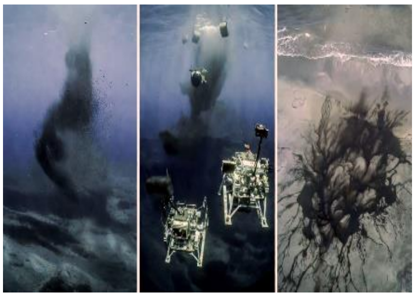
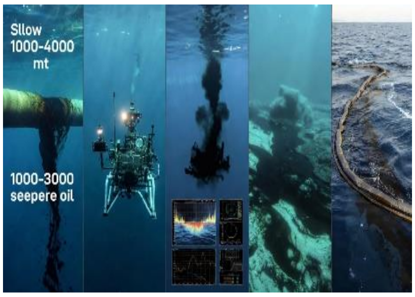
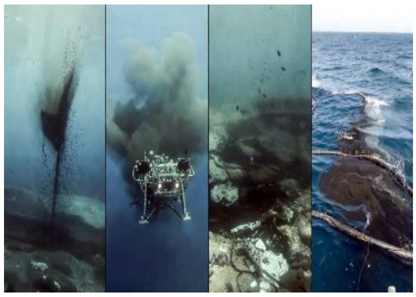
MARINE AND WATER DISASTERS - CASE STUDY

STUDY 4/A - NORMAL SYSTEM

1. Starting position
Offshore pipeline ruptures typically **result in long-term, low-intensity, hard-to-detect oil spills**, especially in deep-water or undersea pipelines.







The situation is aggravated by the following factors:

- **High water depth** (up to 1000-3000 m), which significantly limits access and early detection;
- **Initially low outflow rate**, which in the long run results in cumulative, significant environmental loads;
- **Strong sea currents and winds** that spread pollution over a large area;
- **Proximity to sensitive marine ecosystems** (e.g. plankton, fish stocks, coral structures, coastal habitats).

The primary objective of the intervention is to close the source of pollution, limit the spread and minimize environmental damage, in accordance with the provisions of the IMO MARPOL Convention and OSPAR guidelines.

Reference cases include **damage to the Nord Stream pipeline in 2022** and minor but persistent undersea pipeline damage discovered after the Deepwater Horizon event.

2. Nature of pollution (normal system)

- Slow, continuous oil outflow in the form of micro-sized droplets in the water column;
- **Plume-like (feather-like) dispersal** in deep-water environments;
- **Sediment pollution** on the seabed with chronic toxicity;
- Over time**, surface oil film formation**, increasing the risk of coastal pollution.

Pollution is typically crude oil or condensate that **emulsifies over time**, making detection and treatment more difficult, and **results in long-term ecotoxic effects** (e.g. 20-40% reduction of plankton populations in the affected areas).

3. Traditional intervention methods
3.1 Localization

- Use of ROVs and sonar systems to identify and seal cracks;
- In the case of surface appearance, installation of floating oil trap dams.

Limitations:

- Difficult and time-consuming detection in deep-water environments;
- In the case of a plume spreading in the water column, the surface barriers are ineffective;
- Reaction time of up to 48 to 72 hours, during which pollution increases cumulatively.

3.2 Surface removal

- Mechanical skimmers;
- Absorbent loops and sheets.

Absorbents used: perlite, zeolite, vermiculite, PP-based materials.

Limitations:
- Decrease in efficiency due to saturation with water (30-50%);
- Risk of back-down;
- Formation of a significant amount of hazardous waste (up to 5-10× weight ratio).

3.3 Surface and structure treatment
- Application of dispersants;
- Bioremediation for long-term degradation.

Limitations:
- Increased toxicity in the water column;
- Slow impact in deep-water, low-temperature environments;
- High operating costs.

4. Operational challenges
- Delayed detection;
- Complex actor coordination;
- Logistical difficulties in remote locations;
- High total cost due to chronic nature (€5-20 million per case).

5. Result - normal system
- Partial localization (50–70%);
- Prolonged plume in the water column;
- Significant post-cleaning and monitoring needs;
- Long-term ecological damage (biodiversity loss of 30-50%).

STUDY 4/B - EXOLINE® OIL STOP

1. Baseline (improved system)

The baseline event is the same as described in Study 4/A. The **goal of Exoline® Oil Stop is not to replace traditional systems**, but **to improve their material and functional** properties, especially in the case of chronic, hard-to-detect pollution.

The main objectives are:
- Hydrophobic stabilization **of pollution** near the source;
- Simultaneous treatment of water column and sediment pollution;
- Minimizing chronic transmission.

2. Nature of pollution with Exoline®
- **Exoline® Oil Stop creates a selective hydrophobic bond** with the oil phase;
- The degree of dispersion can be reduced by 50-70%;
- The simultaneous stabilization of the water column and sediment is realized.

3. Improved intervention methods

3.1 Localization
- **Application of Exoline® Oil Stop using ROVs near the point of discharge;**
- Addition of hydrophobic zones to traditional systems.

Result:
- Plume immobilization;
- Up to 70% reduced spread;
- Improved detection and localization.

3.2 Surface removal - absorber enhancement
- Conventional absorbents **in combination with Exoline® are less saturated with water**;
- Recoil is reduced;
- Fewer absorbents are required.

3.3 Surface and structure treatment

- Partial or complete replacement of dispersants;
- Stable, controlled treatment without toxic side effects.

4. Operational impact

- Faster response time (-40% to 60%);
- Simplified logistics;
- Lower waste disposal costs.

5. Result - improved system

- Localization efficiency up to 90%;
- Shorter post-cleaning time;
- Reduction of waste amount ~50%;
- Significant reduction of long-term ecological risk.

Final Note

The study presents **a subsequent technological comparison**. **Exoline® Oil Stop** was not used during the events referred to; the aim is to demonstrate the **potential of existing systems to improve material** in the event of chronic undersea contamination. **It** is recommended to launch pilot projects in a real pipeline environment to confirm quantitative data (cost-benefit, environmental impact, monitoring), in line with the objectives of IMO, OSPAR and the EU Green Deal.