Environmental Evidence Platform: Interactive Map of Pollution and Damage to the Black Sea

Scientific and Methodological Framework for Geospatial Documentation, Multisensor Verification, Field Evidence and Media Archiving

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Institutional contributors: NGO Green Leaf; Research Department of Tuzly Lagoons National Nature Park; National Ecological Centre of Ukraine; International Charitable Organization Environment–People–Law for specified analytical data.

Document status. This report presents the scientific and methodological framework of the platform, its current operational case studies and the principles for further development. It is a working publication intended for scientific review and subsequent extension.

Contents

Abstract

The Environmental Evidence Platform is a living and extensible geospatial system for collecting, structuring, verifying, publishing and preserving evidence of marine pollution and environmental damage, including impacts associated with Russia's aggression against Ukraine. The platform links satellite observations, field records, geographical coordinates, photographs, media files, samples, laboratory documents, biological observations and analytical reconstructions to discrete mapped objects. Each object is presented through a standardised bilingual evidence card that records what was observed, how the information was obtained, who produced or provided it, what uncertainty remains, and which sources can be opened by the user.

The platform was developed from a practical need to work under restricted access, military risk, incomplete official monitoring and rapidly changing environmental conditions. Its current release contains three fully developed operational case studies: the *Volgoneft-212/239* tanker disaster and heavy fuel oil pollution; the VO-1 vegetable-oil spill associated with the Port of Pivdennyi; and the VO-2 vegetable-oil spill associated with the Port of Chornomorsk. These cases test different combinations of source reconstruction, multisensor satellite analysis, longshore transport mapping, field verification, sampling, laboratory integration and biological-impact documentation. They are demonstrations of a reusable methodology rather than the final boundary of the platform.

A central methodological component is the integrated use of Sentinel-1 synthetic aperture radar and Sentinel-2 optical imagery. The authors' published method combines morphological analysis of surface slicks, identification of stable dark-core zones, backward tracing, meteorological and hydrodynamic correction, and optical verification of surface objects. Field verification then tests satellite interpretation against GPS positions, photographs, samples and biological evidence. The platform preserves direct observations separately from interpretations and analytical reconstructions, making uncertainty visible rather than concealing it.

The result is both a scientific monitoring environment and a georeferenced media and evidence repository. It can support environmental research, conservation management, public communication, investigative journalism, expert assessment and the organised preservation of materials potentially relevant to administrative or legal processes. Legal or forensic use nevertheless requires additional procedures for authenticity, chain of custody, laboratory traceability and expert validation.

Keywords: Black Sea; environmental evidence; marine pollution; Sentinel-1; Sentinel-2; synthetic aperture radar; oil slick; heavy fuel oil; vegetable oil spill; field verification; environmental monitoring; evidence mapping; georeferenced media repository; underwater pollution source.

1. Introduction and scope

1.1 Scientific and operational context

The Black Sea is exposed to interacting pressures from shipping, port and industrial infrastructure, river discharge, accidents, Russian strikes, damaged vessels and the mobilisation of contaminants during military operations. In wartime, the locations requiring the greatest attention may be inaccessible, dangerous or controlled by hostile forces. Conventional vessel-based surveys can be delayed or impossible, official information can be incomplete, and evidence can disappear through weathering, burial, dispersion, removal or the loss of online publications.

Under these conditions, environmental documentation must perform several functions at once. It must identify a potential event quickly, preserve its chronology, retain the original media, distinguish observation from inference, support later verification, and remain understandable to users who were not present during the initial analysis. A conventional thematic map is insufficient because it shows the spatial result without necessarily preserving the reasoning, source material, uncertainty or responsibility behind each object.

The platform therefore treats mapping as one component of a wider evidence process. A point, line or polygon is not merely a symbol. It is an entry point into an evidence package: date, coordinates, observation method, images, analytical documents, authorship, provenance, interpretation and limitations. This design converts a map from a final illustration into an active working document that can be revised, audited and extended.

The system originated through the documentation of concrete pollution events, but its architecture is deliberately broader. New incidents may involve fuel oil, petroleum products, vegetable oils, cargoes, combustion products, debris, contaminated sediments, mortality of organisms, habitat damage or other forms of environmental pressure. The event type can change while the internal logic remains stable.

The platform is selective rather than exhaustive. The current geographic and institutional capacity is strongest in the Kerch Strait, the northwestern Black Sea, the Odesa coastal zone, Tuzly Lagoons National Nature Park and Zhebriyanska Spit. Other sectors, including the Caucasian coast and wider Black Sea basin, may be incorporated when reliable observations, analytical capacity and responsible data partners are available. The absence of an event from the platform must not be interpreted as evidence that no pollution occurred.

The platform operates explicitly in the context of the Russian Federation’s aggression against Ukraine and preserves material that may be important for scientific assessment, investigations of environmental crimes, ecocide proceedings and future claims for compensation and reparations. The map does not make legal determinations for individual events; its task is to preserve provenance, methods, uncertainty and relationships between evidence objects.

1.2 Purpose, users and limits

This report presents the platform’s scientific and methodological framework, including the evidence architecture, object-card model, multisensor analysis, probable underwater-source localisation, field and laboratory verification, biological interpretation, cartographic implementation, media preservation, authorship and data governance. It also examines the current operational case studies and defines the procedure for adding future events.

The overall purpose is to develop and operate an extensible geospatial system for the collection, verification, organisation, publication and long-term preservation of evidence concerning marine pollution and related environmental damage in the Black Sea region.

The system is intended to:

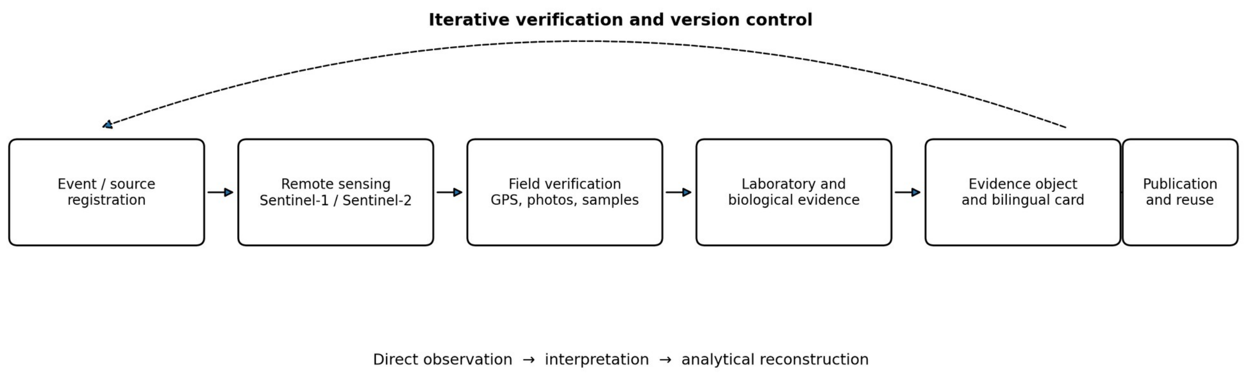
- preserve the spatial and chronological relationship between a pollution source, its development, transport and observed impacts;
- integrate remote-sensing, field, laboratory, biological and media evidence without erasing the differences between them;
- provide a repeatable object-card standard for new incidents;
- make the origin and limitations of evidence visible to users;
- allow photographs, satellite products and documents to be located and reused with correct attribution;
- support scientific comparison across events and pollutant types;
- maintain a versioned working record that can be expanded when new verified data appear.

The platform is designed for environmental scientists, protected-area staff, remote-sensing specialists, laboratory partners, journalists, civil-society organisations, public authorities, prosecutors and investigators, educators, donors and members of the public. Different users require different levels of detail. The map provides rapid spatial navigation, the object cards provide compact evidence summaries, and this report provides the methodological context needed for critical interpretation.

The platform is not an automatic pollution detector, a complete census of Black Sea incidents, a numerical oceanographic model, or a legal determination of responsibility. Satellite anomalies can have non-pollution causes. Field finds can be transported from distant sources. Laboratory data require sample-level traceability. Analytical transport pathways are hypotheses unless directly observed or modelled. These limitations are part of the system design and must remain visible in every downstream use.

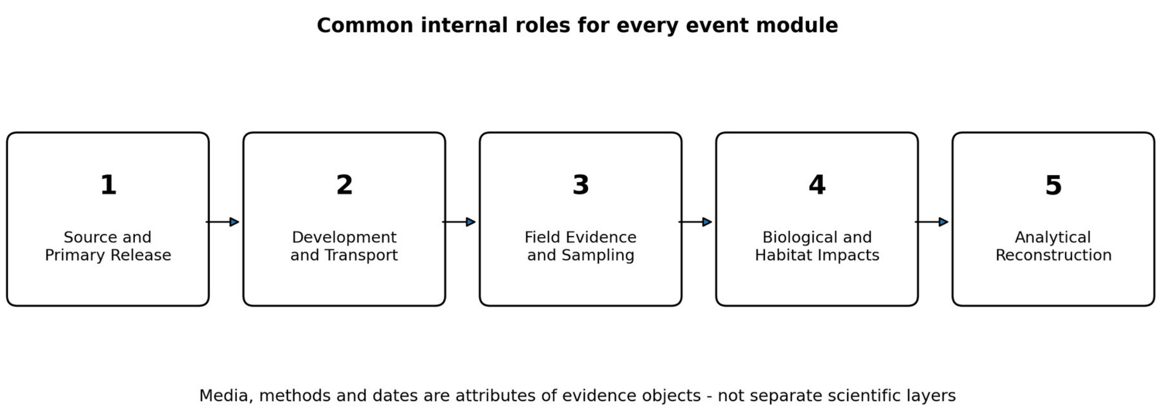
2. Platform architecture and evidence model

2.1 Event-centred architecture



Integrated platform workflow

Each pollution or damage incident is represented as an event module. An event module can contain points, lines, polygons, photographs, documents and analytical links, but these materials are organised according to their role in the evidence chain rather than according to file format or observation date. The approach prevents the proliferation of disconnected layers such as “satellite”, “field”, “photos” and “impacts” that would fragment one causal event.



Common evidence roles

The common internal roles are:

Role	Function in the evidence chain	Typical objects
Source and Primary Release	Identifies the initiating object, accident location or first documented release	damaged vessel, port tank, initial release polygon, stranded hull
Development and Transport	Documents spatial and temporal change	dated slick polygons, fragment positions, drift lines, coastal transport zones
Field Evidence and Sampling	Records direct on-site verification	GPS point, sample location, photographed residue, field-confirmed polygon
Biological and Habitat Impacts	Records contact with organisms or affected habitat	oiled fauna, contaminated psammophilic habitat, mortality area
Analytical Reconstruction	Makes an explicit, qualified inference from multiple evidence types	probable source location, backward-traced pathway, long-range connection

These roles are conceptual and documentary. They do not have to appear as separate public layers. Dates, sensors, photographs and videos are attributes of evidence objects, not alternative scientific architectures.

The current release uses four scientific layers: Volgoneft, VO-1, VO-2 and Shared Geographic and Scientific Context. A fifth presentation-only layer contains the interactive legend. The context layer is intentionally empty until independently meaningful contextual objects are ready. Empty placeholders are avoided because they can imply evidence that does not yet exist.

A real-world object should be represented once in the scientific architecture. Additional media are attached to that object when they document the same spatial evidence. A standalone media point is justified only when the media item has independent spatial meaning. Interviews are linked to the evidence location they explain, not to a studio or office. This rule reduces duplication and prevents users from mistaking repeated media references for independent observations.

2.2 Evidence objects and card standard

Every published object should contain, where applicable:

- a stable event and object identifier;
- an English public name and a Ukrainian name inside the card;
- geometry type and coordinates or interpreted area;
- event date, observation date and publication/version date;
- evidence role and evidence level;
- observation or processing method;
- direct evidence summary;
- scientific interpretation;
- uncertainty and limitations;
- photographs, satellite products, video or documents;
- sample identifier and laboratory link when relevant;
- author, institutional source and data provider;
- rights and licence information;
- revision history.

Object names displayed on the map are in English to maintain a compact and internationally readable catalogue. Each card contains a complete English block followed by a complete Ukrainian block. The two languages are not mixed inside a single appendix or metadata list. Images and sources are repeated in both blocks so that each language version remains complete when copied independently.

2.3 Evidence status and levels

Each evidence card identifies the status of the statement it contains. A field photograph of a dark viscous lump is a direct observation. Identification as weathered heavy fuel oil is a field interpretation that may be strengthened by laboratory analysis. Attribution to a specific tanker accident is a source hypothesis unless chemical fingerprinting or another decisive link is available. A line between the Kerch Strait and Tuzly Lagoons is an analytical reconstruction, not an observed trajectory.

The platform does not reduce evidence to a single numerical confidence score. Instead, it uses transparent categories:

1. primary field observation;
2. satellite-derived primary data;
3. optical or independent spatial verification;
4. laboratory-supported evidence;
5. multi-source analytical reconstruction;

6. contextual or secondary-source evidence.

An object may combine several levels. The card should identify the strongest supporting material and the unresolved uncertainty.

2.4 Public interface and use of the map

Users open the layer catalogue, select an event or evidence type and click a point, line or polygon. The evidence card provides the date, coordinates, observation method, photographs, sources, scientific interpretation and cautions. The full-screen view should be used for detailed work.

Points mark observations, finds, sampling locations or probable sources. Lines show documented movement or cautiously framed analytical reconstructions. Polygons show interpreted boundaries of satellite anomalies, contaminated areas or affected habitats and must not be read as perfectly exact physical boundaries of pollution.

The public map is a viewing and verification interface. It does not replace protected storage of original files, the internal evidence register or a procedural chain of custody.

3. Data sources, provenance and scientific responsibilities

3.1 Remote-sensing and environmental data

Sentinel-1 is the principal remote-sensing source for retrospective analysis of extended surface slicks in the current methodology. The mission provides synthetic aperture radar imagery independent of daylight and with strong all-weather capability. Radar backscatter responds to water-surface roughness. Surface films may damp short waves and appear as dark anomalies, but low wind, atmospheric processes, natural surfactants and other “look-alikes” can produce similar signatures. Consequently, a dark area is an analytical lead, not automatic proof of pollution.

The published method used Sentinel-1 Interferometric Wide Swath imagery with VV+VH polarisation and processed scenes through EO Browser/Sentinel Hub. For the tested Volgoneft case, the authors evaluated 18 visualisation scripts. The best reported result was obtained with the customised “VV - Linear Gamma0 - 50% green” visualisation, selected for dark-core contrast, resistance to background noise and boundary detail. Other useful visualisations included VV Gamma0 in decibels and SAR Urban.

Sentinel-2 provides multispectral optical information and is used for complementary verification. The MultiSpectral Instrument records visible, near-infrared and shortwave-infrared information, with four bands at 10 m spatial resolution and additional bands at 20 m and 60 m. In the current workflow, Level-2A surface-reflectance products are used where suitable.

The published method evaluated ten Sentinel-2 visualisation approaches. NDWI, SWIR composites and False Color Urban were particularly useful for checking slick boundaries, emulsified accumulations and surface objects such as debris or buoys. Optical images are easier to interpret intuitively but depend on cloud cover, illumination, sun glint and the spectral contrast of the pollutant. Sentinel-2 therefore complements rather than replaces SAR analysis.

Archived wind fields and related meteorological information are used to interpret changes in slick orientation, to reject implausible connections and to correct backward tracing. The published study used Meteoblue archives for the Volgoneft analysis. Where current or future work includes numerical currents, wave models or particle tracking, the model name, resolution, forcing, run time and assumptions must be recorded. A qualitative wind-consistency check must not be presented as a fully coupled hydrodynamic simulation.

3.2 Field, laboratory and institutional data

Field evidence includes GPS positions, photographs, notes, measurements, sample collection, descriptions of substrate and depositional context, observations of fauna and vegetation, and the spatial delineation of affected areas. Field verification in Tuzly Lagoons National Nature Park is conducted through the Park's Research Department under the scientific supervision of Ivan Rusev. The M-series heavy-fuel-oil photographs and materials are attributed to Vladyslav Balinsky and Ivan Rusev according to the current project record. FP-1, FP-2 and FP-3 observations, photographs and source materials are attributed to Ivan Rusev and the Park.

Ruslan Havryliuk coordinates the registration of samples, integration of laboratory data and scientific interpretation of analytical results for the platform. Analytical data associated with the M-6/M-7 survey were obtained within the work of the International Charitable Organization Environment–People–Law (EPL) and provided to the project by Olena Kravchenko.

A laboratory report can strengthen a field interpretation, but values must be assigned to a mapped point only when the sample identifier, date and location are explicitly matched. Regional analytical context must not be presented as a point-specific result. The M-6/M-7 cards therefore state the reported range for the documented sample set while preserving the requirement for sample-ID matching before assigning a value to an individual object.

NGO Green Leaf functions as an important publication and media platform for field reports, satellite interpretations and explanatory materials. The National Ecological Centre of Ukraine provides related institutional and project materials, including SUNDANSE publications. Direct institutional links are preserved because individual articles, media posts and downloadable files can become difficult to locate through general search over time.

3.3 Scientific responsibilities

Contributor	Principal responsibility in the platform
Vladyslav Balinsky, ORCID 0009-0007-5036-7897	remote-sensing methodology; Sentinel-1 and Sentinel-2 processing and interpretation; scientific mapping; field verification; evidence-system design; manuscript preparation
Ruslan Havryliuk, ORCID 0000-0002-6465-9440	project leadership; scientific coordination; sample and laboratory-data coordination; analytical integration; environmental interpretation; scientific review
Ivan Rusev, ORCID 0000-0003-4993-3672	scientific supervision of field verification; biological and ecosystem interpretation; validation and provision of Park field materials

Authorship of individual photographs, samples or analytical datasets is stated at the most specific level supported by the record. Institutional participation does not erase the need for item-level attribution.

The integrated Sentinel-1/Sentinel-2 methodology was disseminated at the XXV International Science Conference “Ecology. Human. Society”, held at Igor Sikorsky Kyiv Polytechnic Institute in Kyiv on 12 June 2025. The contribution by Vladyslav Balinskyy was entitled “Integrated methodology for tracing oil slicks using Sentinel-1 and Sentinel-2 data: backward modelling, meteorological correction, and visualization analysis”. The conference certificate is reproduced in Appendix D.

4. Integrated methodology

4.1 Multisensor remote sensing and source reconstruction

The multisensor workflow is iterative rather than linear:

1. register the incident, approximate source area and time window;
2. retrieve Sentinel-1 and Sentinel-2 acquisitions before, during and after the event;
3. inspect meteorological and sea-state conditions;
4. compare multiple visualisation approaches;
5. delineate candidate anomalies conservatively;
6. analyse morphology, persistence and relation to potential sources;
7. compare consecutive dates and reconstruct movement;
8. verify with optical imagery, known objects, field records or independent sources;
9. classify the result as direct observation, interpretation or analytical reconstruction;
10. publish the geometry and evidence card with limitations and version information.

Oil and other surface films can reduce capillary-wave roughness and lower radar backscatter. However, the same visual effect can occur in low-wind zones, rain cells, current boundaries, natural films, biological activity and areas sheltered by land or vessels. Interpretation therefore considers:

- whether wind conditions were sufficient to create measurable background roughness;
- whether the anomaly has a source-consistent geometry;
- whether it persists or evolves coherently between dates;
- whether its boundaries and internal dark-core zones are morphologically plausible;
- whether optical, field or media evidence supports the interpretation;
- whether neighbouring dark areas show atmospheric or oceanographic patterns inconsistent with pollution.

The platform avoids treating colour enhancement as measurement. A visualisation script changes readability, not the underlying physical quantity. Thresholds and channel modifications must be documented as interpretive settings.

Sentinel-2 can show colour, reflectance and surface-object information unavailable from SAR. It is especially useful for checking visible debris, buoys, thick accumulations, emulsions and large contrast boundaries. Optical evidence is strongest when the feature is present at the same location as a persistent SAR anomaly and when environmental conditions are suitable. Absence in Sentinel-2 does not disprove a thin film if cloud, sun glint, low contrast or acquisition timing reduce visibility.

The published method identifies a stable dark-core zone as a possible surface expression of an underwater leak. If a pollutant rises from depth while being displaced horizontally, the surface head will be offset from the source. The method expresses the horizontal displacement as:

$$L_h = (h \times v_h) / w_r$$

where **Lh** is horizontal displacement, **h** is source depth, **vh** is horizontal current velocity and **wr** is particle rise velocity. The source is then estimated by moving backward from the mapped head of the dark core along the normalised current direction:

$$P_{source} = P_{head} - L_h \times dir$$

where **Psource** is the calculated source position, **Phead** is the dark-core head mapped from SAR, and **dir** is the horizontal-current direction vector.

These equations do not remove uncertainty. Source depth, current velocity, rise velocity, georeferencing and identification of the slick head all affect the result. The method therefore combines the calculation with morphology, meteorological correction, repeated observations and Sentinel-2 verification. In the published Volgoneft test, the estimated localisation accuracy was reported as 40–150 m depending on the quality of input data, source depth, currents and georeferencing. This accuracy is a result for the tested conditions, not a universal guarantee.

In the reported case, Sentinel-1 allowed the interpreted slick boundary to be followed for more than 14.8 km from the debris, while the best suitable Sentinel-2 image showed approximately 7.4 km. During winter and spring, Sentinel-1 also supplied more usable acquisitions because cloud cover did not prevent radar imaging. Sentinel-2 remained important for confirming surface objects and pollution morphology. The practical conclusion is to use Sentinel-1 as the primary backward-tracing platform and Sentinel-2 as complementary verification when image quality permits.

Mapped boundaries represent interpreted spatial evidence, not exact physical limits or concentration contours. Delineation should be reproducible enough that another analyst can understand the decision, but it should not claim pixel-level certainty unsupported by the sensor. The platform records the complete interpreted area in the scientific object. Display clipping may then be used where larger polygons would hide smaller or earlier evidence; this cartographic operation does not change the documented full area.

4.2 Field, sampling, laboratory and biological verification

Field work tests whether the material, substrate and biological context are consistent with the satellite or analytical interpretation. It can also identify impacts that are invisible from orbit: buried residues, small aggregates, adhesion to organisms, contamination within porous sand, odour, viscosity, brittleness, emulsification and the condition of habitats.

Field verification is not merely confirmation. It can contradict a satellite interpretation, reveal a different pollutant, show that the affected area is larger or smaller than expected, or indicate that clean sediment has buried earlier contamination. Negative findings are informative only when the survey extent, timing and detection limits are known.

A field record should include:

- date and local time;
- observer and organisation;
- GPS coordinates and device or method;
- overview and close-up photographs;
- shoreline, substrate and weather conditions;
- dimensions, colour, texture, odour and association with sand or vegetation;
- distance from the waterline or other spatial reference;
- sample identifier, container, preservation and transfer information;
- observed fauna, flora or habitat contact;
- survey route or length, including areas without detections;
- a statement of uncertainty and possible alternative explanation.

A defensible sample record links field identification, container label, GPS point, collection time, collector, custody transfer, laboratory receipt, analytical method and result. The platform card is an access and interpretation layer; it does not replace the original custody and laboratory records. Where the full chain is not available for public release, the card should state what exists and what remains restricted or unresolved.

Petroleum-product concentration, PAH composition and physical characteristics can establish the presence and degree of contamination. Source attribution is more demanding. Similar weathered heavy fuels can converge in appearance, and environmental transformation changes volatile and soluble fractions. Comparative fingerprinting requires suitable reference materials, compatible analytical methods and a reasoned assessment of weathering. The platform therefore distinguishes “consistent with weathered heavy fuel oil” from “chemically attributed to a named source”.

Biological observations document contact and response, including oiled organisms, mortality, abnormal accumulation, contamination of stranded vegetation and changes in habitat condition. Photographs should identify the organism or habitat as specifically as the available expertise permits. Where identification is uncertain, the taxonomic level must not be overstated.

A pollutant can affect open water, the intertidal zone, sandy barriers, psammophilic vegetation, lagoons, reed beds, benthic substrates and other habitats differently. Vegetable oil, although a food product, can form films, emulsions and polymerised or buried material, coat organisms and alter oxygen exchange or substrate conditions. Heavy fuel oil can persist as weathered aggregates, become incorporated into sediment and expose organisms to hydrocarbons and PAHs. The platform records the observed habitat state and separates it from general ecological mechanisms inferred from the literature.

Protected-area staff provide continuity that short expeditions cannot. Repeated observations make it possible to distinguish a single stranded object from a recurrent deposition pattern, to interpret kilometre references, and to relate pollution to sensitive habitats and species. In the current platform, field verification in Tuzly Lagoons National Nature Park is scientifically supervised by Ivan Rusev and integrated with satellite and cartographic work by the wider team.

4.3 Georeferenced media and cartographic implementation

The platform's photographs, satellite crops, videos and downloadable documents are part of the evidence record. A user can enter through a mapped object, examine the media, identify the stated source and understand why the material is connected to that location. This is more reliable than a disconnected gallery in which files lose their spatial and analytical context.

Media are attached to an existing object when they document the same spatial evidence. A separate media point is created only when the media item has independent geographic meaning. Route video should be represented as a line only when meaningful GPS information is available. An interview is linked to the relevant evidence object, not to the place where the interview was recorded.

Where dated polygons overlap, the smaller or earlier object must remain visible and clickable. The larger polygon may lose fill in the overlap, and two helper boundaries can be displayed: an artificial cartographic cut and the actual external boundary. Helper geometries are non-interactive and do not represent additional evidence. The full interpreted area remains in the card and source geometry.

The public interface uses an interactive catalogue through Browser → Layers, an active legend, English object names and bilingual evidence cards. Real objects display a hover name and open a card on click. Technical helpers remain hidden or non-interactive. Probable analytical transport lines use a visually cautious style to avoid implying a directly observed route.

Every public release should preserve the source map, a technical manifest, a QA report and checksums. Material changes to geometry, interpretation, media, attribution or laboratory links should create a new version. Version control allows later users to determine what was known, interpreted and published at a particular time.

4.4 Long-term and cyclical consequences of pollution

The evidence chain does not end when a surface slick disappears. A fraction of contaminants may disperse, bind to suspended particles, settle and accumulate in bottom sediments and later be remobilised by waves, storms, currents, dredging, bioturbation or other disturbance. Renewed release into the water column creates secondary cycles of exposure and can continue to affect biota after the primary event has ended (Gulin et al., 2019).

The Black Sea is a semi-enclosed basin with a large-scale cyclonic current system that generally circulates counterclockwise along the continental slope. Together with coastal currents and mesoscale eddies, this circulation can transport tracers between eastern and northwestern sectors, including towards the Odesa coast and the Danube Delta (Osadchiev and Korshenko, 2017). Exchange through the Kerch Strait is highly variable and is strongly governed by wind forcing (Zavialov et al., 2020).

Analytical transport lines on the platform are therefore not presented as universal or directly measured pathways. Chronology, wind, waves, satellite morphology, regional circulation, field finds and, where available, numerical modelling are assessed separately for each event. Repeated deposition, beaching and remobilisation are emphasised because wartime pollution can have long-lived, cyclical and transboundary consequences.

5. Operational case studies

5.1 Volgoneft tanker disaster and heavy fuel oil pollution

The Volgoneft module demonstrates the most methodologically complex evidence chain in the current platform. It combines an approximate accident location, a stranded hull, interpreted positions of submerged fragments, visual or buoy confirmations, reconstructed drift lines, a probable long-range transport pathway, field detections, samples and laboratory context. The module is organised as one causal event rather than splitting satellite, field and media materials into separate thematic layers.

The approximate accident point of *Volgoneft-212* is explicitly classified as an analytical estimate. It was reconstructed from the earliest interpreted fragment positions, the storm-driven separation pattern and subsequent movement. It must not be treated as a surveyed accident coordinate.

The stranded main hull section of *Volgoneft-239*, without the bow section, is represented as both a wreck object and a potential continuing or residual source of heavy fuel oil. The card documents position and associated surface-pollution imagery but does not claim a measured remaining fuel inventory or release rate.

The platform contains dated SAR-derived positions for fragments 212/1 and 212/2 between 18 December 2024 and 12 January 2025. These points are interpretations of persistent anomalies and associated slick morphology; they are not underwater-survey fixes. The objects are treated as potential residual sources because submerged hull fragments may retain and intermittently release heavy fuel oil.

Sentinel-2 observations on 7 January 2025 showed visible surface objects near the SAR-derived fragment positions. These may have been buoys or markers and are used as independent spatial-consistency checks. The optical resolution is insufficient to determine the exact shape, depth or condition of the underwater fragments.

The dated positions were connected to show cumulative mapped displacement. The reconstructed path for fragment 212/1 reached 6.85 km through 12 January 2025, while the path for 212/2 reached 1.43 km. The contrast between the more mobile 212/1 and the comparatively stable 212/2 supported the source reconstruction. The lines connect discrete observations and are not continuous GPS tracks; the actual routes between dates may have differed from the straight segments shown.

The platform contains a more than 650 km analytical line linking the Kerch Strait source region with later M-series detections in and near Tuzly Lagoons. It is based on regional circulation, chronology and spatial correspondence. It is deliberately styled and described as probable. It is not a directly observed trajectory, particle-tracking output or chemical source fingerprint. Stronger attribution would require hydrodynamic modelling, source-specific reference materials and comparative chemical analysis.

M-1 to M-5 document weathered, dark, viscous or compact petroleum-like residues found on the Alibey sandbar in Tuzly Lagoons National Nature Park on 24 June 2025. The points preserve GPS positions, photographs, descriptions of texture, odour, relation to sand and sample collection.

Their distribution across southern, central, north-central and northern sections demonstrates multiple detections rather than one isolated object.

The field morphology is consistent with weathered heavy fuel oil. Attribution to the Volgoneft accident remains a working source hypothesis unless supported by comparative chemical fingerprinting. This distinction is important: regional chronology and circulation can make a source plausible without making it chemically proven.

M-6 and M-7 represent two nearby sections of a spatially extended survey on Zhebriyanska Spit on 15 July 2025. Dense dark-brown weathered aggregates were mixed with sand and, in some cases, stranded vegetation. The paired points document contamination over a combined coastal length exceeding 500 m, with much of the material located 25–30 m from the waterline in a storm-deposition setting.

Analytical data associated with this survey were obtained within the work of Environment–People–Law and provided to the project by Olena Kravchenko. Ruslan Havryliuk coordinates the documentation, integration and interpretation of the laboratory results. The linked analytical record reports petroleum-product concentrations ranging from 3,000 to 85,000 mg/kg in the documented sample set and identifies a range of PAHs. An individual value should be assigned to M-6 or M-7 only where the sample register explicitly links the point and sample identifier.

M-8 and M-9, collected on Zhebriyanska Spit on 17 July 2026, illustrate how weathered petroleum residues can differ physically. M-8 is a large, rounded, sand-rich aggregate that remained plastic and adhesive but had only a weak petroleum odour, consistent with substantial loss of lighter fractions. M-9 is a compact triangular and brittle material that fractured along natural cracks and is provisionally interpreted as an asphaltene-rich weathering product. Chemical and toxicological analysis is required to determine composition and to test the field interpretation.

The Volgoneft case demonstrates how repeated SAR scenes, optical checks, morphological reasoning, field records and analytical data can be integrated when direct access to the source area is restricted. It also demonstrates the importance of maintaining several levels of uncertainty at once: uncertainty of satellite identification, uncertainty of submerged-source position, uncertainty of transport, and uncertainty of source attribution for distant field finds.

5.2 VO-1 vegetable-oil spill from the Port of Pivdennyi

VO-1 contains three successive Sentinel-1 interpretations dated 21, 22 and 23 December 2025 following the attack on the Port of Pivdennyi on 20 December. VO-1A records the initial offshore plume, VO-1B records expansion and fragmentation, and VO-1C records the maximum extent mapped in the available sequence.

The polygons represent surface anomalies interpreted as vegetable oil. Their colour sequence distinguishes dates and stages, not concentration, toxicity or ecological severity. The sequence provides a time-ordered spatial record of release, expansion and redistribution. It does not quantify the released volume and does not imply that contamination ended at the last satellite boundary.

VO-1 demonstrates that the platform’s multisensor and evidence-card approach is not restricted to petroleum. Vegetable oil can also damp surface roughness, form visible accumulations, spread over large coastal areas and later polymerise or become buried. Interpretation still requires meteorological context and independent observations because radar darkening is not pollutant-specific.

The working dataset did not contain a later acquisition suitable for consistent continuation of the same polygon sequence. Subsequent field reports indicated coastal transport and ecological effects beyond the last satellite-mapped boundary. These later observations are contextual evidence and must not be represented as part of the VO-1C geometry unless independently delineated.

5.3 VO-2 vegetable-oil spill from the Port of Chornomorsk

VO-2A documents yellowish surface streaks within Sukhyi Lyman on 26 April 2026, interpreted from Sentinel-2 imagery as sunflower oil moving through port waters toward the open sea. This object occupies the Source and Primary Release role within the event.

The subsequent sequence was mapped primarily from Sentinel-1:

- VO-2B, 27 April: a compact elongated coastal anomaly extending approximately 9.17 km southward from the port;
- VO-2C, 28 April: expansion into the marine area between Chornomorsk and Odesa, approximately 35.73 km long;
- VO-2D, 29 April: a broad fragmented slick of approximately 694.23 km^2 in Odesa Bay;
- VO-2E, 30 April: maximum satellite-mapped extent of approximately 899.50 km^2 and maximum mapped length of about 49.56 km;
- VO-2F, 3 May: a coastal component of approximately 227.8 km^2, perimeter 136.34 km, extending south beyond the Dniester Liman toward Serhiivka;
- VO-2G, 4 May: the southern coastal component between Serhiivka and Kurortne, immediately north of Tuzly Lagoons National Nature Park.

These values describe mapped geometries, not pollutant mass or concentration. The sequence demonstrates the transition from a port release to a large bay-scale event and then to a longshore transport belt.

FP-1 records field-confirmed sunflower-oil contamination on the protected sandy barrier at the 23rd–24th kilometre reference during 7–17 May 2026. The visually estimated affected area within the Park exceeded 10 ha. Repeated deposition followed strong easterly and southerly winds, and clean sand locally buried earlier contaminated layers. Oiled molluscs, the hermit crab *Diogenes pugilator* and oil-coated stranded macroalgae were documented.

The field polygon represents the documented affected section rather than a concentration contour. Burial by clean sand is important because a beach can appear visually cleaner while retaining oil below the surface.

FP-2 records vegetable oil distributed across a sandy psammophilic habitat at the 26th kilometre. The polygon follows the shoreline and represents an interpreted 300–400 m section based on the field location and visible spatial pattern, not a directly measured closed transect. The direct evidence is the photographed contamination; statements about penetration into pore spaces and coating of grains are ecological interpretations based on substrate properties.

FP-3 records a visible surface film and oil-in-water emulsion in shallow coastal waters at the 33rd kilometre. Photographs show the jellyfish *Aurelia aurita* and *Rhizostoma pulmo* in contact with contaminated water. The field evidence confirms that the pollutant was present both at the surface and as dispersed or emulsified material. Statements about gas exchange, transparency and physiological effects remain interpretations unless supported by direct measurements.

VO-2 is the clearest current example of the complete platform chain: port source, optical detection, successive SAR stages, southward transport, protected-area field confirmation, habitat effects and biological contact. Satellite data establish the chronology and regional geometry; field data establish the nature of the material and the affected habitats. Neither source is sufficient alone for the full interpretation.

6. Expansion, quality assurance and governance

6.1 Adding new events

A new event can be triggered by a satellite anomaly, field report, official notification, media evidence, vessel incident, attack on infrastructure or biological observation. Preliminary registration records the reported time, location, possible source, original link or file, reporter and verification status. The platform should not wait for complete certainty before preserving a lead, but an unverified lead must not be published as a confirmed object.

The editorial team determines whether the lead belongs to an existing event or constitutes a new causal event. Objects should not be grouped solely because they use the same method or occur in the same month. The event boundary is causal: common source, release and development chain.

Stage	Required action	Publication result
Intake	preserve original file, URL, timestamp and reporter	internal incident record
Triage	check time, location, duplication, obvious inconsistencies and security concerns	verified lead or rejected/held lead
Remote analysis	retrieve suitable imagery and environmental context	candidate geometry and interpretation
Field/laboratory work	GPS, photographs, samples, biological observations where feasible	direct evidence objects
Evidence review	separate observations, interpretations and reconstruction; check provenance	publishable object card
Cartographic integration	assign event layer, code, style and overlap rules	map object
Editorial QA	language, names, sources, rights, coordinates and uncertainty	release candidate
Versioned release	archive map, manifest, QA and checksum	public platform update

The architecture reserves code families and roles for future sources, transport pathways, field samples, impacts, analytical reconstructions and spatially justified media. Reservation does not create empty public objects. New sectors of the Black Sea may be added as institutional partnerships and evidence capacity grow.

Publication can create risks. Exact locations of sensitive species, active field teams, strategic infrastructure or uncollected evidence may require delay, generalisation or restricted access. Personal information must be minimised. Media showing injured or dead organisms should be used only when evidentially necessary and presented with appropriate context.

Members of the public, scientists, protected-area staff and journalists may submit photographs and reports of heavy fuel oil, petroleum, vegetable oil, dead or affected dolphins, birds and other biota to zeleniy.list1@gmail.com. A minimum submission should include the original photographs, date, location or coordinates and a short description. Personal safety takes priority: no one should approach mines, munitions, unknown substances or dangerous objects in order to document an event.

6.2 Quality, uncertainty and governance

Every release should verify layer count, feature count, geometry validity, stable identifiers, coordinate ranges, media URLs, link availability, bilingual structure and visibility of smaller overlapping objects. Automated checks are necessary but not sufficient. The public map must be opened and visually inspected after import because server versions can render markers, legends and popups differently.

Scientific review asks whether the evidence supports the statement in the card. Key questions include:

- Is a dark SAR anomaly being treated as proof rather than a candidate?
- Is an analytical pathway being described as observed movement?
- Is a regional laboratory result assigned to a point without sample matching?
- Is absence of optical detection being treated as absence of pollution?
- Is a field photograph sufficient for the taxonomic or chemical claim?
- Are mapped areas described as interpreted rather than exact?
- Are alternative explanations and uncertainty visible?

Names, dates, units, transliteration, authorship and institutional titles must be standardised. English public names should remain concise. Cards must avoid duplicated titles, first-person working notes, unsupported certainty and mixed-language appendices. Scientific terminology should be consistent across cases while preserving pollutant-specific differences.

The platform distinguishes authorship, institutional source, data provider and funder. These are not interchangeable. A person who supplies a laboratory report is not automatically the analyst; an organisation that funds the work is not responsible for the conclusions; Copernicus is the source of original Sentinel data while derived crops and interpretations have project authorship.

Errors should be corrected transparently. A correction can modify text, attribution, coordinates, media or geometry. Material corrections create a new version and are recorded in the manifest. Previous releases should remain archived where legally and ethically possible.

7. Applications, limitations and sustainability

7.1 Scientific, conservation, public and administrative uses

The platform supports hypothesis formation, comparison of events, prioritisation of field surveys, retrospective reconstruction and communication across disciplines. Its strongest contribution is the preservation of relationships: source to slick, slick to transport, transport to field find, field find to sample, sample to analysis, and observation to ecological interpretation.

Protected-area managers can use the platform to identify recurrent deposition sectors, sensitive habitats, kilometre references and the timing of field checks. Repeated records can support cleanup decisions, follow-up sampling and communication with authorities and communities.

The georeferenced media repository allows journalists and the public to access images together with dates, coordinates, sources and limitations. This reduces the risk that dramatic images circulate without location or context. Reuse must preserve attribution and the terms of third-party materials.

The platform can organise materials potentially relevant to complaints, expert assessments and investigations. Coordinates and analytical reconstructions can help authorities identify where to request additional information or conduct surveys. However, the public platform alone does not establish admissibility, authenticity or legal causation. Legal use requires original files, metadata, witness or collector records, chain of custody, laboratory accreditation, expert methodology and compliance with the applicable procedural rules.

7.2 Limitations, access and sustainability

The principal limitations are incomplete geographic coverage, irregular satellite acquisition, weather and sea-state effects, restricted field access, uncertain pollutant volumes, variable sample traceability, possible source look-alikes and the absence of continuous hydrodynamic modelling for some analytical pathways. Public visibility can also be affected by link decay and platform-specific rendering. These limitations are addressed through explicit card language, multi-source verification, versioning and preservation of direct institutional links.

The platform is designed for continued addition rather than one-time publication. Sustainability requires named maintainers, a defined review process, archived releases, institutional mirrors and a plan for broken links. New evidence should improve the record without silently rewriting earlier knowledge.

The platform is developed and implemented with financial support from the German Federal Environmental Foundation - Deutsche Bundesstiftung Umwelt (DBU), project reference 30025/100. DBU support enables methodological development, remote and field monitoring, evidence-system architecture, integration of laboratory and media materials and public

presentation. The authors and partner organisations gratefully acknowledge this support. Responsibility for scientific content, interpretations and conclusions remains with the authors and participating organisations.

8. Conclusions

The Environmental Evidence Platform is not a static map of three incidents. It is a reusable scientific and documentary framework that connects remote sensing, field science, laboratory information, biological evidence, cartography and media preservation through standardised geospatial objects.

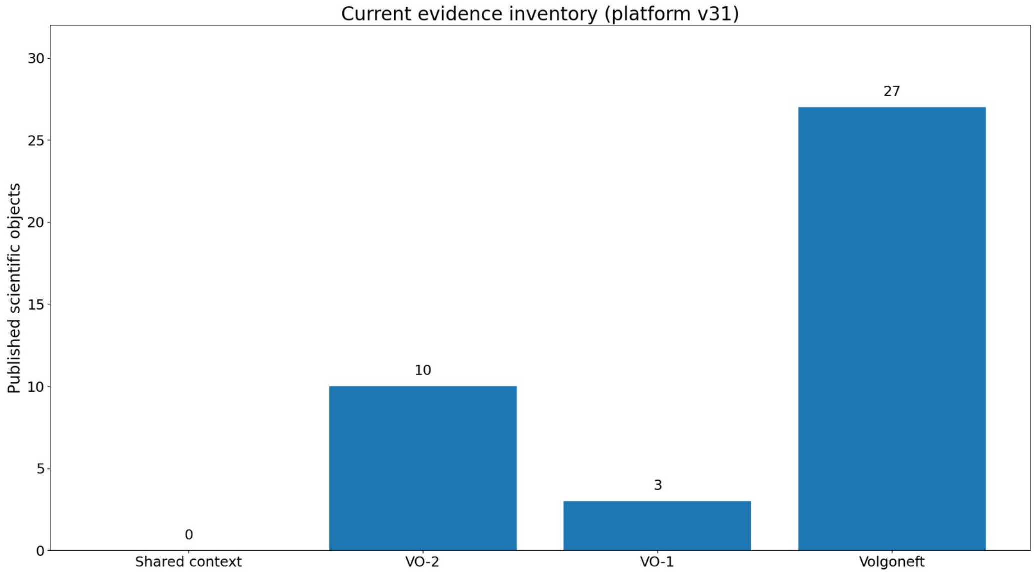
The current operational cases demonstrate complementary strengths. Volgoneft tests backward tracing, probable underwater-source localisation, fragment movement and distant field verification. VO-1 tests rapid mapping of a large non-petroleum industrial surface spill. VO-2 demonstrates the complete chain from port release and bay-scale transport to protected-area field and biological confirmation.

The methodological principle is integration without conflation. Sentinel-1, Sentinel-2, field observations, laboratory results and media sources are combined, but each retains its own evidentiary status and limitations. Direct observation is not replaced by visual certainty, and analytical reconstruction is not presented as a measured trajectory.

The platform can be extended to new vessel losses, port attacks, industrial releases, contaminated cargoes, sediment events, mortality of dolphins, birds and other biota, and other environmental consequences, provided that provenance, uncertainty, authorship and versioned review are maintained. Long-term assessment must address not only the primary release but also repeated deposition, remobilisation and cyclical return of contaminants to the water column.

Appendix A. Current published evidence inventory

The following inventory describes the platform as of version 31. Technical helper geometries and legend samples are excluded. The inventory is a release snapshot, not a limit on future content.



Current inventory by event module

Event	Published object	Geometry	Evidence role	Principal evidence basis
VO-2	FP-1 – Field-Confirmed Vegetable Oil Contamination of the Protected Sandy Barrier (23–24 km)	Polygon	Field Evidence; Biological and Habitat Impacts	field observation and photography; interpreted field polygon
VO-2	FP-3 – Field-Confirmed Vegetable Oil Film and Emulsion in Coastal Waters (33 km)	Polygon	Field Evidence; Biological and Habitat Impacts	field observation and photography; interpreted field polygon
VO-2	VO-2A – Initial Vegetable Oil Release within Sukhyi Lyman (26 April 2026)	Polygon	Source and Primary Release	Sentinel-2 optical interpretation
VO-2	VO-2B – Initial Coastal Vegetable Oil Slick (27 April 2026)	Polygon	Development and Transport	Sentinel-1 SAR interpretation
VO-2	VO-2C – Northward Expansion toward Odesa (28 April 2026)	MultiPolygon	Development and Transport	Sentinel-1 SAR interpretation
VO-2	VO-2D – Large-	MultiPolygon	Development and	Sentinel-1 SAR

Event	Published object	Geometry	Evidence role	Principal evidence basis
	Scale Odesa Bay Vegetable Oil Slick (29 April 2026)		Transport	interpretation
VO-2	VO-2E – Maximum Satellite-Mapped Surface Extent (30 April 2026)	MultiPolygon	Development and Transport	Sentinel-1 SAR interpretation
VO-2	VO-2F – Southward Coastal Transport toward Tuzly Lagoons (3 May 2026)	Polygon	Development and Transport	Sentinel-1 SAR interpretation
VO-2	VO-2G – Southern Coastal Component near Tuzly Lagoons (4 May 2026)	Polygon	Development and Transport	Sentinel-1 SAR interpretation
VO-2	FP-2 – Field-Confirmed Vegetable Oil Contamination of Psammophilic Habitat (26 km)	Polygon	Field Evidence; Biological and Habitat Impacts	field observation and photography; interpreted field polygon
VO-1	VO-1A – Initial Offshore Vegetable Oil Slick (21 December 2025)	Polygon	Development and Transport	Sentinel-1 SAR interpretation
VO-1	VO-1C – Maximum Satellite-Mapped Vegetable Oil Slick (23 December 2025)	MultiPolygon	Development and Transport	Sentinel-1 SAR interpretation
VO-1	VO-1B – Expanded Offshore Vegetable Oil Slick (22 December 2025)	MultiPolygon	Development and Transport	Sentinel-1 SAR interpretation
Volgoneft	M-4 – Compact Weathered Heavy	Point	Field Evidence and Sampling	GPS, field photography,

Event	Published object	Geometry	Evidence role	Principal evidence basis
	Fuel Oil Lump on the Northern Alibey Sandbar			sample record; laboratory context where linked
Volgoneft	M-1 – Weathered Heavy Fuel Oil Residues on the Southern Alibey Sandbar	Point	Field Evidence and Sampling	GPS, field photography, sample record; laboratory context where linked
Volgoneft	M-3 – Weathered Heavy Fuel Oil Residues on the North-Central Alibey Sandbar	Point	Field Evidence and Sampling	GPS, field photography, sample record; laboratory context where linked
Volgoneft	M-5 – Weathered Heavy Fuel Oil Residue near the Northern Park Boundary	Point	Field Evidence and Sampling	GPS, field photography, sample record; laboratory context where linked
Volgoneft	M-6 – Weathered Heavy Fuel Oil Deposits on Zhebriyanska Spit, Survey Section 1	Point	Field Evidence and Sampling	GPS, field photography, sample record; laboratory context where linked
Volgoneft	M-7 – Weathered Heavy Fuel Oil Deposits on Zhebriyanska Spit, Survey Section 2	Point	Field Evidence and Sampling	GPS, field photography, sample record; laboratory context where linked
Volgoneft	M-2 – Weathered Heavy Fuel Oil Residues on the Central Alibey Sandbar	Point	Field Evidence and Sampling	GPS, field photography, sample record; laboratory context where linked
Volgoneft	M-8 – Large Weathered Heavy Fuel Oil Aggregate on Zhebriyanska Spit	Point	Field Evidence and Sampling	GPS, field photography, sample record; laboratory context where

Event	Published object	Geometry	Evidence role	Principal evidence basis
				linked
Volgoneft	M-9 – Brittle Asphaltene-Rich Petroleum Residue on Zhebriyanska Spit	Point	Field Evidence and Sampling	GPS, field photography, sample record; laboratory context where linked
Volgoneft	VG-AR-1 – Probable Kerch Strait–Tuzly Lagoons Transport Pathway	LineString	Analytical Reconstruction	regional circulation, chronology and spatial correspondence
Volgoneft	Volgoneft-239 – Stranded Hull without Bow Section (12 January 2025)	Point	Source and Primary Release	mapped hull position, satellite and photographic documentation
Volgoneft	Volgoneft-212 Fragment 212/1 – Visual/Buoy Confirmation (7 January 2025)	Point	Development and Transport	Sentinel-2 optical consistency check
Volgoneft	Volgoneft-212 Fragment 212/1 – SAR-Derived Position (18 December 2024)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 Fragment 212/1 – SAR-Derived Position (19 December 2024)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 Fragment 212/1 – SAR-Derived Position (23 December 2024)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 Fragment 212/1 – SAR-Derived Position (31 December 2024)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 Fragment 212/1 –	Point	Development and Transport;	Sentinel-1 SAR

Event	Published object	Geometry	Evidence role	Principal evidence basis
	SAR-Derived Position (12 January 2025)		potential residual source	interpretation
Volgoneft	Volgoneft-212 Fragment 212/2 – Visual/Buoy Confirmation (7 January 2025)	Point	Development and Transport	Sentinel-2 optical consistency check
Volgoneft	Volgoneft-212 Fragment 212/2 – SAR-Derived Position (18 December 2024)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 Fragment 212/2 – SAR-Derived Position (19 December 2024)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 Fragment 212/2 – SAR-Derived Position (23 December 2024)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 Fragment 212/2 – SAR-Derived Position (31 December 2024)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 Fragment 212/2 – SAR-Derived Position (11 January 2025)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 Fragment 212/2 – SAR-Derived Position (12 January 2025)	Point	Development and Transport; potential residual source	Sentinel-1 SAR interpretation
Volgoneft	Volgoneft-212 – Approximate Accident Location	Point	Source and Primary Release	analytical reconstruction from fragment positions and drift sequence
Volgoneft	Volgoneft-212 Fragment 212/1 –	LineString	Development and	line connecting dated satellite-

Event	Published object	Geometry	Evidence role	Principal evidence basis
	Reconstructed Drift Path through 12 January 2025		Transport	derived positions
Volgoneft	Volgoneft-212 Fragment 212/2 – Reconstructed Drift Path through 12 January 2025	LineString	Development and Transport	line connecting dated satellite-derived positions

Appendix B. Minimum metadata schema for a new evidence object

Field	Requirement
Event identifier	Stable identifier linking the object to one causal event module.
Object identifier	Unique code that remains stable across revisions.
Public name	Concise English name; Ukrainian name in the card.
Evidence role	One or more of the five internal roles.
Geometry	Point, line or polygon with coordinate reference and precision appropriate to the evidence.
Dates	Event, acquisition, field observation, sample, analysis and publication dates as applicable.
Method	Sensor, visualisation, field protocol, laboratory method or analytical procedure.
Direct evidence	What was actually observed or measured.
Interpretation	Scientific meaning assigned to the direct evidence.
Uncertainty	Alternative explanations, spatial and temporal limits, and confidence language.
Media	Images, video, satellite crops and document links with captions.
Sample traceability	Sample ID, collector, custody, laboratory and report linkage.
Authorship and provenance	Author, photographer, institution, data provider and funder recorded separately.
Rights	Licence or third-party-use conditions.
Version history	Creation, review and material revision record.

Appendix C. Contribution and responsibility matrix

Activity	Vladyslav Balinsky	Ruslan Havryliuk	Ivan Rusev	Partner institutions
Conceptualisation and evidence architecture	Lead	Co-lead / review	Field-science review	Institutional consultation
Remote-sensing methodology and processing	Lead	Scientific coordination	Contextual review	Copernicus data; NECU/SUNDANSE context
Scientific mapping and card system	Lead	Review	Field-data validation	Green Leaf publication platform
Field verification	Participant / documentation	Coordination and integration	Scientific supervision	Tuzly Lagoons NNP research team
Samples and laboratory-data integration	Field/sample participation	Lead coordination and interpretation	Field context	EPL for M-6/M-7 analytical data; Olena Kravchenko as provider
Biological and habitat interpretation	Co-analysis	Environmental integration	Lead	Tuzly Lagoons NNP
Writing and editorial control	Lead drafting	Scientific review	Biological/field review	Contributing organisations
Funding support	Implementation	Project leadership	Scientific contribution	DBU project 30025/100

Appendix D. Scientific presentation and supporting documentation

The certificate below documents Vladyslav Balinskyy's participation in the XXV International Science Conference "Ecology. Human. Society" and identifies the title, date and venue of the contribution. The published proceedings paper and DOI listed in the references remain the principal bibliographic record of the methodology.


National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"
Національний технічний університет України «Київський політехнічний інститут імені Ігоря Сікорського»

CERTIFICATE
IS PRESENTED TO

Vladyslav BALINSKYY

for participation in
XXV International Science Conference
"Ecology. Human. Society"
with the theme of

Integrated methodology for tracing oil slicks using sentinel-1 and sentinel-2 data: backward modelling, meteorological correction, and visualization analysis

June 12, 2025
Kyiv

Dr. Anatoliy MELNYCHENKO
Rector of
Igor Sikorsky Kyiv Polytechnic Institute

Dr. Daniel BENATOV
Head of the
Organizing Committee

Figure D1. Certificate documenting Vladyslav Balinskyy's participation with the contribution "Integrated methodology for tracing oil slicks using Sentinel-1 and Sentinel-2 data: backward modelling, meteorological correction, and visualization analysis", XXV International Science Conference "Ecology. Human. Society", Kyiv, 12 June 2025.

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Recommended citation

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