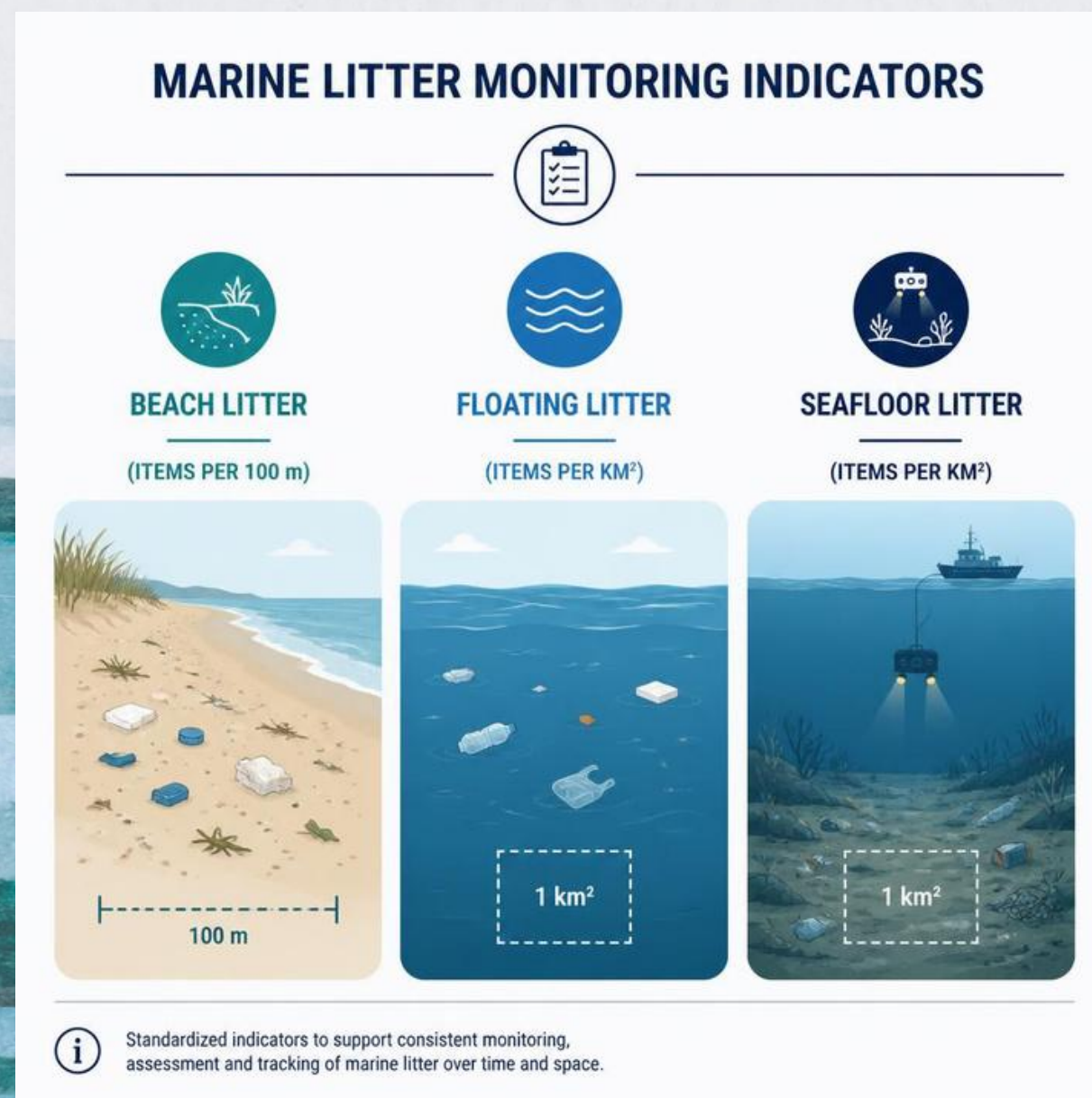
10. The Joint List of Litter Categories (J-CODE list)

Type-Code	J-Code	G-Code	Name	Definition
CHEMICALS				
ch_nn_drk_	J216		unidentified generally dark-coloured oil-like chemicals	Unidentified generally dark-coloured oil-like chemicals, i.e. no chemical analysis carried out.
ch_nn_lig_	J217		unidentified generally light-coloured paraffin-like chemicals	Unidentified generally light-coloured paraffin-like chemicals, i.e. no chemical analysis carried out.
ch_nn_uch_	J218		unidentified chemicals	Any unidentified chemicals, i.e. no chemical analysis carried out.
Cloth/Textiles				
ct_cl_clg_	J137	G137	clothing	Any type of clothes, garments and headwear made of natural or artificial polymer materials.
ct_cl_ftw_	J138	G138	shoes & sandals made of leather and/or textile	Various types of footwear, such as shoes and sandals made of leather and/or textile.
ct_nn_cpt_	J141	G141	cloth textile carpet & furnishing	Thick woven fabric used for covering the floor or other fabric used for furniture, fittings, and other decorative house accessories such as curtains.
ct_nn_sac_	J140	G140	hessian sacks/packaging	Sacks and other packaging items made of a strong, coarse fabric from hemp or jute (Hessian).
ct_nn_sal_	J143	G143	sails, canvas	A heavy durable cloth made of cotton, hemp, or jute, used for sails, tents, etc.
ct_nn_tex_	J145	G145	other textiles	Other textile items, including pieces of cloth, rags, etc. that are unidentifiable, as well as other identifiable cloth textile items, which do not fit in any other category of this list.
ct_re_bps_	J139	G139	cloth textile backpacks & textile bags	Textile receptacles with an opening at the top, shoulder straps or a handle, used for carrying things.
FOOD WASTE				
fw	J215	G215	food waste	All types of anthropogenic non-packaged food and food remains.
GLASS/CERAMICS				
gc_co_btc_	J204	G204	glass ceramic construction materials (bricks, tiles, cement)	Any glass and ceramic material which is used for construction purposes such as brick, roof tiles, floor tiles, bricks, cement, etc.
gc_fc_tab_	J203	G203	glass and ceramic tableware (plates/cups/glasses)	Glass or ceramic dishes or dishware used for serving food and dining, plates, cups, glassware, serving dishes and other useful items for practical as well as decorative purposes.
gc_fi_trp_octo_	J207	G207	ceramic or glass octopus pots	Pots made of pottery, weighted with concrete, and typically having a volume of 4 litres. Octopus seeking refuge in the pots can be trapped.
gc_nn_b&c_bott_	J200	G200	glass bottles	Glass or ceramic containers with a narrow neck, used for storing drinks or other liquids. Includes pieces of glass that can be identified as coming from a bottle.

- **Artificial Polymer Materials:** the dominant category (plastics and polystyrene), often accounting for over 80–90% of found items.
- **Rubber:** tyres, balloons, and footwear.
- **Cloth/Textiles:** clothing, rugs, and rags.
- **Processed Wood:** pallets, crates, and fragments of timber.
- **Metals:** beverage cans, foil, and industrial scraps.
- **Glass/Ceramics:** bottles, jars, and light bulbs.
- **Paper/Cardboard:** packaging and napkins.

Marine Litter in the Black Sea

The Black Sea is considered a hotspot for marine litter accumulation.



Key monitoring indicators include:

- **Beach litter** - items per 100 m coastline
- **Floating litter** - items per km²
- **Seafloor litter** - items per km² or kg per km²

Some coastal hotspots may exceed 500–1000 items per 100 m.

Main Sources of Marine Litter

Marine litter originates from multiple land- and sea-based sources:

- Riverine inputs
- Coastal cities and urban runoff
- Tourism and recreational activities
- Fisheries and aquaculture
- Shipping and maritime transport
- Waste mismanagement



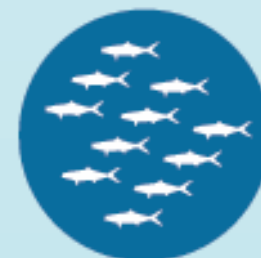
ECONOMIC ACTIVITIES IMPACTED BY MARINE LITTER



SHIPPING



FISHING



AQUACULTURE



TOURISM



RECREATION

Major rivers transport waste from large catchment areas to the sea.

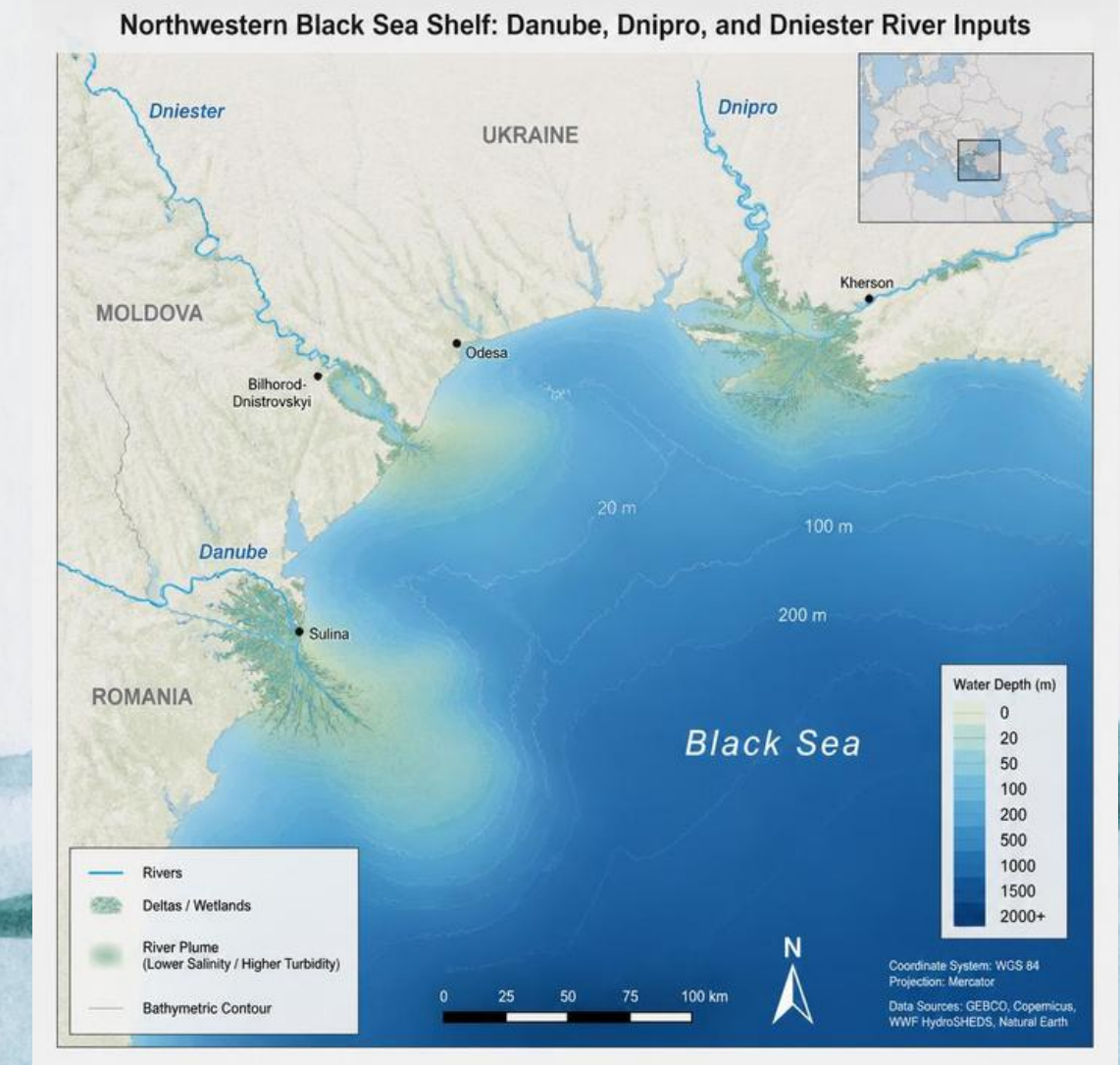
II. Main Sources of Marine Macrolitter

Riverine Transport of Marine Litter

Rivers are among the most significant sources of marine litter.

Key rivers influencing the north-western Black Sea:

- The Danube: as the most significant contributor, the Danube carries litter from 10 European countries. Surveys indicate it **can discharge between 6 and 50 items of litter per hour** into the Black Sea.
- The Dniester and Dnipro: these rivers contribute significantly to the litter load near major coastal hubs like Odesa. The *Dnipro-Black Sea-Danube water route* is a critical corridor for both natural flow and anthropogenic transport.
- Accumulation Zones: high densities of floating marine macrolitter (FMML) are frequently observed in the territorial sea (within 12 NM) near river mouths and the Odesa region.



These rivers transport plastic waste, packaging materials and urban debris from inland regions to the marine environment.

II. Main Sources of Marine Macrolitter

Coastal and Maritime Sources

Important sea-based sources include:

- Lost or abandoned fishing gear ("**ghost gear**" [lost or discarded nets], lines, and plastic floats are common in both coastal and benthic surveys)
- Aquaculture equipment
- Waste generated by shipping activities (**operational waste**, despite international regulations (MARPOL), accidental or illegal discharge of galley waste, packaging, and shipping-related debris continues to contribute to the benthic litter load)
- Recreational boating and tourism

Typical items recorded:

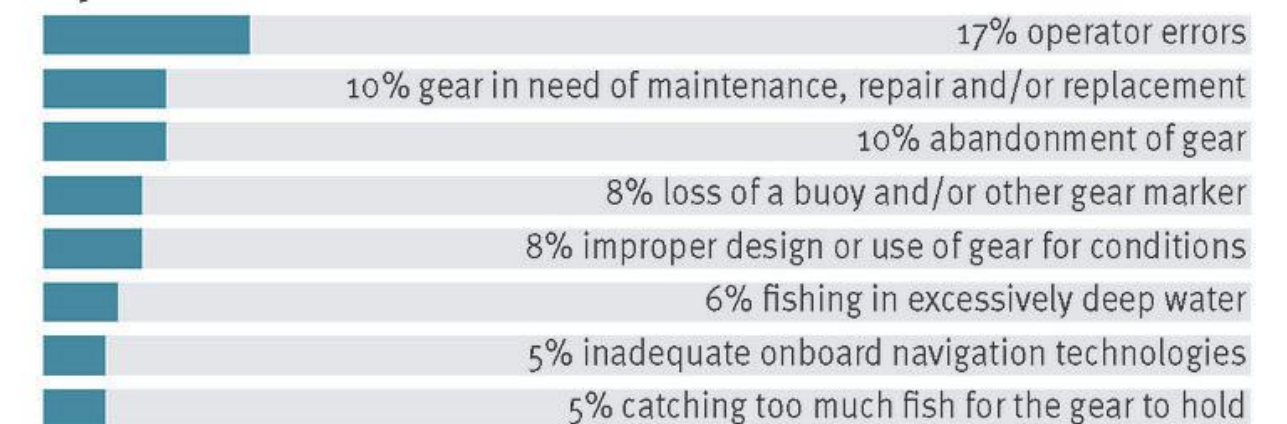
- Fishing nets and ropes
- Plastic containers
- Packaging materials
- Polystyrene fragments

Common causes of abandoned, lost or otherwise discarded fishing gear

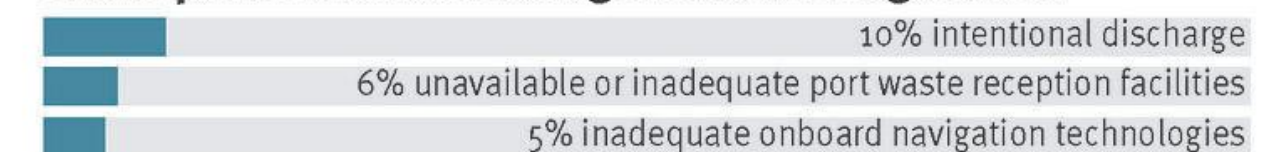
Environmental



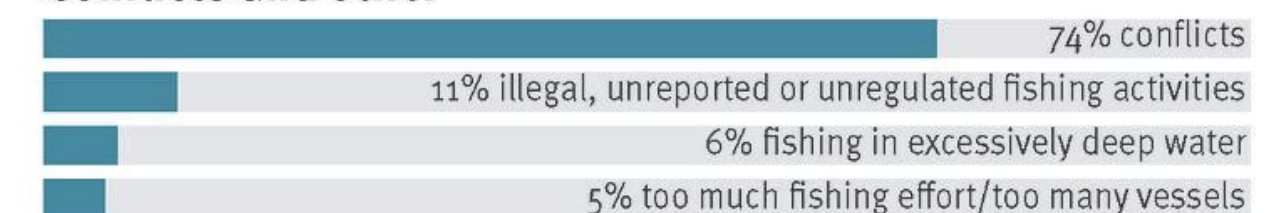
Operational



Inadequate fisheries management and regulation



Conflicts and other



The numbers show the percentage of studies reporting the listed specific causes of ALDFG. Based on a review of 176 reports over which 58% reported causes for ALDFG.

Source: MEPC (2020).

Illustrated by GRID-Arendal (2021).

UNEP (2021). Drowning in plastics – Marine Litter and Plastic Waste Vital Graphics.

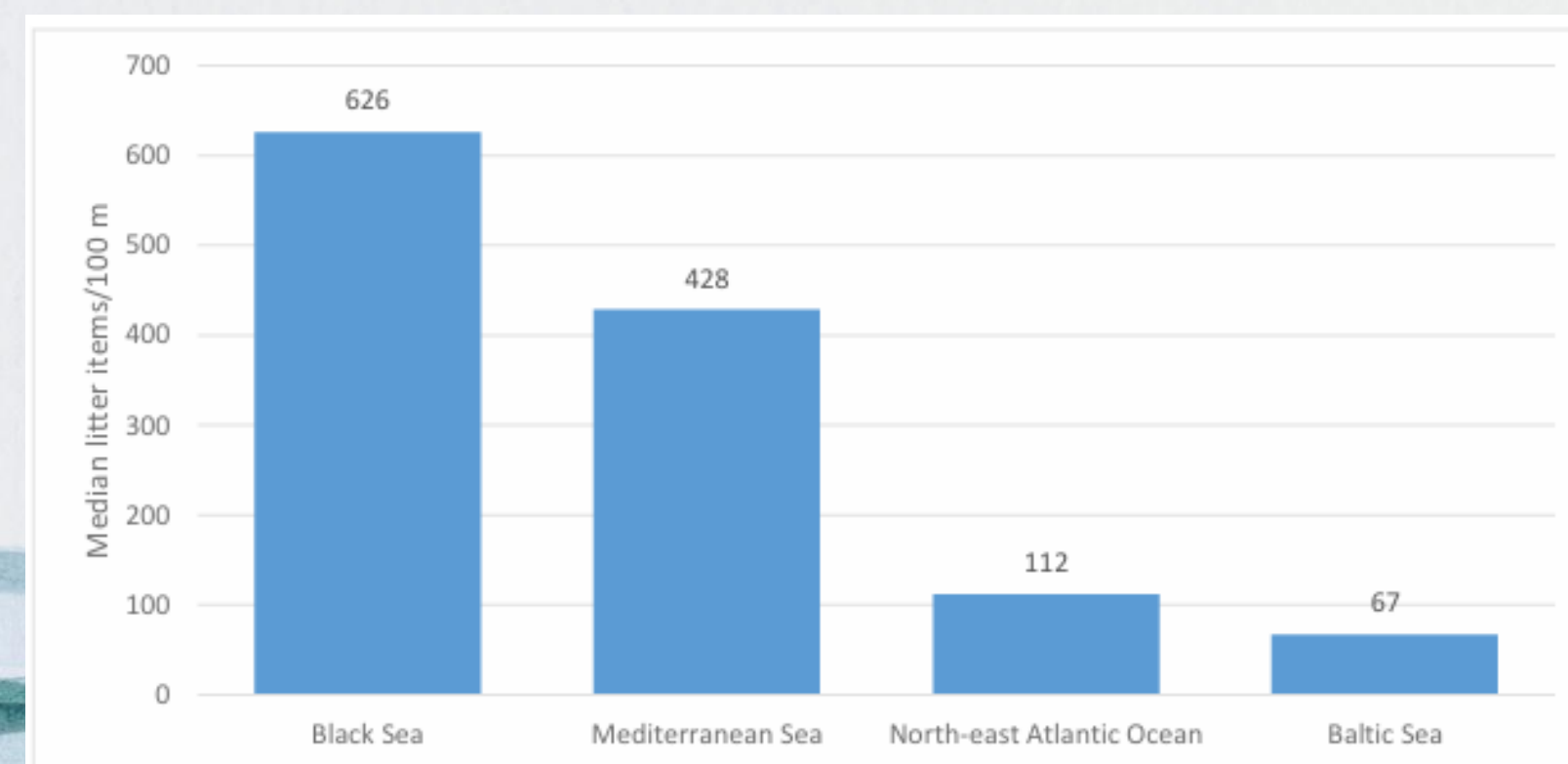
II. Main Sources of Marine Macrolitter

Marine Litter in Coastal Ecosystems

Densely populated coastal cities and seasonal tourism are major localized sources of macrolitter.

- **Urban Centers**: such as Odesa, Chornomorsk, and Pivdennyi contribute significantly to land-based waste through urban runoff and inadequate waste management.
- **Tourism Impact**: during the summer season, beach litter abundance spikes. Plastics (bottles, packaging, and bags) account for approximately 83% of the litter found, much of which is directly linked to recreational activities on the shore.

Median litter levels (items/100 m) found on the beaches of EU regional seas during 2015–2021 based on Marine Litter Watch monitoring data



Beach monitoring often reveals the following litter items:

- Plastic bottles and packaging
- Cigarette butts
- Food containers
- Fishing gear fragments
- Polystyrene foam

II. Main Sources of Marine Macrolitter

Land-based Waste Mismanagement

The overall litter load is exacerbated by systemic issues in waste handling across the river basins and coastal zones.

Specialists from the Schmalhausen Institute of Zoology of the NAS of Ukraine conducted necropsies on nine marine mammals found dead on the Odesa Oblast coastline



- **Illegal Dumping:** waste dumped in floodplains of the Dnipro and Dniester rivers is frequently mobilized during high-water events or heavy rains, leading to "pulses" of macrolitter entering the shelf.
- **Infrastructure Gaps:** inadequate storm-water filtration in coastal municipalities allows smaller macrolitter items to bypass treatment and enter the marine environment directly.

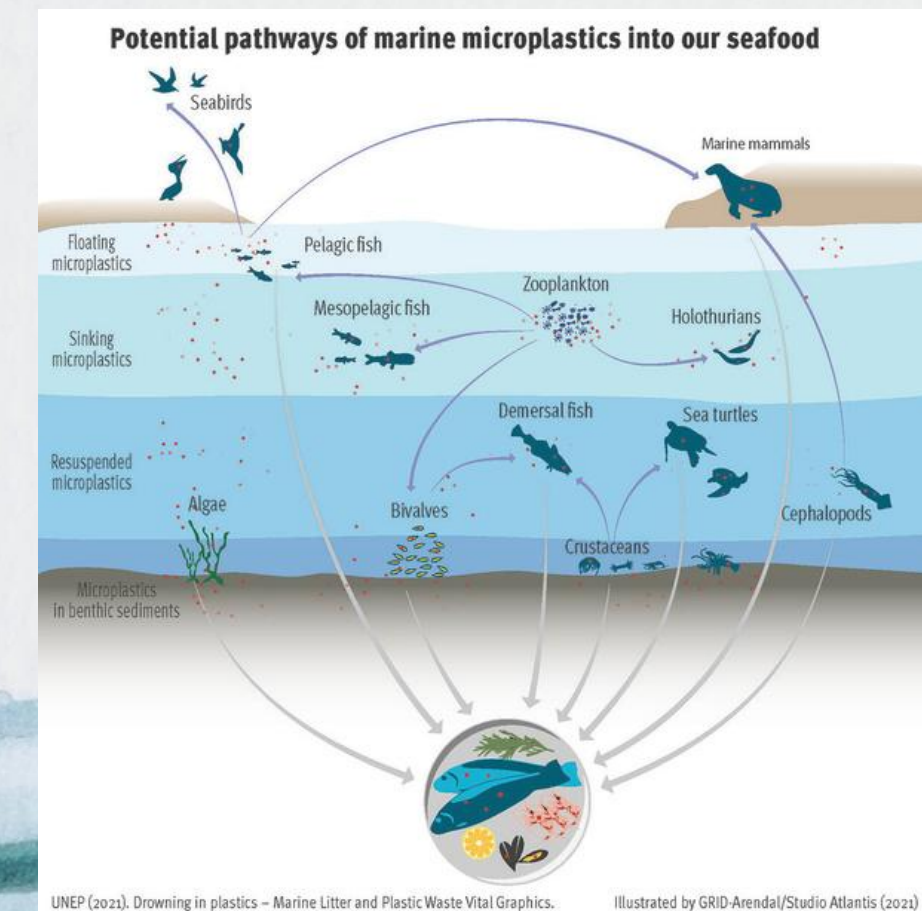
II. Main Sources of Marine Macrolitter

Marine Litter on the Seafloor

The seafloor is considered a major sink for marine litter.

Common benthic litter types include:

- Lost fishing nets (“ghost gear”)
- Plastic bags and packaging
- Metal objects
- Glass bottles
- Rubber materials



These items may **persist for decades** due to slow degradation. Material Composition in Ukraine's benthos plastics (83%): the most common items include plastic bags, beverage bottles, and single-use food packaging.

III. Types of Marine Litter in Coastal and Benthic Ecosystems

Marine Litter on the Black Sea Floor

THE POLLUTION SNAPSHOT

639
items/km²



Average density of
marine litter on the Black Sea floor



Plastic is the #1 Pollutant

77%

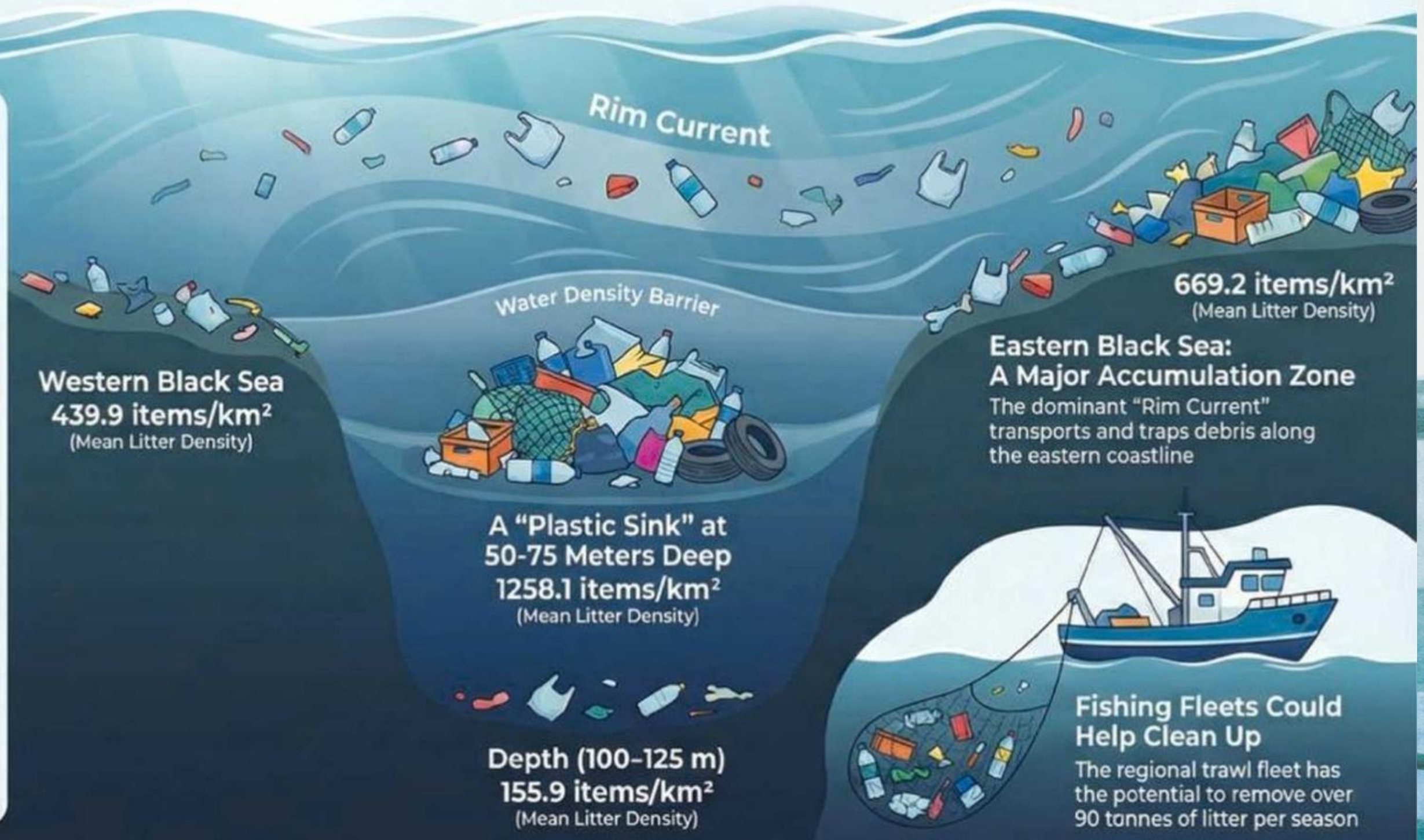
Plastics make up 77%
of all seafloor litter items
found in the study



Black Sea Mediterranean

**A Globally
Significant Problem**

Black Sea pollution
levels are comparable
to other regional
seas like the
Mediterranean



III. Types of Marine Litter in Coastal and Benthic Ecosystems

Plastics as the Dominant Litter Type

Plastics dominate marine litter because they are:

- Lightweight and buoyant
- Durable and resistant to degradation
- Produced and used in large quantities



Environmental risks include:

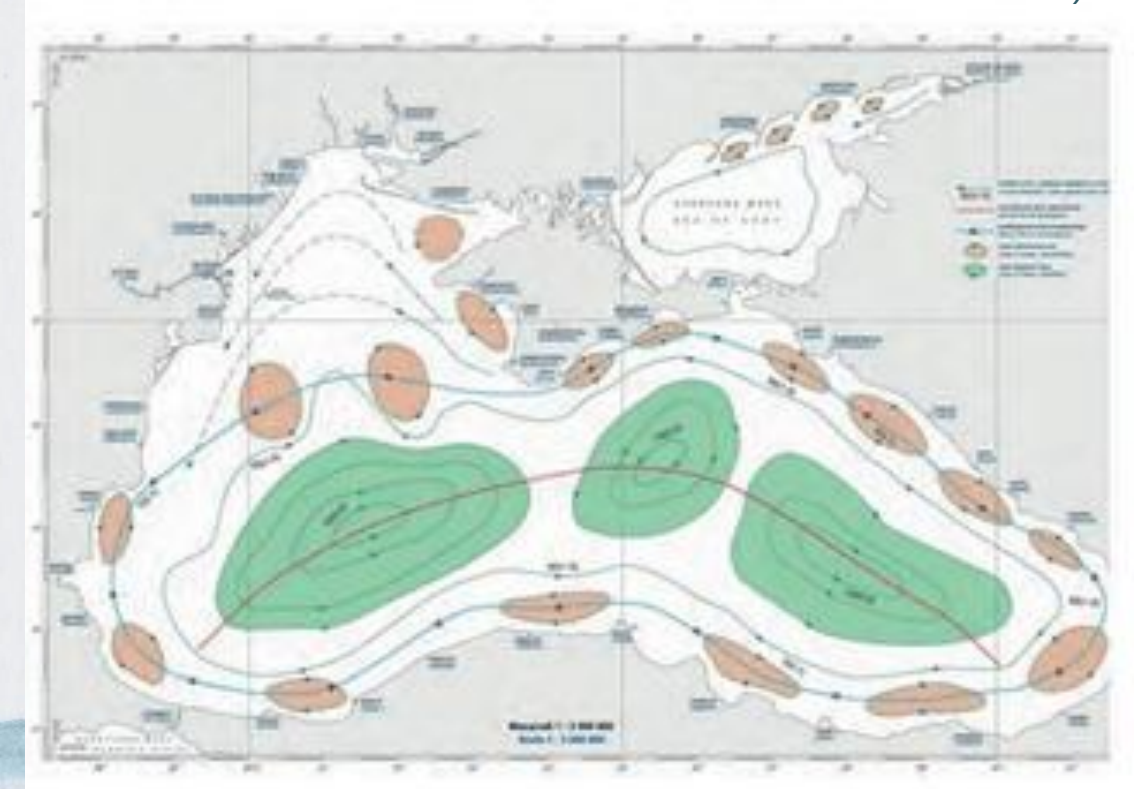
- fragmentation into microplastics
- ingestion by marine organisms
- long-term ecosystem contamination

Physical Characteristics of the Black Sea

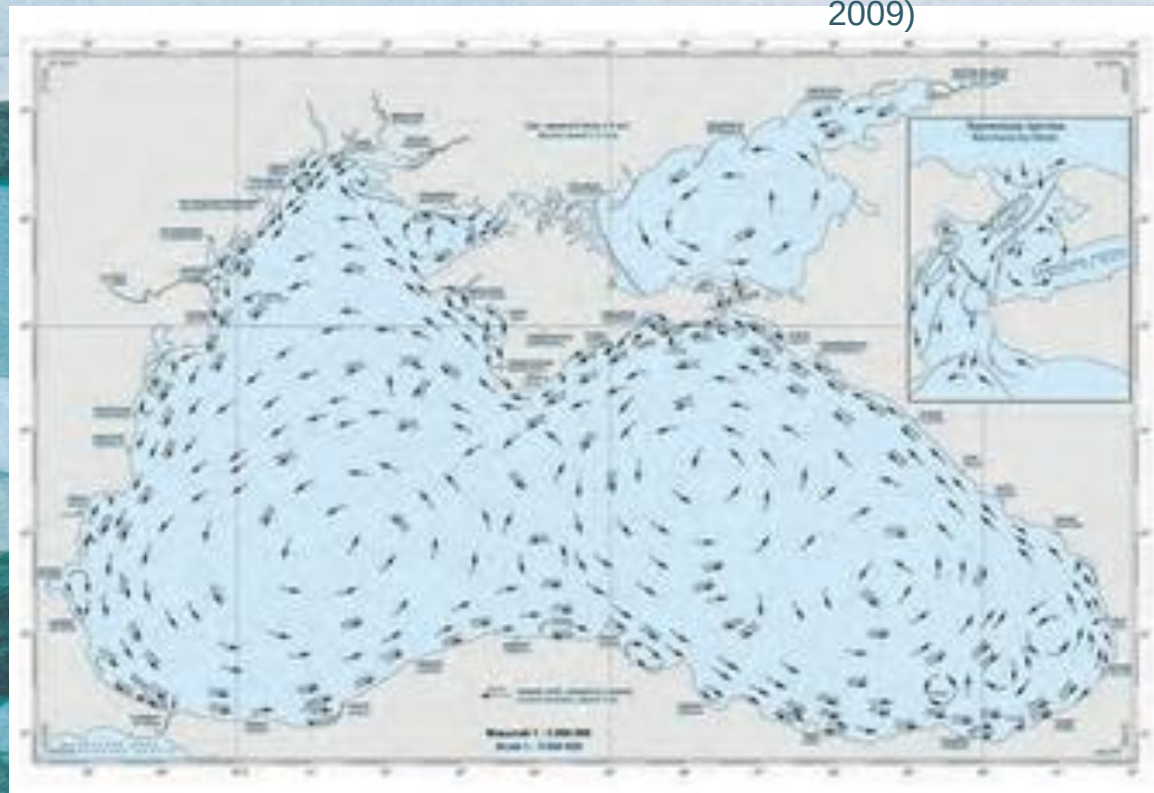
The Black Sea has several unique characteristics:

- Semi-enclosed basin connected to the Mediterranean through the Bosphorus Strait
- Large river catchment basin
- Strong vertical stratification

Water circulation in the Black Sea (Eremeev at al., 2009)



Water circulation in the Black Sea (Eremeev at al., 2009)



Below ~150-200 meters, the water becomes **anoxic** and contains **hydrogen sulfide**, which slows degradation processes.

IV. Specific Characteristics of the Black Sea

Circulation and Litter Accumulation

The displacement and accumulation of marine macrolitter and microplastics in the North-Western Black Sea (NWBS) are governed by a complex interplay of riverine discharge, wind-driven surface currents, and the cyclonic circulation of the basin.

Litter movement in the NWBS is highly dynamic, driven by several physical factors:

- **Currents:** The Rim Current, a large-scale cyclonic flow, is the primary driver of litter transport across the shelf. It captures riverine output and redistributes it along the shelf break.
- **Wind and Waves:** Surface macrolitter is highly sensitive to "windage." Strong seasonal winds can push floating debris towards the coast or pull it into the open sea, regardless of the underlying water currents.
- **Eddy Dynamics:** Mesoscale features like the Sevastopol Eddy act as temporary traps or "dispersal hubs" that move litter from the nearshore zone to the deeper shelf.

Floating Marine Macro Litter – densities of the transects uploaded during the cruises in 2017



Key effects:

- transports floating debris along the basin margins
- redistributes litter between coastal regions
- creates temporary accumulation zones

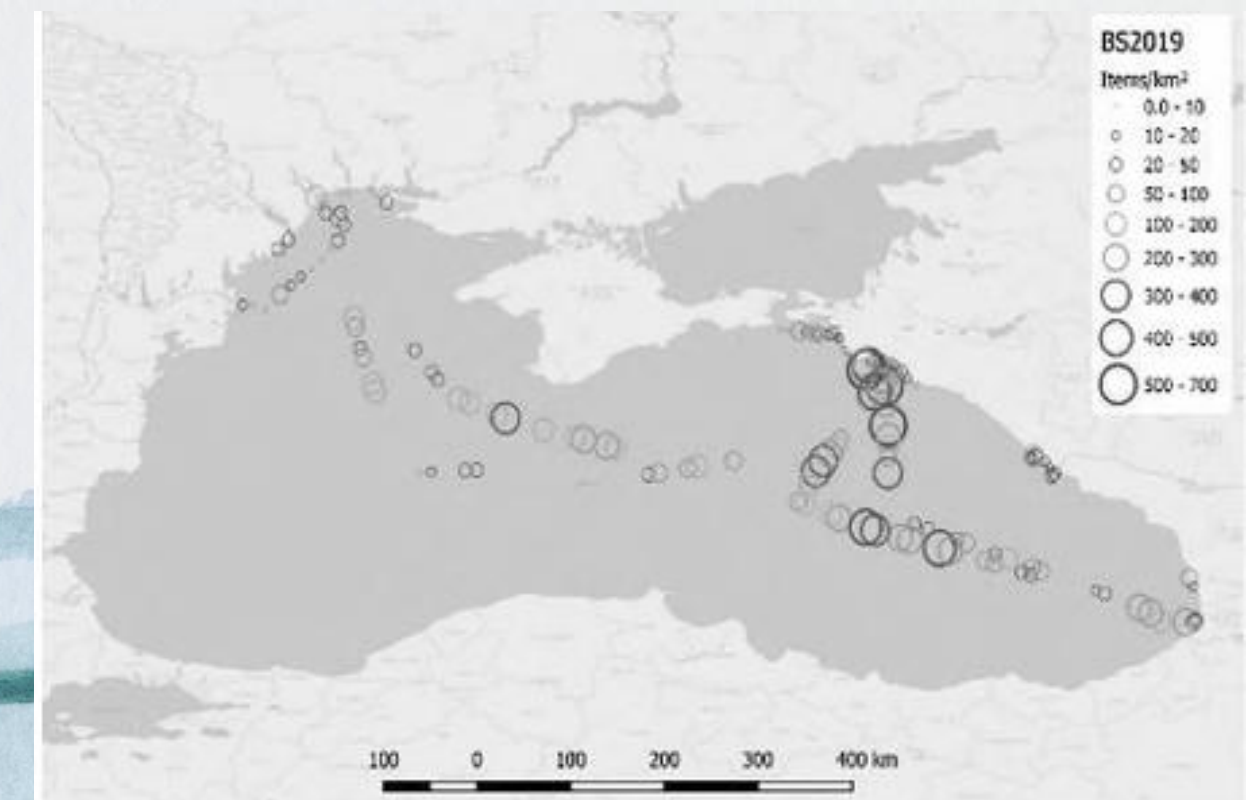
IV. Specific Characteristics of the Black Sea

Accumulation Zones and Hotspots

Research indicates that where litter ends up is often independent of its original source (e.g., specific river mouths) and is instead dictated by basin-wide circulation.

- **NWBS Shelf and Shelf Break:** modeling shows an increasing trend in litter accumulation over the NWBS shelf, particularly near the mouths of the Danube, Dniester, and Dnipro.
- **The "Western Gyre":** floating litter often converges in the center of the western cyclonic gyre, creating offshore hotspots far from the original land-based sources.
- **South-Western Convergence:** much of the litter released in the Ukrainian sector eventually drifts southward, accumulating along the Bulgarian and Romanian coasts due to the southward flow of the Rim Current.

Floating Marine Macro Litter – densities of the transects during the cruises in 2019



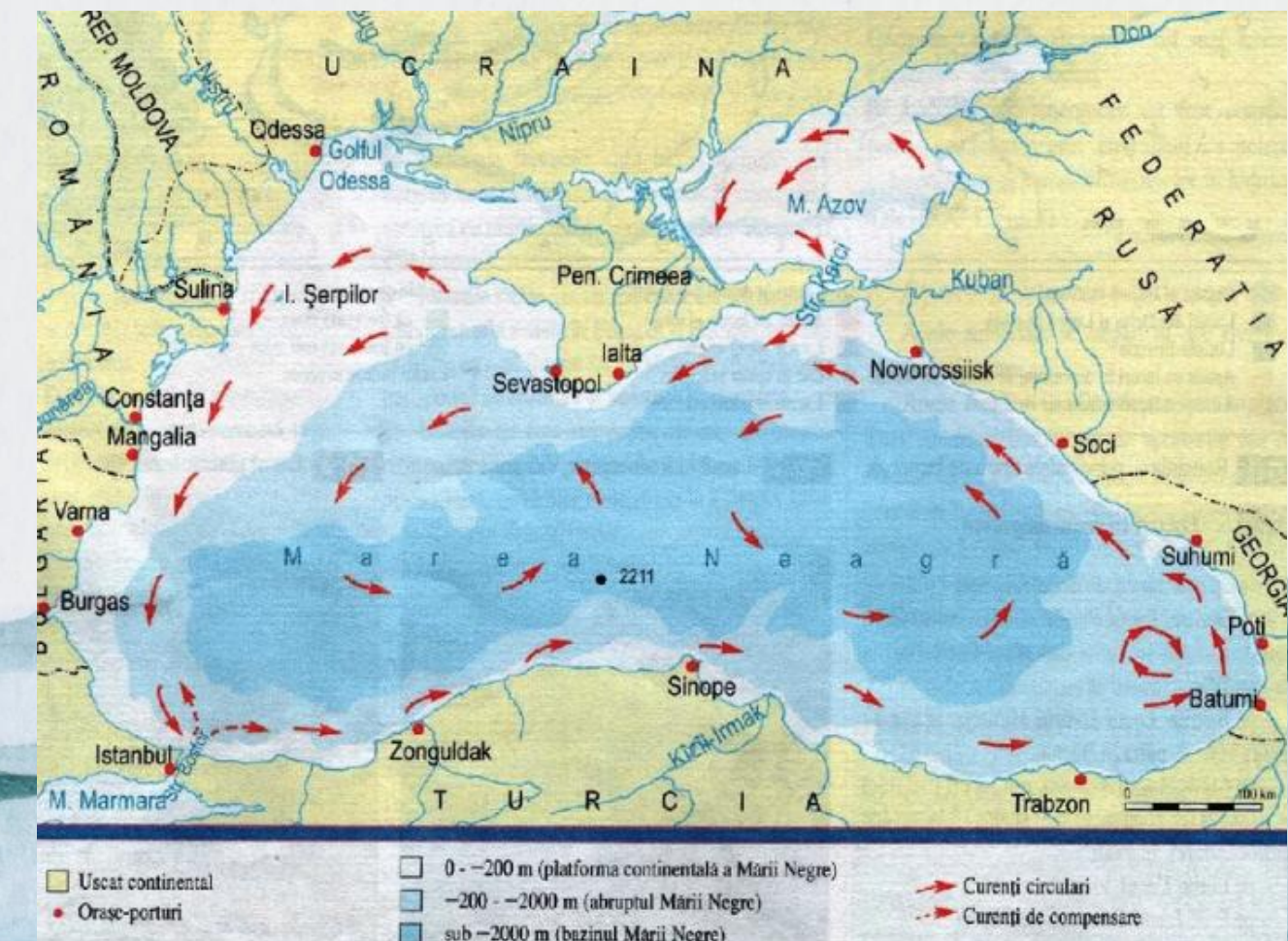
NWBS Shelf is one of a major accumulation zone for marine litter.

IV. Specific Characteristics of the Black Sea

Seasonal and Hydrodynamic Drivers

Black Sea marine currents

- **Spring/Summer Peaks:** high river discharge in the spring (Danube/Dnipro freshets) leads to massive "pulses" of litter entering the NWBS.
- **Winter Redistribution:** stronger winter storms and intensified Rim Current circulation accelerate the transport of litter out of the NWBS toward the southern Black Sea.



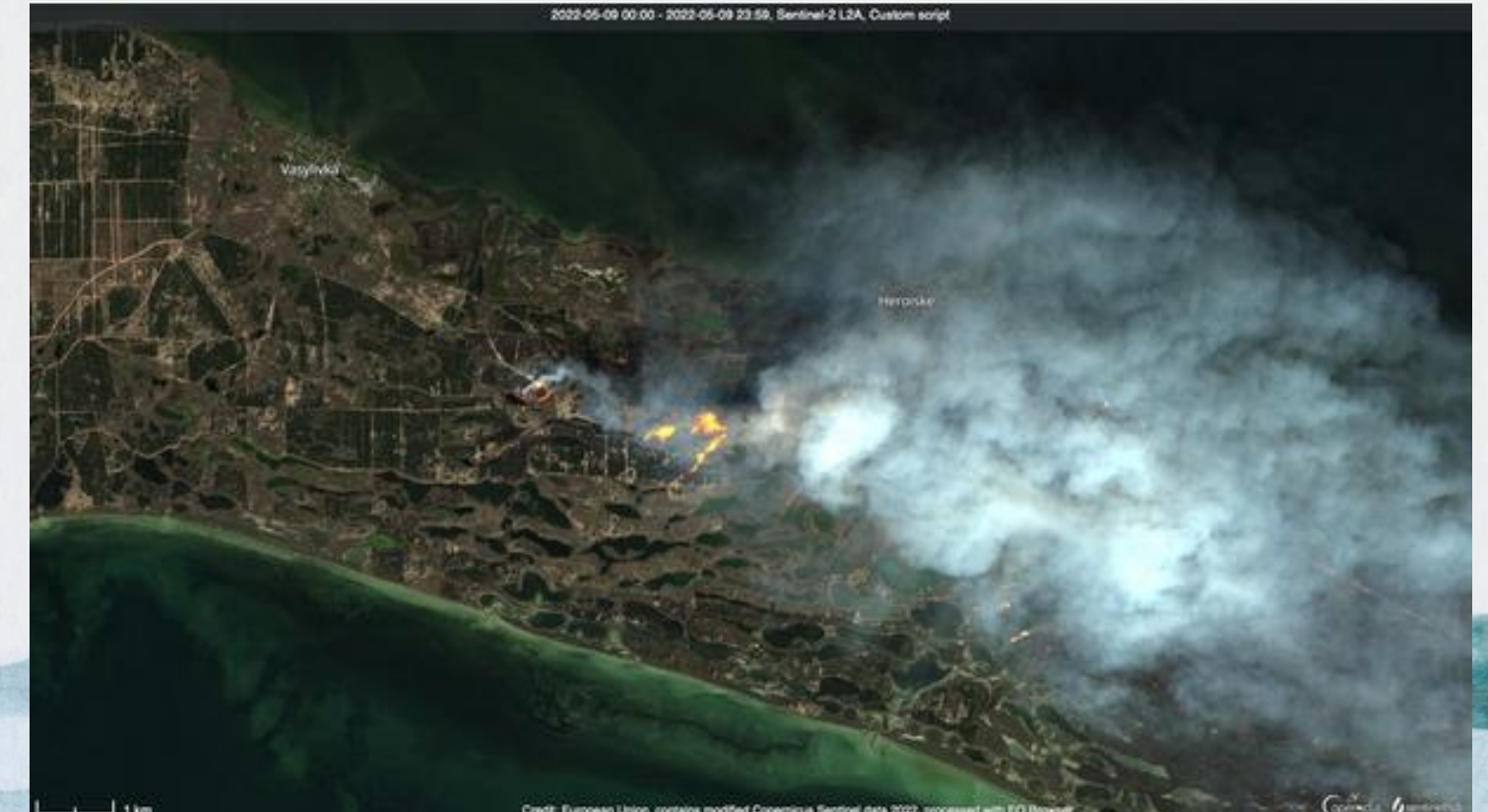
IV. Specific Characteristics of the Black Sea

War as a New Source of Marine Pollution

The ongoing war in Ukraine (since 2022) has created new and complex sources of marine pollution in the Black Sea.

Military activities affect marine ecosystems through both direct and indirect impacts:

- destruction of coastal infrastructure
- sinking of ships, aircraft and military equipment
- placement of naval mines and ammunition
- missile launches and underwater explosions
- oil and chemical spills
- accumulation of military debris



Fires on the Kinburn Spit (May 2022). Sentinel satellite image

These impacts extend beyond Ukraine and may affect the entire Black Sea region and connected basins, including the Mediterranean and Danube systems.

New Types of War-Related Debris

War introduces new categories of marine debris that differ from typical civilian waste.

Examples include:

- shipwrecks and sunken military vessels
- aircraft debris and missile fragments
- naval mines and unexploded ammunition
- parts of military equipment and mechanisms
- damaged offshore and coastal infrastructure

Consequences of military exercises near the Opuk Nature Reserve (Autonomous Republic of Crimea, 2016).



Such debris can remain on the seafloor for decades, becoming a long-term source of contamination.

Munitions and Explosive Fragments

The seafloor and coastal zones now contain a significant volume of metal and chemical debris from active combat:

- **Missile and Shell Casings:** fragments of *russian Kalibr missiles* and *S-300 rockets* have been documented in the coastal waters near Odesa and Mykolaiv. These contribute heavy metal fragments (steel and aluminum alloys) to the benthic environment.
- **Sea Mines:** over 400–600 *naval mines* were estimated to be drifting or anchored in the NWBS early in the conflict. Many have been destroyed by controlled explosions, leaving behind high-density metal fragments and unreacted explosive residues (TNT/RDX).



Hostile moored naval mines washed right up to the coast of Odesa Oblast by stormy weather (May 2022). Photo: Operational Command South

Sea Mines as Long-Term Environmental Threats

Naval mines represent one of the most dangerous forms of war-related marine debris.

Environmental risks include:

- corrosion of metal casings, releasing heavy metals
- leakage of explosive compounds such as TNT (2,4,6-trinitrotoluene)
- underwater explosions causing shock waves
- destruction of seafloor habitats



Mine explosions can cause severe injuries or death in fish, invertebrates and marine mammals. Some mines may remain active for decades.



Consequences of hostile shelling, 'Tuzly Lagoons' National Nature Park. Photo by Ivan Rusiev.

VI. Environmental Risks and Toxic Components

Military Hardware and Vessels

The "Moskva" cruiser is the most prominent example of a large-scale sunken vessel becoming a massive source of benthic debris.

- **Sunken Vessels:** ships like the Moskva and various landing craft (e.g., at Snake Island and Berdiansk) introduce tons of complex materials: electronics, lead-acid batteries, wiring, and heavy paints.
- **Aviation and Drones:** fragments of downed aircraft (Su-25/Su-34) and "Shahed" type drones contribute carbon fiber, glass-reinforced plastics, and lithium-ion battery components to the sediment.



Fire on a struck Russian warship off the coast of occupied Berdiansk, March 2022

Destroyed Infrastructure and Construction Debris

The destruction of coastal and port facilities has converted urban structures into marine litter:

- **Port Infrastructure**: debris from grain elevators, cranes, and storage tanks in the Odesa, Chornomorsk, and Pivdennyi ports has entered the shelf. This includes large-scale structural steel and industrial rubber.
- **Energy Infrastructure**: strikes on coastal energy facilities have released insulation materials, transformer oils (contained in submerged equipment), and specialized ceramic insulators.
- **Coastal Settlements**: the destruction of residential areas near the Dnipro estuary resulted in a massive influx of "anthropogenic sediment" - pulverized concrete, glass, roofing tiles (slate/asbestos), and brick.



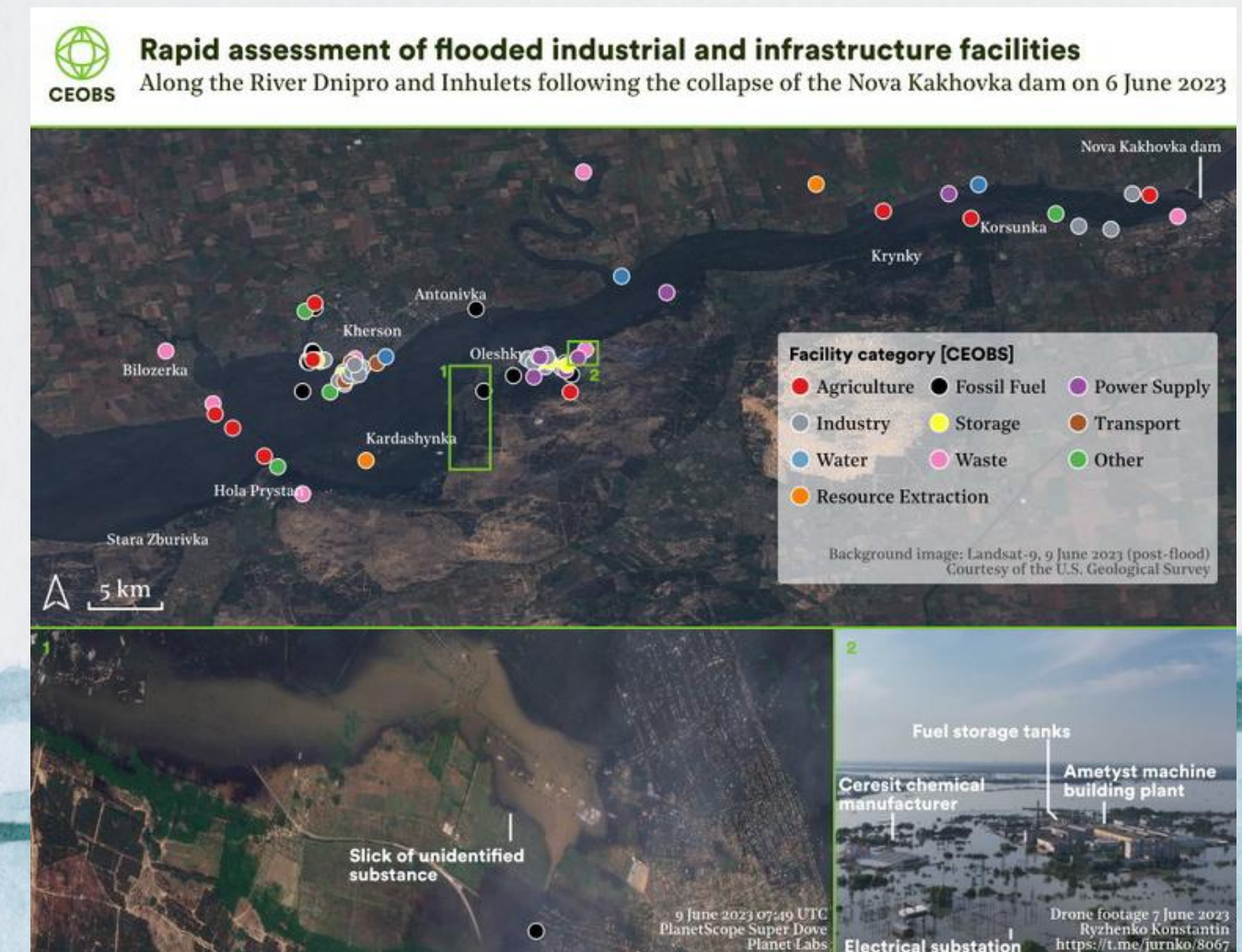
Locations and types of pollution incidents documented and verified by CEOBS in the Bug Estuary; lines connect the map locations with satellite imagery and social media materials. Social media sources: Military depots, MV Banglar Samriddhi, 'Qterminals Olvia' terminal, 'Nika-Tera' port, Halytsynove wastewater treatment plant, Alumina Refinery.

These materials can **accumulate in coastal areas and continental shelf zones**, particularly in the north-western Black Sea.

Plastic Elements of Defensive Structures

A new category of "defensive litter" has appeared on Ukrainian beaches and in the nearshore zone:

- **Fortification Materials**: thousands of polypropylene sandbags used for beach defenses are frequently shredded by winter storms and wave action, releasing massive amounts of synthetic fibers (microplastics) and plastic fragments directly into the water.
- **Anti-Submarine and Anti-Landing Nets**: synthetic netting and cables deployed to protect harbors and critical infrastructure contribute to entanglement risks for marine mammals like the Black Sea harbor porpoise.
- **Geotextiles and Barriers**: large-scale plastic sheets and geotextiles used in trenches or as temporary barriers along the shore have been mobilized by coastal erosion and high-water events.



Over time, these **materials may degrade** due to mechanical stress, sunlight and seawater exposure, **generating secondary microplastics** that enter marine food webs.

Chemical Risks of Military Debris

Military debris may release a wide range of hazardous substances into marine ecosystems.

Potential contaminants include:

- explosive compounds such as TNT (2,4,6-trinitrotoluene) and DNT (2,4-dinitrotoluene)
- nitroaromatic explosives and RDX (hexahydro-1,3,5-trinitro-1,3,5-triazine)
- heavy metals including copper, lead, zinc and nickel
- rocket fuel components and chemical stabilizers
- combustion products from explosives

Satellite view of the sunflower oil spill spreading at the 'Everi' terminal.



More than 70 chemical substances may be associated with weapon components. Corrosion of metal casings gradually releases these substances into seawater and sediments.

Ecological Impacts

War-related pollution can have significant ecological consequences.

Potential impacts include:

- toxicity to marine organisms
- habitat destruction on the seafloor
- bioaccumulation of toxic substances in marine food webs
- disruption of fish spawning grounds
- reduction of biodiversity



These **impacts** threaten both **marine ecosystems** and **fisheries resources** in the Black Sea.

Impacts on Marine Mammals and Marine Life

Military activities may affect marine animals through several mechanisms:

- underwater explosions and shock waves
- intense underwater noise from naval sonar and military operations
- injuries caused by shrapnel and pressure waves
- disturbance of migration routes

A dead dolphin on the coast of the 'Tuzly Lagoons' National Nature Park (April 2022). Photo by Ivan Plachkov.



In 2022, researchers documented a sharp increase in cetacean mortality in the Black Sea.

Recorded cases:

- **914 cetacean deaths** across the Black Sea region
- **more than double** the average mortality level of previous years

Other Environmental Impacts of the War

Beyond marine debris, the war causes multiple additional pressures on the marine environment:

- oil spills from damaged tankers and vessels
- contamination from destroyed industrial facilities
- eutrophication caused by nutrient discharge
- microbiological contamination from damaged wastewater systems
- underwater noise pollution from military operations



Pollution of the Bug Estuary resulting from damage to Mykolaiv's main wastewater treatment facilities

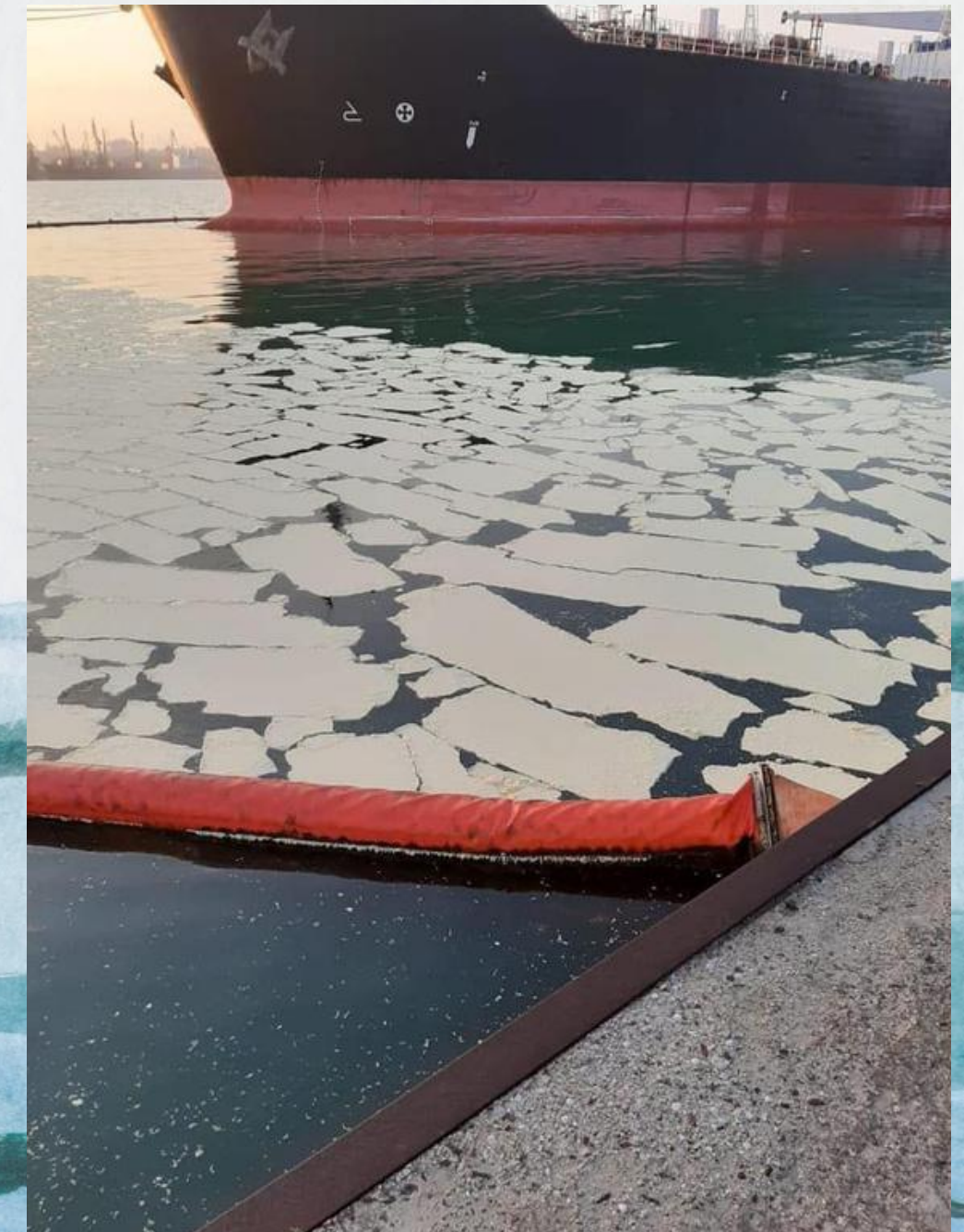
These combined pressures increase environmental stress on marine ecosystems.

VI. Environmental Risks and Ecological Impacts

Primary Sources of War Debris

The input of war-related macrolitter into the Ukrainian sector occurs through several distinct vectors:

- **Direct Coastal Bombardment:** strikes on coastal cities (Odesa, Mykolaiv, Kherson) and defense positions release materials directly into the nearshore zone. This includes pulverized masonry, glass, and metal from residential and industrial buildings.
- **Port and Terminal Destruction:** the systematic targeting of grain terminals and port infrastructure (e.g., in the Reni, Izmail, and Odesa ports) generates industrial-scale debris, including twisted structural steel, specialized machinery parts, and large volumes of synthetic insulation.
- **Naval Combat Incidents:** the sinking of vessels (e.g., the Moskva, landing ships in Berdiansk/Snake Island) and the destruction of drones create point sources of high-density benthic litter (heavy metals, batteries, engines) and floating slicks of lighter materials.



Palm stearin in the waters of Pivdennyi Port, Odesa Oblast, April 2020. Source: latifundist.com

Riverine Pathways (The "Conveyor Belts")

Rivers remain the most significant pathway for moving land-based conflict waste into the open sea:

- **The Dnipro River:** post-2022, the Dnipro has become a major conduit for war-related debris. The Kakhovka Dam breach in June 2023 demonstrated this, carrying thousands of tons of material - from household furniture to entire building sections - through the Dnipro estuary and into the NWBS within days.
- **The Danube and Dniester:** while less impacted by direct dam destruction, these rivers carry waste from damaged upstream infrastructure and military fortifications located along their banks.



The Black Sea following the destruction of the Kakhovka Hydroelectric Power Plant in June 2023.

Source: Ivan Strakhov

Spatial Distribution and Accumulation Zones

Based on monitoring and hydrodynamic modeling, several key accumulation zones have been identified:

- **The Odesa-Gulf Hotspot:** the coastline from the Dnipro-Bug estuary to Odesa is a primary deposition zone for debris entering from the Dnipro.
- **Danube Delta Convergence:** the interaction of the Danube's freshwater plume with the Rim Current creates a convergence zone that traps floating macrolitter, leading to high densities of both civilian and war-related waste in the delta's protected areas.
- **The Western Gyre Center:** lighter, persistent plastics and synthetic materials from military gear are eventually pulled into the center of the Western Gyre, where they can remain for years.
- **Sunken Object Clusters:** areas around former active combat zones (e.g., the waters around Snake Island) have become clusters for "ghost" military debris, including sunken equipment and unexploded ordnance.



A Russian warship in the Sea of Azov behind a sunken Ukrainian vessel in the Mariupol commercial seaport, Ukraine, April 29, 2022. Ukraine's coastal and marine ecosystems have suffered from chemical and acoustic pollution, physical destruction of natural habitats, and the decline of conservation efforts and fisheries management. Photo: EPA-EFE/SERGEI ILNITSKY

CASE STUDY:

Kakhovka Dam Destruction as a Source of Marine Debris

1

All benthic organisms in the reservoir were killed, and floodwaters carried downstream toxic reservoir-bottom sediments.

2

Flooding affected 600 km² of protected areas downstream, threatening narrow-range endemic species with extinction.

3

Freshwater fauna perished once flushed into the Black Sea, where 32,000 km² of water was affected by desalinisation, turbidity, and eutrophication.



Further reading on Lower Dnieper Revival on our web-pages:

UNCG
Ukrainian Nature Conservation Group

UWEC
Ukraine War Environmental Consequences Work Group



CASE STUDY:

Kakhovka Dam Destruction as a Source of Marine Debris

The destruction of the Kakhovka Hydropower Plant dam on 6 June 2023 triggered a large-scale environmental disaster that affected the Dnipro River basin, coastal ecosystems, and the north-western Black Sea.

The sudden release of water transported **massive quantities of debris and waste from flooded territories** into the Dnipro-Bug estuary and subsequently into the Black Sea.

Major **debris sources** included:

- destroyed residential buildings and infrastructure
- construction materials (wood, concrete, metal fragments)
- household waste and plastic products
- agricultural equipment and vehicles
- uprooted trees and organic debris



Sediment deposits on the streets of Kherson following the destruction of the Kakhovka Reservoir, June 2023.
Source: Suspilne Kherson

This material formed **large floating debris fields** that were transported by river discharge and coastal currents toward Odesa Bay and adjacent coastal areas, creating **temporary accumulation zones of marine debris**.

CASE STUDY:

Marine Pollution and Environmental Risks after the Kakhovka Dam Collapse

The influx of debris and contaminated water significantly increased marine pollution pressure in the north-western Black Sea.

Key **environmental risks** included:

- transport of floating macro-debris into coastal waters (*floating gas canisters and oxygen tanks were recovered from the sea surface, posing physical hazards to local navigation and clean-up crews*)
- fragmentation of debris into secondary marine litter and microplastics
- contamination of seawater and sediments by pollutants transported with debris
- accumulation of waste along coastlines and shallow marine areas

Silt transport by the water flow from the Kakhovka Reservoir (18.06.2023). Source: Sentinel



Monitoring in Odesa Bay identified elevated levels of **contaminants in seawater and marine organisms**, including:

- industrial pollutants (naphthalene, phenanthrene, anthracene)
- agricultural pesticides (β -HCH, heptachlor) - *containers of fertilizers and pesticides from flooded agricultural zones were found mixed with the physical debris.*
- heavy metals (copper, zinc, chromium, nickel)

These pollutants can **accumulate in marine biota** and may pose **long-term risks** to marine ecosystems, fisheries, and human health.

VI. Ecological Impacts

CASE STUDY:

Environmental Impact of the Kerch Bridge on the Marine Environment

The construction of the **Kerch Bridge (Crimean Bridge)** across the Kerch Strait has significantly **affected the marine environment** of the **Black Sea-Azov Sea system**.

Major environmental pressures include:

- large-scale dredging and seabed disturbance during construction
- removal and displacement of bottom sediments
- installation of numerous bridge support piles altering water circulation
- increased shipping activity and construction vessel operations
- underwater noise, light pollution and mechanical disturbance



Sunken anti-submarine ship Ochakov at the entrance to Lake Donuzlav (Source: topwar.ru)



These activities have led to:

- destruction and silting of benthic habitats
- increased water turbidity and reduced transparency
- disturbance of spawning grounds and feeding habitats
- physical disturbance of marine organisms and migration routes

The Kerch Strait is an **Ecologically and Biologically Significant Area (EBSA)** and an **Important Marine Mammal Area**, making these impacts particularly critical for regional biodiversity.

VI. Ecological Impacts

CASE STUDY:

MARine Debris and Pollution Associated with the Kerch Bridge

The construction and operation of the Kerch Bridge also contribute to marine debris accumulation and pollution in the Kerch Strait.

Key sources of pollution include:

- construction materials and infrastructure debris entering the marine environment
- seabed disturbance and sediment resuspension during dredging operations
- increased vessel traffic generating operational waste and pollution
- leakage of fuels, oils and chemical substances from construction equipment



Tuzla Island in the Kerch Strait. On the left: lakes and natural ecosystems that were virtually destroyed following the bridge construction. On the right: the Kerch Bridge, built directly across the island (Source: ecoaction.org.ua)

Additional impacts include:

- accumulation of bottom sediments around bridge piles
- increased dredging activities, further disturbing seabed ecosystems
- long-term alteration of hydrodynamics affecting sediment transport and debris distribution

These processes increase the risk of marine litter accumulation and habitat degradation in the Kerch Strait and adjacent coastal areas.

Impacts on Coastal and Marine Ecosystems

Military activities **affect coastal ecosystems** through:

- construction of fortifications and defensive structures
- excavation and movement of soil
- fires and explosions
- accumulation of military waste



Oil slick on the Odesa coastline, December 2025.
Photo: Odesa Oblast Prosecutor's Office

Consequences include:

- destruction of coastal habitats
- increased sediment turbidity
- changes in hydrological conditions
- disturbance of wildlife habitats

Current Research Gaps

Despite growing evidence, important knowledge gaps remain.

Key research challenges include:

- limited data on the distribution of war-related marine debris
- insufficient monitoring of chemical contaminants from military materials
- lack of long-term ecological impact assessments
- limited information on underwater noise impacts on marine mammals



"A bird killed by an oil spill, found on the Odesa coast on December 24, 2025. Photo by Oleksandr Gimarov

Improved monitoring systems and international scientific cooperation are needed to better assess these risks.

Why Monitoring Marine Litter is Important

Marine litter monitoring helps to:

- assess pollution levels
- identify pollution sources
- evaluate mitigation measures
- support environmental policy



Monitoring also contributes to evidence-based decision-making.

Monitoring Standards and Protocols

Marine litter monitoring is guided by international standards:

- **MSFD** (*Marine Strategy Framework Directive, **Descriptor 10***): the primary regulatory framework that defines "**Good Environmental Status**" (**GES**) regarding marine litter. It mandates the monitoring of trends in the amount, composition, and source of litter.
- **EMBLAS Project (I, II, and Plus)**: this initiative has been crucial for capacity building in Ukraine. It introduced standardized **Black Sea Monitoring Guidelines** that align with MSFD protocols, ensuring data comparability across the basin.
- **Bucharest Convention**: the regional convention for the protection of the Black Sea against pollution, which provides the legal basis for joint monitoring efforts among littoral states.

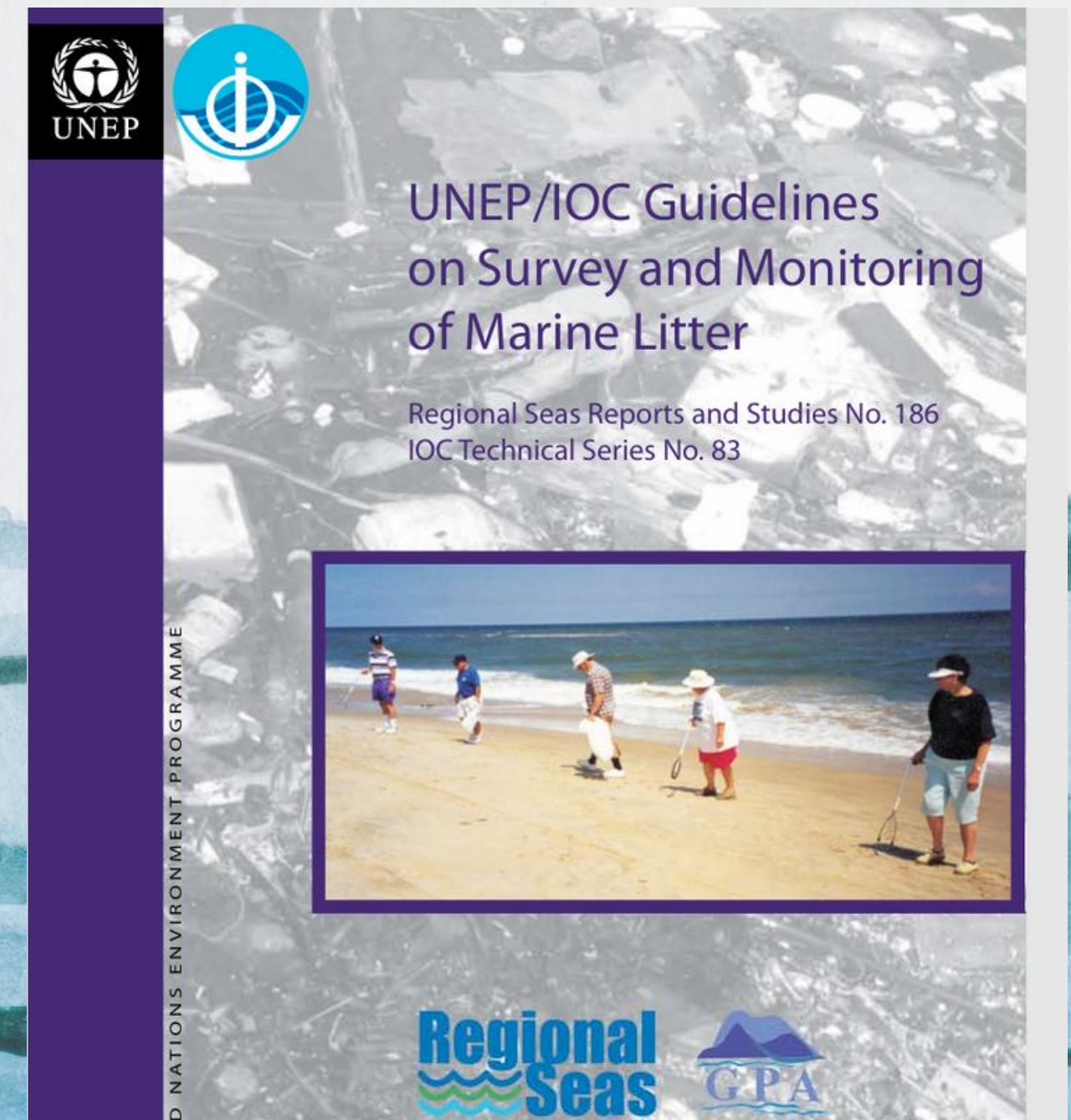


Standardized methods ensure **comparability of data** between regions.

Adaptation of OSPAR and UNEP/IOC Guidelines

While the OSPAR (North-East Atlantic) and UNEP/IOC guidelines were developed for other basins, they provide the technical foundation for the Black Sea:

- **OSPAR Influence:** the 100-meter beach transect methodology used in the Black Sea is largely derived from OSPAR protocols, which are considered the "gold standard" for coastal macrolitter assessment.
- **UNEP/IOC Guidelines:** these are used to provide the broader global context, particularly for the Sustainable Development Goal (SDG) 14.1.1b, which tracks plastic litter density.



Global and regional initiatives to combat plastic pollution

	Land-based		Ocean		Binding
	Source of 80% of marine litter		National Jurisdiction (NJ)	Areas Beyond NJ	
Pollution prevention and protection					
Basel Convention					yes
Stockholm Convention					yes
UN Convention on the Law of the Sea					yes
MARPOL Annex V					yes
London Convention					yes
London Protocol					yes
Global Programme of Action					no
Regional Seas Action Plans					no*
SACIM					no
Biodiversity and species focus					
Convention on Biological Diversity					yes
Convention on Migratory Species					yes
UN Fish Stocks Agreement					yes
FAO Code of Conduct for Responsible Fisheries					no

*Except the Mediterranean

Sources: UNEP (2017), Goncalves and Faure (2019). Illustrated by GRID-Arendal (2021).
UNEP (2021). Drowning in plastics – Marine Litter and Plastic Waste Vital Graphics.

Beach Litter Survey Methodology

Monitoring follows standardized international protocols (EU MSFD) to ensure data can be compared across the Black Sea and with other European basins:

- **Survey Units:** surveys are conducted on **100-meter stretches of beach**, extending from the water's edge to the back of the beach (e.g., foot of a dune or sea wall).
- **Sampling Frequency:** monitoring is typically performed **4 times a year** (once per season) to capture the influence of tourism (summer) and storm-driven deposition (winter/spring).
- **Item Threshold:** only **items larger than 2.5 cm (25 mm)** are counted and categorized, consistent with the definition of macrolitter.
- **Classification:** researchers use the **Joint List of Categories of Marine Litter**, which assigns each item a specific code (e.g., G7 for drink bottles, G21 for plastic bags).



Indicator used:

- number of items per 100 meters

Methodologies for Seafloor Assessment

Approaches for benthic monitoring are categorized by depth and the type of habitat:

- **Trawl Surveys**: this is the most common method for large-scale shelf monitoring. It involves using bottom-trawl nets (often during fisheries research cruises) to collect litter over a known area. Results are expressed in items/km² or kg/km².
- **Diver-Based Surveys**: used in shallow coastal zones (<20 m depth). Divers conduct visual censuses along fixed transects, often in sensitive areas like the Zernov's Phyllophora Field or near port infrastructure.
- **Remote Visual Surveys**: remotely Operated Vehicles (ROVs) and towed underwater cameras are used in deeper shelf areas (20–100 m) to avoid the physical impact of trawling on the seabed.
- **Acoustic Sensing**: emerging technologies like Side-Scan Sonar and multibeam echosounders are used to detect large-scale "war-related" debris, such as sunken vessels or discarded military hardware, which appear as high-relief anomalies on the seabed.

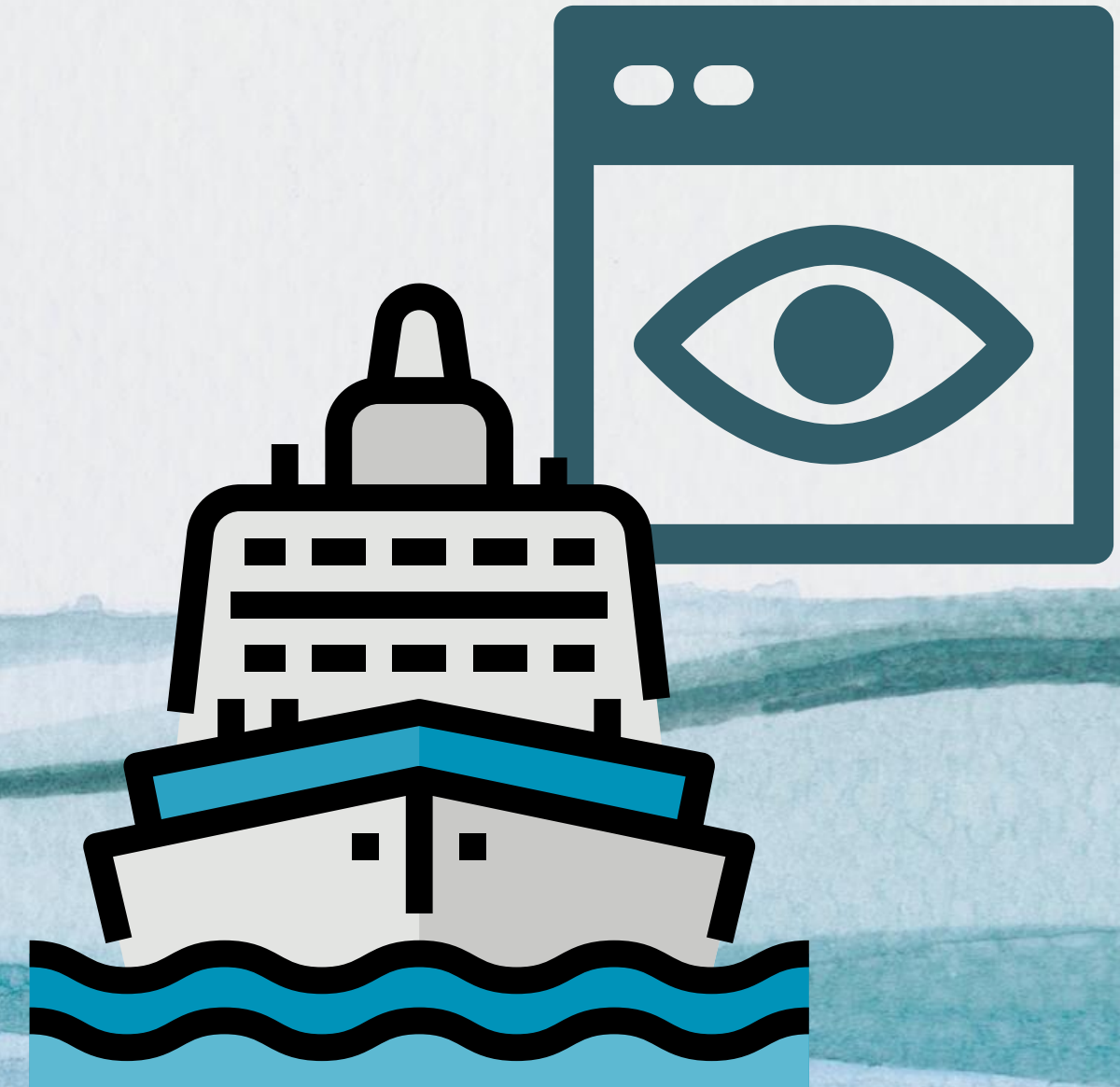


These methods allow identification of litter on the seabed.

Ship-Based Visual Surveys

This remains the baseline method for assessing **Floating Marine Macro Litter (FMML)** in the open sea.

- **Methodology:** observers on research vessels (e.g., during EMBLAS Joint Black Sea Surveys) monitor a fixed-width strip (transect) along the ship's path.
- **Technological Integration:** the JRC Floating Litter Monitoring App is used to georeference observations in real-time, allowing for the direct calculation of litter density (items/km²).
- **Limitation:** highly dependent on sea state and observer fatigue; can only detect items >2.5 cm.



Aerial and Drone-Based Monitoring (UAVs)

Unmanned Aerial Vehicles (UAVs) are one of a useful tool for monitoring beach and nearshore macrolitter in modern times.

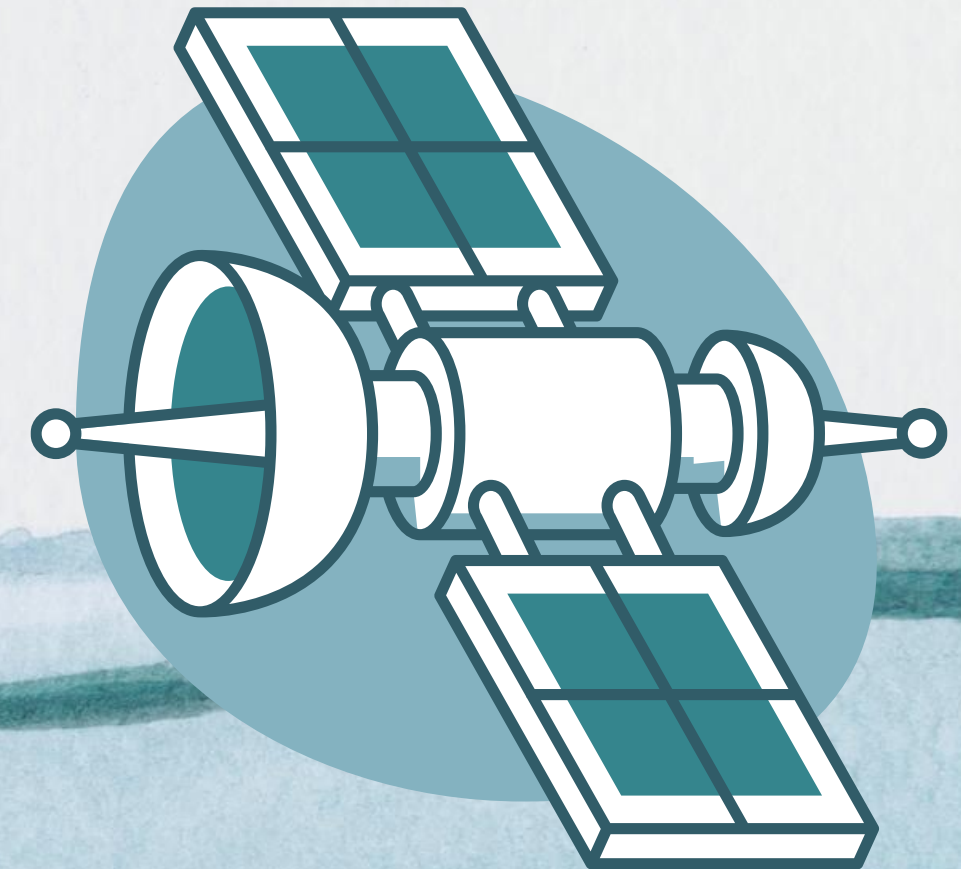
- **Capabilities:** drone-based monitoring of beach litter uses commercial uncrewed aerial vehicles (UAVs) equipped with high-resolution RGB cameras to survey coastlines. Paired with artificial intelligence and machine learning - such as YOLO models - these drones rapidly capture and georeference images to identify, classify, and map marine debris and plastic pollution up to 40 times faster than manual visual censuses.
- **Advanced Analysis:** recent studies utilize Pixel-Level Area Segmentation (PLAS-Net) to quantify the actual area occupied by litter, rather than just item counts, providing a more accurate assessment of ecological risk.



Satellite Remote Sensing

For the broad NWBS shelf, satellite data (particularly Sentinel-2) is used to identify large-scale debris accumulations and "fronts".

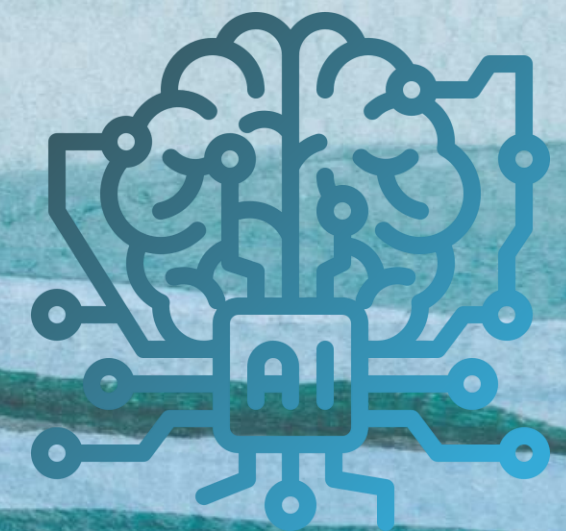
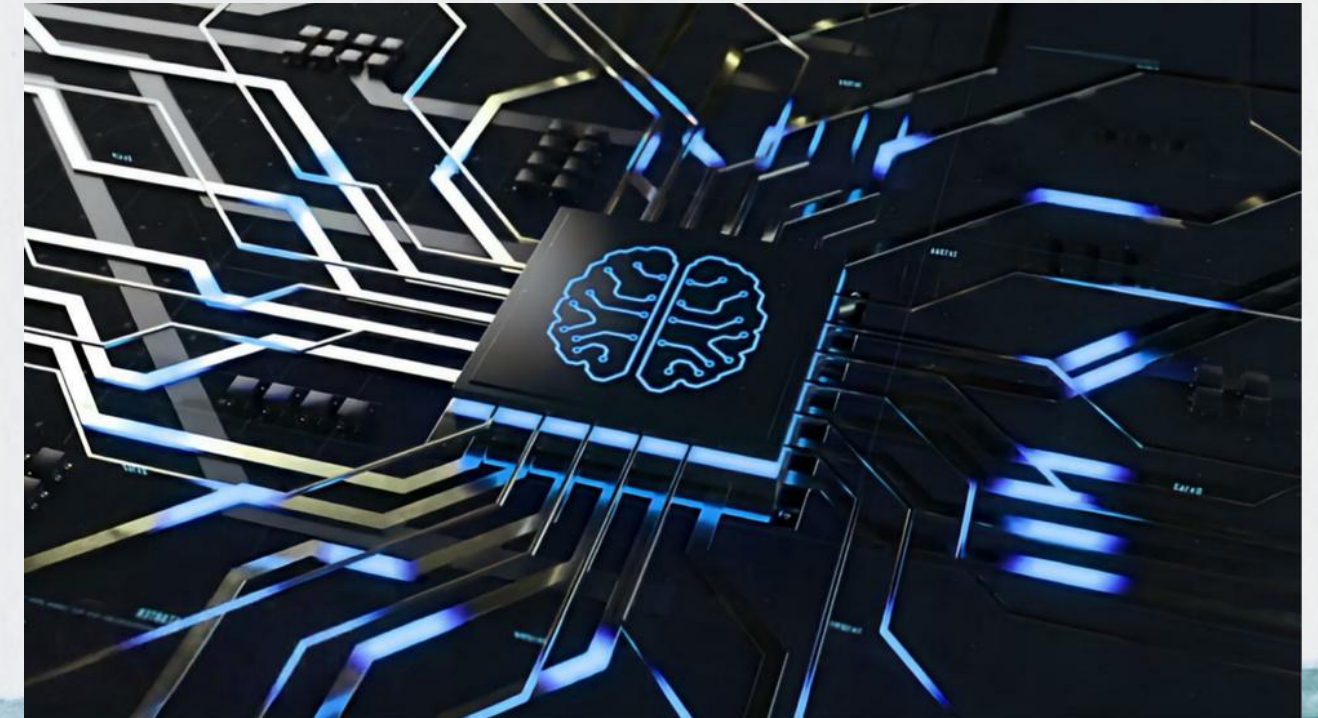
- **Spectral Signatures:** researchers use specific indices (like the Floating Debris Index) to distinguish plastic and anthropogenic debris from natural materials like driftwood or algae.
- **Large-Scale Detection:** this is particularly effective for tracking massive "pulses" of debris, such as the plume from the Kakhovka Dam breach in 2023, which was visible across the NWBS.



AI and Deep Learning Detection

To handle the massive datasets generated by drones and satellites, AI-based object detection (e.g., YOLO models) is being deployed.

- **Automated Classification:** AI can automatically sort items into categories (bottles, tires, nets) with high accuracy, reducing the manual labor required for monitoring.
- **Super-Resolution:** For underwater or low-resolution satellite images, deep learning is used to enhance image quality, allowing for the detection of smaller macrolitter items that would otherwise be missed.



Role of Citizen Science

Citizen science plays an important role in marine litter monitoring.

Benefits include:

- increased spatial coverage of monitoring
- public awareness and engagement
- additional data collection



Citizen science complements scientific monitoring programs.

Participation of Volunteers and Stakeholders

Various stakeholders may participate in monitoring:

- local communities
- fishermen
- divers
- environmental NGOs
- students and researchers



*Dive Against
Debris*



Examples of initiatives:

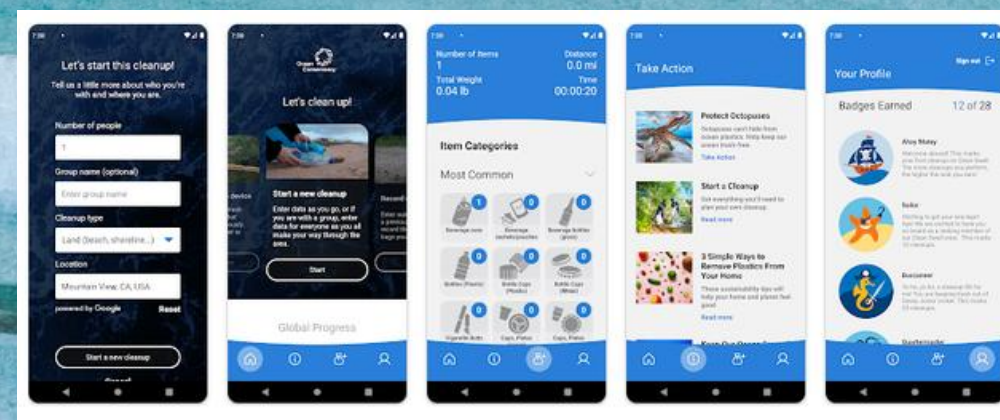
- ***Dive Against Debris*** - is the flagship citizen-science program by the PADI AWARE Foundation, empowering scuba divers to remove and document marine rubbish from the seafloor (<https://www.padi.com/aware/marine-debris>).
- ***Marine LitterWatch*** - is a European citizen science initiative and data collection platform established by the European Environment Agency (EEA) to monitor and combat beach and marine litter.

Mobile Applications and Data Platforms

Digital tools support citizen science initiatives.

Examples include:

- **Marine LitterWatch**
- **JRC Floating Litter Monitoring App**: A specialized tool used by researchers and trained citizen scientists on vessels to record floating macrolitter via a "touch-screen" interface that automatically logs GPS coordinates and survey width.
- **Clean Swell App**: developed by the Ocean Conservancy, this app is widely used during Coastal Cleanup events. It focuses on user-friendly categorization and global data sharing.
- **Ocean Conservancy databases** ([TIDES -Trash Information and Data for Education and Solutions](#))

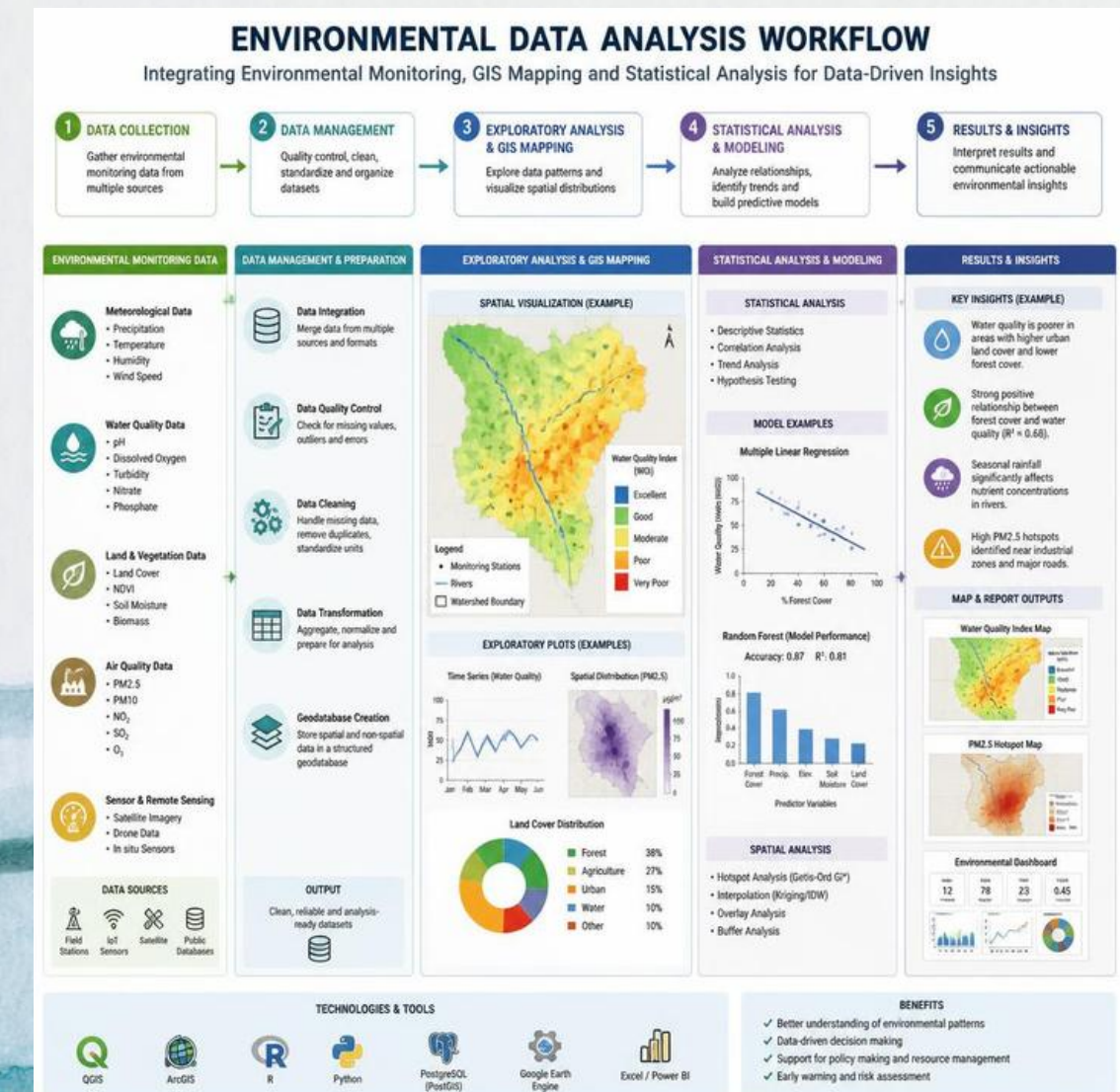


These tools allow standardized recording and sharing of monitoring data.

Data Classification and Analysis

Marine litter data analysis typically involves:

- classification of litter items
- coding according to standardized categories
- statistical analysis of datasets
- spatial analysis using GIS



Such analysis helps identify pollution hotspots and trends.

Using Monitoring Results for Policy and Management

Monitoring results can support:

- environmental policy development
- ecosystem risk assessment
- public health protection
- integration into regional monitoring programs



They also contribute to regional monitoring programs in the Black Sea.



Black Sea SIERRA – Project 101124670

Training Courses



Co-funded by
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Thank you for your attention!

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