



Black Sea SIERRA – Project 101124670

Training Courses



Co-funded by
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Piloting session: UkrSCES (Ukraine)

War-Related Pollution in Black Sea Coastal Waters

Detection, Interpretation, and Tracking of Impact Signals

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Date: 17th June 2026





Military activity creates multiple episodic and chronic pressures in coastal and marine systems.

The monitoring challenge

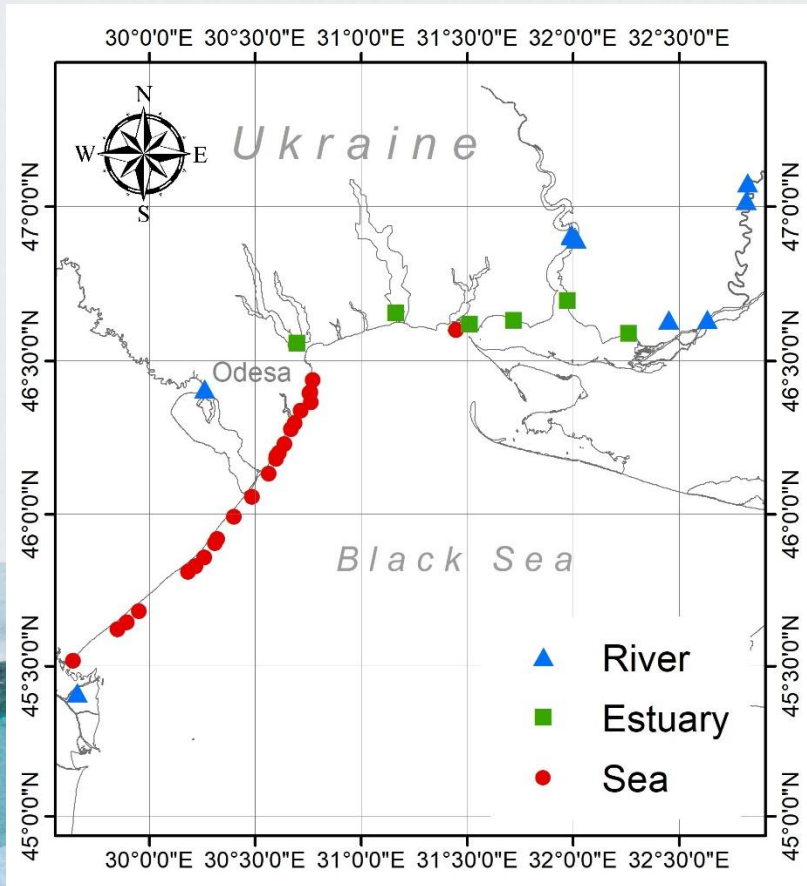
- ✓ New and mobile sources appear: damaged infrastructure, vessels, mines, debris and emergency discharges.
- ✓ Offshore sampling becomes constrained by security risks and operational limitations.
- ✓ Evidence must remain useful for screening, response and recovery planning without overstating certainty.

Practical answer

Combine field observations + chemical evidence + remote sensing + modelling

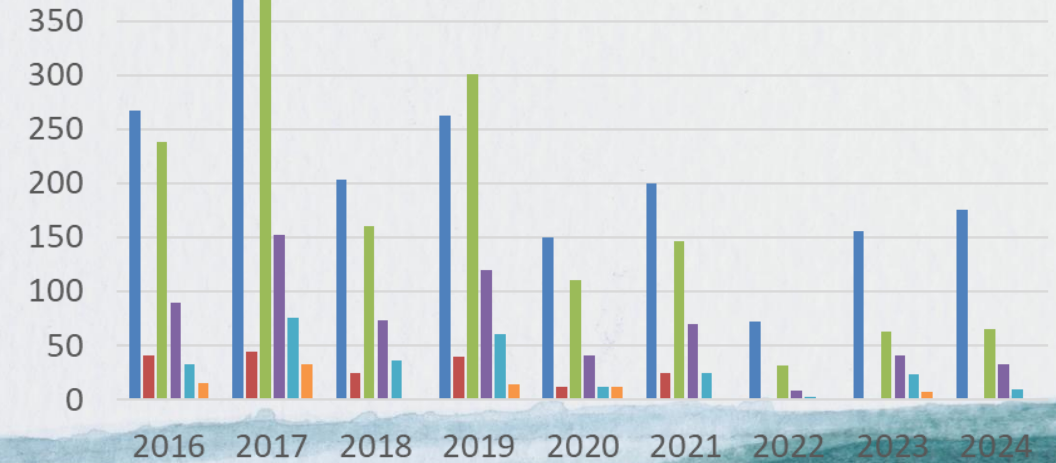
Interpret signals as scenarios under uncertainty

Keep results reproducible and decision-relevant



Targeted contaminant survey network in the northwestern Black Sea (2023–2025)

Monitoring backbone



- Long-term coastal observations provide baseline and trend context.
- After 2022, offshore sampling effort decreased because of security constraints.
- Adaptive coastal schemes partially restored biological and chemical evidence lines.

Key interpretation frame: baseline → event signal → post-event persistence



Bombardments & explosions

direct input
secondary release
transport to shore



Sea mines & munitions

direct input
secondary release
transport to shore



Infrastructure destruction

direct input
secondary release
transport to shore



Hazardous debris

direct input
secondary release
transport to shore



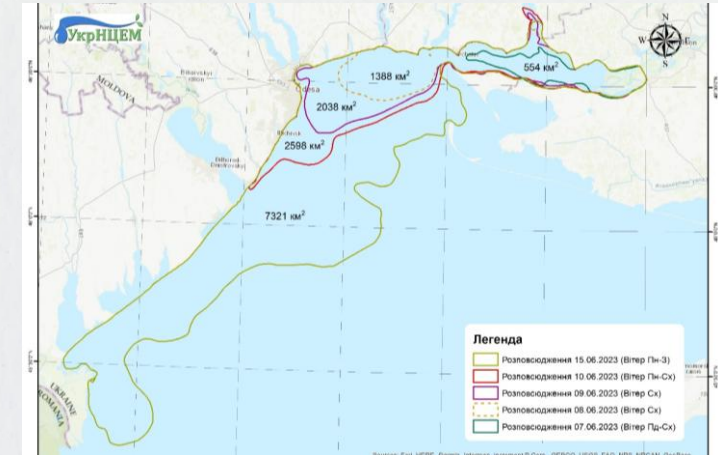
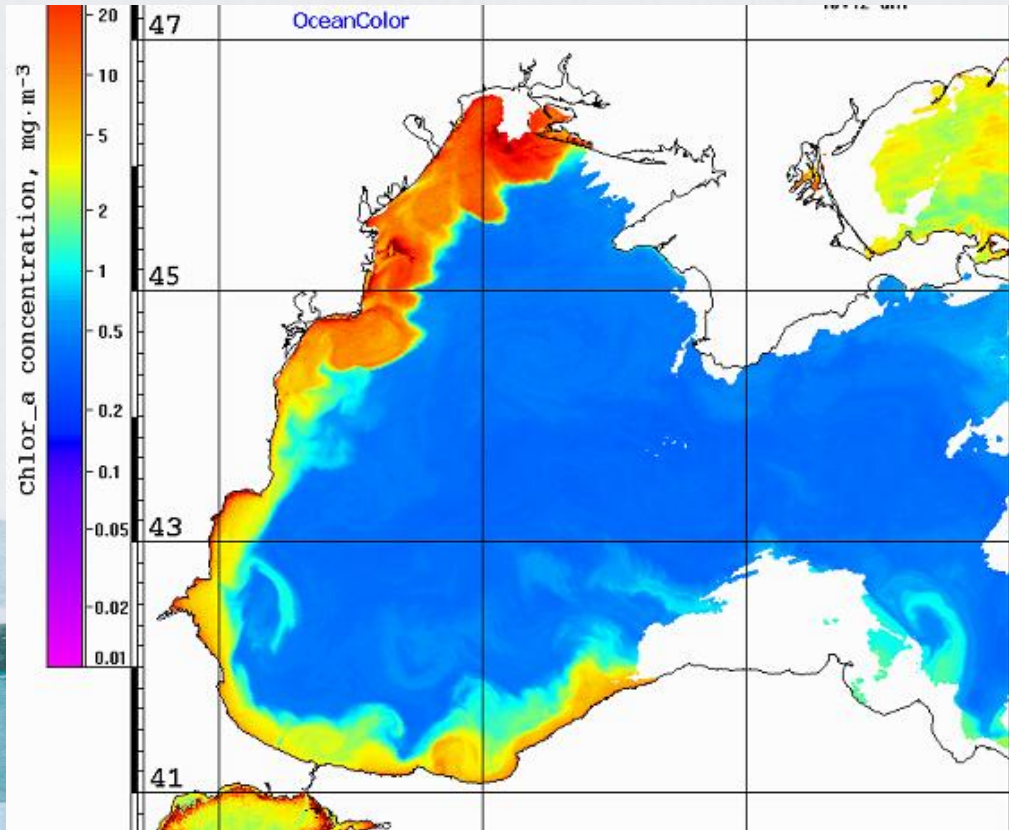
Industrial fires & spills

direct input
secondary release
transport to shore

river inflow • nearshore circulation • storms • remobilisation

**Coastal waters and
sediments**

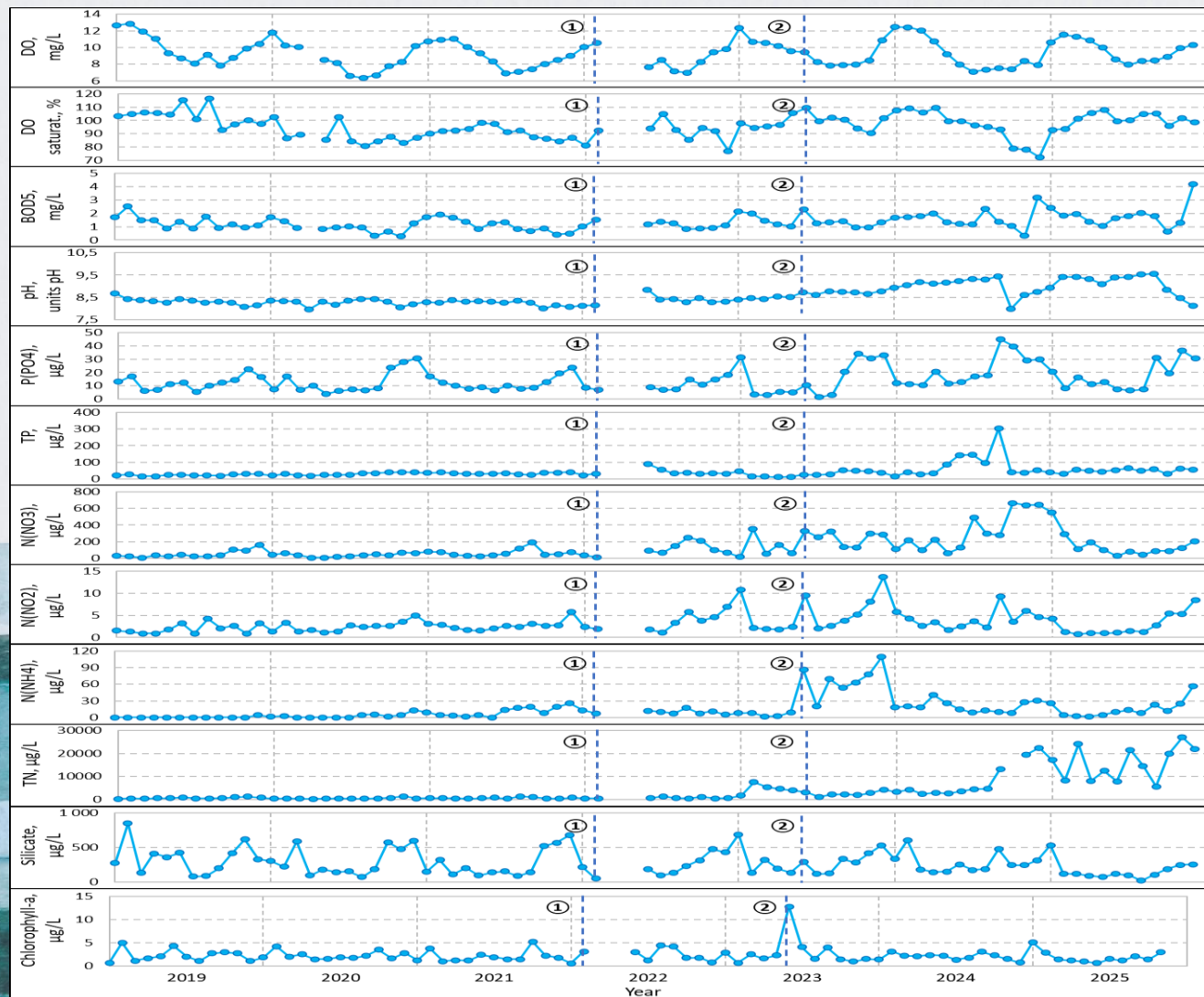
04 Event signal example: Kakhovka dam destruction



What reached the sea?

- Polluted river water and suspended matter
- Organic material and debris
- Short-lived but strong water-quality deviations
- Potential toxic pollution pulses
- Changes in phytoplankton and coastal water transparency

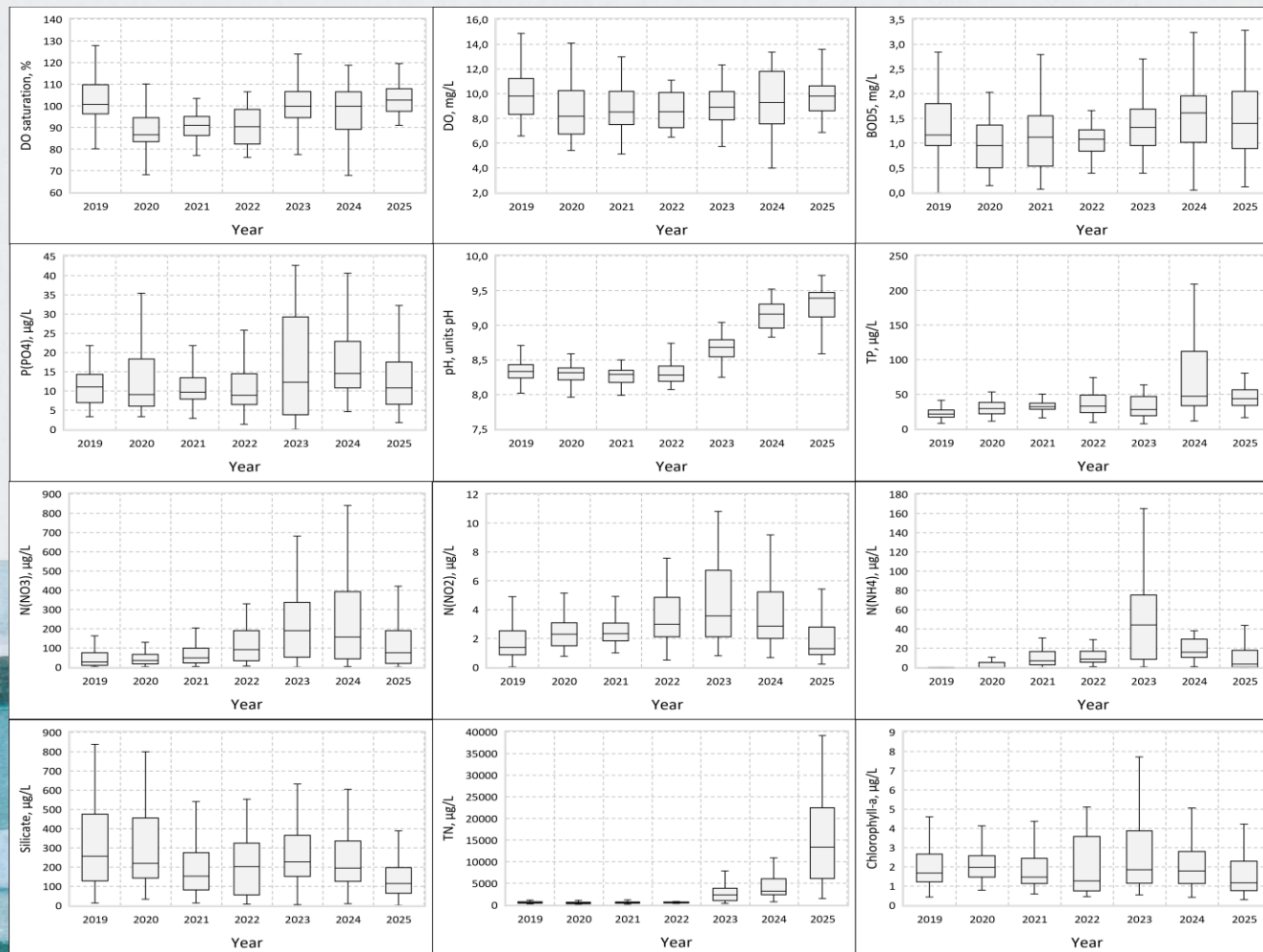
Lesson for monitoring: combine satellite observations with nearshore field evidence.



Monthly hydrochemical time series, Odesa coastal water body (2019–2025).
Dashed lines: 24 Feb 2022 and 6 Jun 2023.

What routine data can show

- Timing of abnormal periods against long-term coastal variability
- Oxygen regime and organic enrichment signals
- Nutrient dynamics and bloom-related changes
- pH and BOD-type shifts that indicate changed pressure conditions



Strength

Feasible, repeatable and comparable when access is constrained.

Limit

Hydrochemistry alone rarely identifies a source or mechanism.

Use hydrochemistry as the “when did conditions change?” line of evidence

Annual boxplots (2019–2025) summarise pre-war vs wartime shifts in central tendency and variability of key hydrochemical parameters.

Metals

corrosion, industrial inputs, fires

PAHs

combustion, oil/fuel residues

PCBs

legacy industrial contamination

OCPs

agricultural and historical sources

TPH

petroleum hydrocarbons and fuel residues

How to read the figure

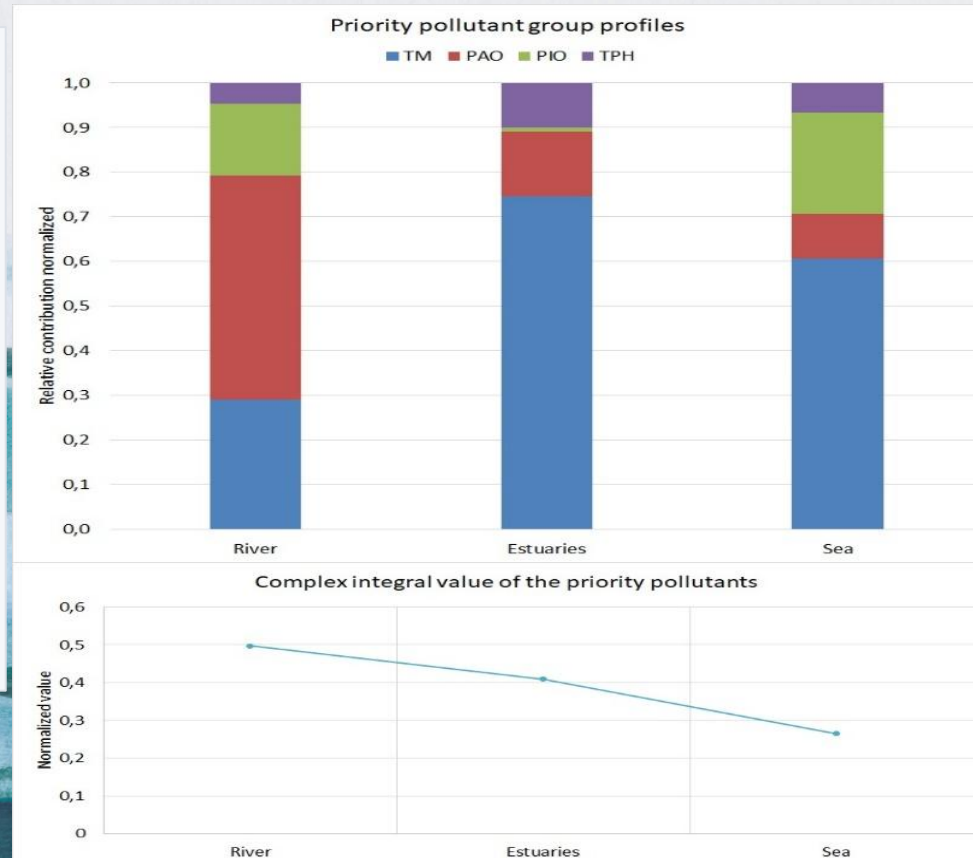
TM = toxic metals

PAO = agricultural-origin pollution (OCP-dominated)

PIO = industrial-origin organics (PAHs + PCBs)

TPH = total petroleum hydrocarbons

Bottom panel: the integral indicator declines from river → estuary → sea.



Interpretation logic

Targeted chemistry helps answer: “what pressure is driving the signal?”

Targeted chemistry answers: “what kind of pressure is driving the signal?”

Routine hydrochemistry

when?



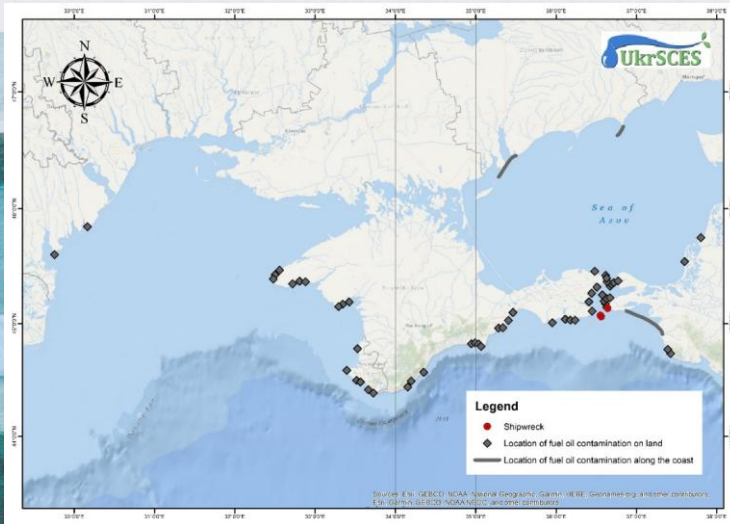
Priority pollutants

what?

Robust interpretation under uncertainty

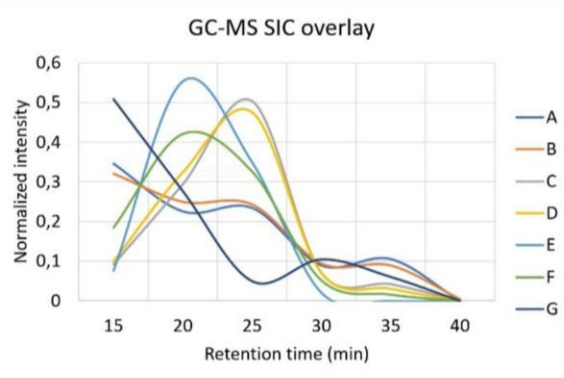
where from?

Shoreline oil residues

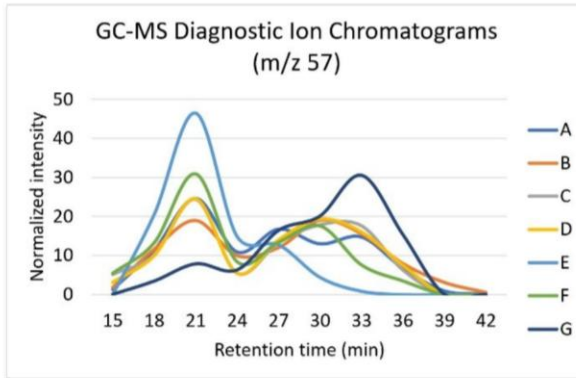


GC-MS fingerprinting: separating residue classes

Chromatographic envelopes and diagnostic ions distinguish product families and weathering states.



Selected-ion chromatogram overlays

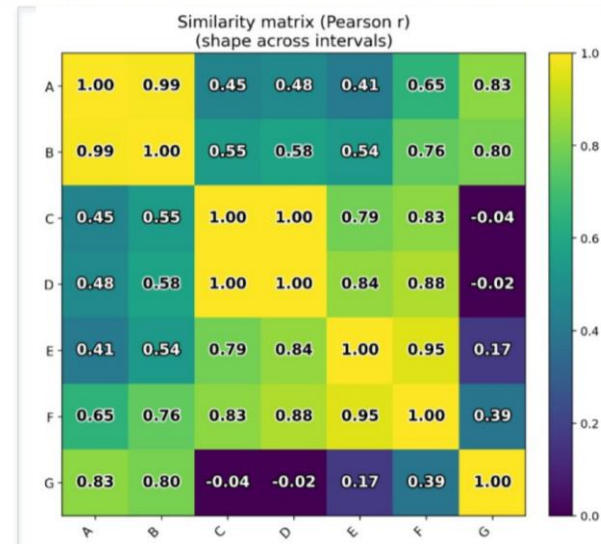


Diagnostic ion chromatograms (m/z 57)

Scientific caution: fingerprinting narrows plausible scenarios, but weathering and mixing limit product-specific attribution without reference materials.

Similarity analysis and product heterogeneity

Pairwise profile correlations show which residues are similar and which likely represent independent sources/pathways.



Strong grouping

Some samples cluster as related weathered residual fuel-oil-type material.

Independent signatures

Other samples are not similar to the main group, supporting interpretation of separate product types or pathways.

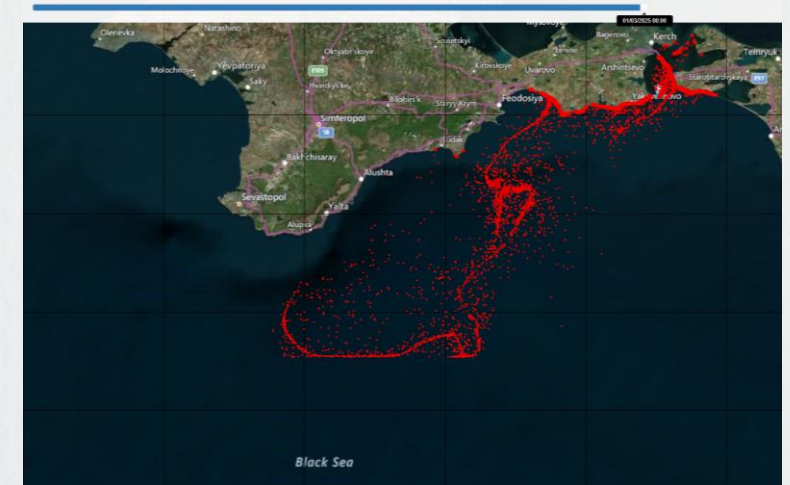
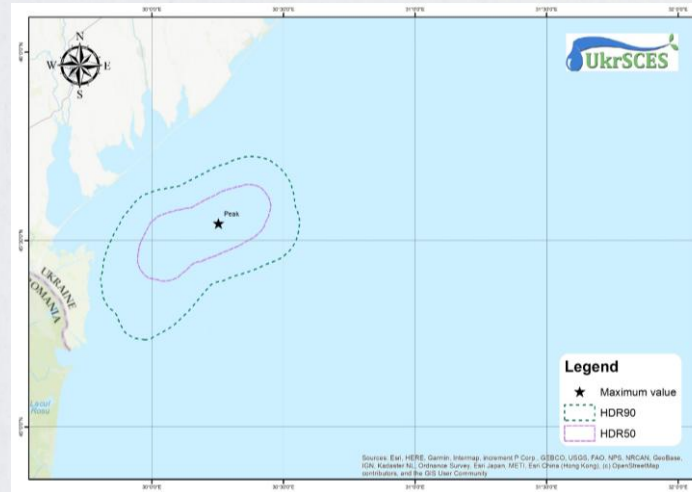
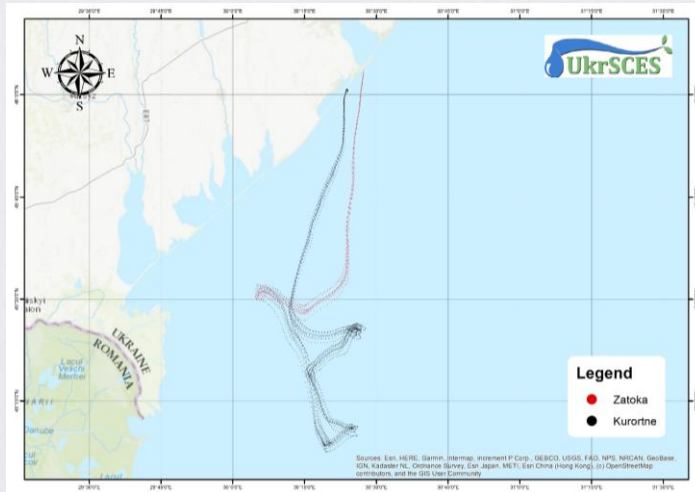
Why it matters

The coast may receive repeated deliveries and later remobilisation, so shoreline material should be treated as a secondary source.

What GC-MS helps to determine

- Weathering state and depletion of lighter fractions
- Heavy fuel-oil / mazut-like versus distillate-type signatures
- Similarity or difference between samples and stranding episodes
- Potential independent sources or residue classes

Chemical fingerprinting narrows scenarios; it should be combined with transport evidence and field context.



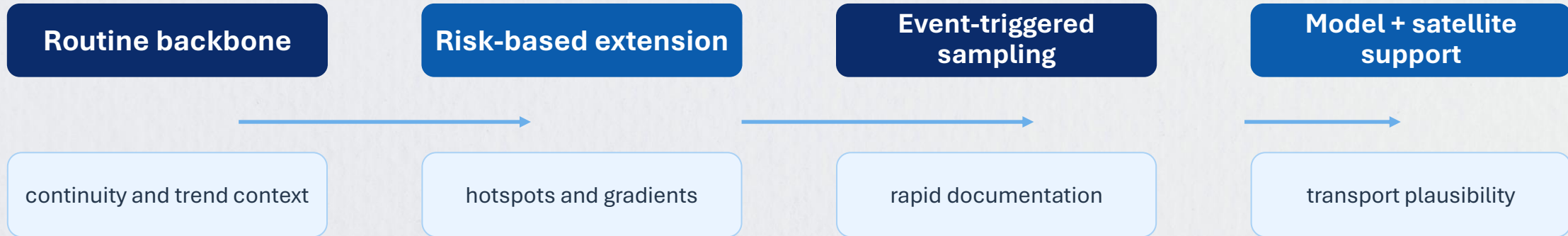
Use in interpretation

- Test whether candidate source zones are transport-plausible.
- Compare stranding dates with wind and current forcing.
- Map risk zones for response and targeted observation.

Caution

- A trajectory is not attribution by itself.
- Use ensemble runs and sensitivity tests.
- Report uncertainty explicitly.

Best use:
scenario narrowing
and operational
prioritisation



Recommended station typology

Background stations

Hotspot stations

Gradient stations

Temporal tiers

Emergency

Short-term

Long-term

Working principle

Do less offshore if necessary — but make every sample more diagnostic, better documented, and easier to integrate with models and data platforms.

Key messages



- War introduces new episodic pollution pathways while limiting regular monitoring.
- Hydrochemistry shows when conditions change; targeted pollutants help explain what changed.
- Stranded oil residues and backtracking modelling narrow plausible source scenarios.
- Results support risk screening, emergency response and restoration planning — not direct legal attribution alone.
- Future monitoring should be event-triggered, risk-oriented, harmonised and data-driven.

Discussion prompt

How can Black Sea partners maintain comparable evidence when access, safety, and sampling effort are uneven?



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Thank you for your attention!

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