Response to spills of alternative fuels and energy products

Non-floating oils

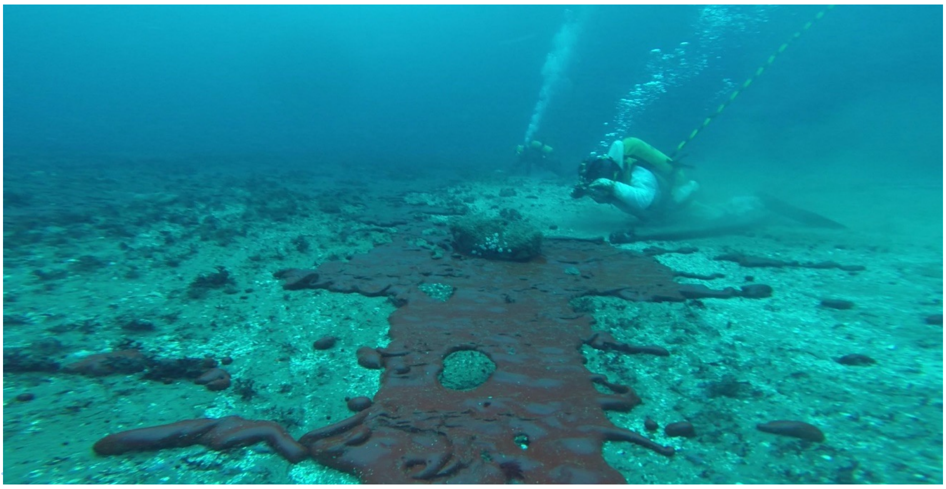


Image source: Piraino et al., 2017

INTRODUCTION

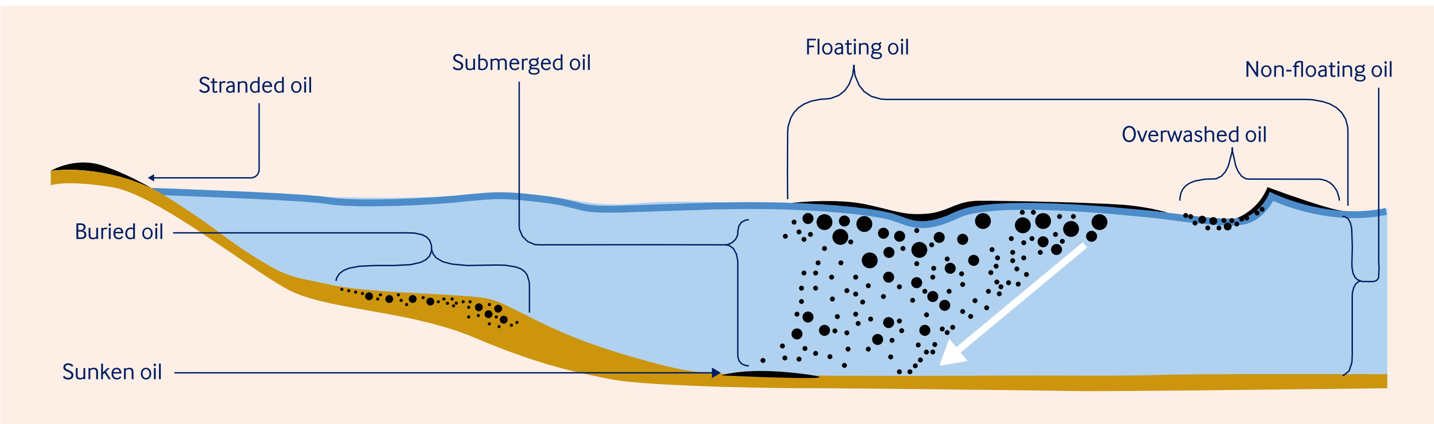
The increased production and marine transport of extra heavy oils from shale and oil sand formations have brought renewed interest in the behaviour, detection and potential removal of non-floating spilled oil. Some heavy oils may float briefly before undergoing physicochemical processes that increase their density beyond that of the receiving water, resulting in their sinking (Figure 1).

This fact sheet examines the properties and behaviour of non-floating oils and outlines methods for their detection, assessment and possible removal. Information common to all the fact sheets in this series is provided here.

KEY MESSAGES

- Heavy oils may initially float or sink immediately depending on their density and the properties of receiving environment (e.g. salinity or sediment content). Whilst floating, they may be subject to surface containment and recovery techniques
- Some blended heavy oils can contain substantial amounts of light product (e.g. condensates), so they can initially present health and safety hazards, due to flammability, vapour inhalation and skin contact hazards (see condensate fact sheet) prior to sinking
- Sunken oil detection and removal is challenging and may require specialised equipment and personnel

Figure 1: Terminology used in the description of various oil forms in a spill (source: uSCAT, 2018)



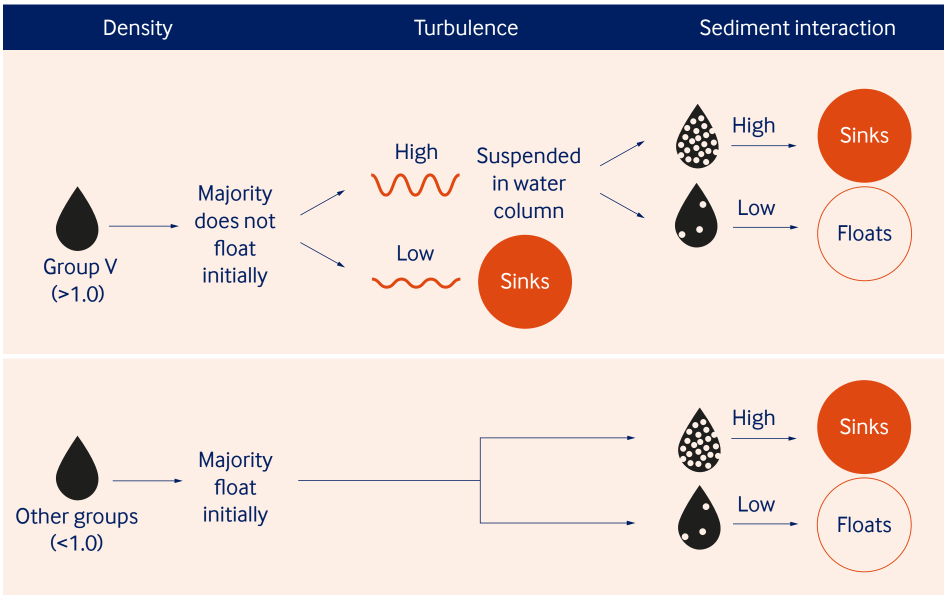
PHYSICOCHEMICAL PROPERTIES AND BEHAVIOUR

An oil or oil/sediment mixture that is negatively buoyant relative to the receiving water, submerges and sinks to the seabed or riverbed and may become entrained in sediments. Due to differences in salinity and density of the receiving water, it is possible for the same oil to sink in fresh water, be partially suspended in brackish water, and float in seawater. Buoyancy of the oil may also vary due to local temperature fluctuations. Some oil slicks may sink immediately but others may float or remain partially suspended unless sufficient inorganic material (e.g. sand) becomes attached (Figure 2).

Examples of oils which may sink include extra heavy crudes, residual fuels, bio-crude, vacuum gas oil, bitumen and asphalt derivatives, coal tar, carbon black and diluted bitumen (dilbit). Dilbit is a blend of viscous bitumen and a lighter product such as condensate. These dense oils can be referred to as Group V (extra heavy) oils or Low API Oils (LAPIOs), having a specific gravity of >1.0 (<10 °API). In some cases, highly weathered oils from lower density oil groups may also sink. When spilled, some blended heavy oils such as dilbits will gradually lose volatile diluent prior to sinking. Once sunk, lighter hydrocarbons may continue leaching into the water.

Figure 2 illustrates the factors affecting the potential for oil to sink. Complex interactions in a spill scenario determine whether, and at what point in the weathering process, an oil may begin to submerge and sink. Dynamic changes in environmental conditions such as turbulence, sediment load, or salinity may alter the floating, submergence or sinking potential of an oil over time. Oil may sink in the form of mats or smaller particles, and this will influence the detection and recovery potential.

Figure 2: Simplified summary of influencing factors leading to potential sinking of oil (source: adapted from National Research Council, 1999)



DETECTION, MONITORING AND SAMPLING

Non-floating oil can be difficult to detect depending on the location and prevailing conditions. A variety of detection techniques may be considered, and a combination of methods needed. In principle a systematic assessment survey of the potentially affected seabed or riverbed area should be undertaken, prior to taking decisions on the viability of removal.

In clear and shallow waters, a diver or snorkeller may be able to survey and locate nearshore areas affected by sunken tar balls and tar mats. However, deeper or turbid waters may require technologically advanced methods. Some detection techniques which may be considered are:

- **Visual:** towed or tethered video, autonomous underwater vehicle (AUV), remotely operated vehicle (ROV), surface viewing tube, towed sorbent or snare drag (e.g. vessel-submerged oil recovery system – V-SORS) and aerial observation (helicopter or unmanned aerial vehicle, UAV)
- **Acoustic/sonar:** acoustic camera, towed side-scan sonar, and fixed mount multibeam echosounder
- **Chemical survey**: fluorometry, laser-induced fluorometry and gas chromatography mass spectrometry

There are also sampling techniques available to support detection efforts. These include grab and core samplers, fixed sorbent sentinels and sediment traps. Whilst some of these techniques are relatively simple to deploy, they have limitations in the area they can cover and the accuracy with which they can identify sunken oil deposits.

RESPONSE AND CLEAN-UP

Response to floating heavy oil needs to consider the likelihood of its increasing density and viscosity and possible complications as the oil approaches neutral buoyancy. Floating oil recovery operations may only have a short window and typically require a heavy oil skimmer paired with a pump capable of handling viscous oil or trawled netting to capture the oil. In-situ burning and dispersant application are generally not considered primary response options for Group V (extra heavy) oils.

Once the oil is submerged or sunk, and depending on the form of the oil, containment is likely to be difficult and limited to very specific circumstance. In practice, any oil removal is likely to focus on natural collection or accumulation areas on the sea or riverbed. Bathymetry maps can be important.

Once the sunken oiled area(s) are identified and mapped and a decision has been made to engage in removal activities, the following factors should be considered in planning the methodology and resources to be employed: water depth, currents, visibility, access issues, underwater obstructions, extent of the sunken oil area(s), and sensitivity of the oiled and surrounding habitat.

Possible recovery methods include hydraulic suction dredging, diver-directed pumping, direct excavation or clamshell dredging, airlift dredging and bottom trawled sorbents or nets. Guidance on the advantages and limitations of these techniques is provided by the National Oceanic and Atmospheric Administration (NOAA) reference listed in the relevant resources section.

RESPONDER AND PUBLIC HEALTH CONCERNS

Standard protocols for protecting the health and safety of responders should be followed when responding to oils that are still floating. For products that have had light hydrocarbons mixed in, such as dilbits, there is potential for inhalation of volatile organic compounds (VOCs). Decontamination of equipment is significantly more challenging for heavy oil; it may take longer, and high-pressure washing can release aerosolized PAHs.

Dilbit type heavy oils may also have flammability and ignition potential, and the potential for dermal and other routes of exposure to polycyclic aromatic hydrocarbons (PAHs). Where spills threaten shorelines, the public should be excluded to avoid their exposure and responders should wear suitable personal protective equipment. The deployment of underwater operations and/or divers will require risk assessments and strict controls and supervision to ensure safety.

POTENTIAL IMPACTS ON MARINE LIFE

Seabed or riverbed dwelling animals may be physically smothered or contaminated by sunken oil. Sensitive and biologically important nearshore habitats such as coral reefs and seagrass meadows are vulnerable, though impacts may be localised. Group V oils typically have proportionally less acutely toxic components than other oil groups. Furthermore, extra heavy oils do not tend to disperse in water so present a relatively small oil-water surface area for the toxic elements to dissolve into the surrounding water. This results in few acute toxicity concerns but there is potential for chronic low-level exposures to leaching lighter oil components (if present) or PAHs from the spilled oil, which may have sub-lethal effects on marine life.

MODELLING SPILLS

Modelling the fate and trajectory of extra heavy oils is complicated by several factors involved in the weathering process, including sediment interactions. Whilst an extra heavy oil remains floating, it may be less influenced by wind and/or more over-washed by waves compared to lower density oil, and modelling sub-surface currents can be difficult, further compromising the algorithms used to predict oil movement. However, attempts have been made to model the behaviour of sunken oil and such modelling tools may provide guidance to responders looking to find sunken oil and understand its fate.

RELEVANT RESOURCES

API (2016). *Sunken oil detection and recovery.* www.oilspillprevention.org/~/media/Oil-Spill-Prevention/spillprevention/r-and-d/inland/sunken-oil-technical-report-pp2.pdf

API (2016). *Sunken oil detection and recovery operational guide.* www.oilspillprevention.org/~/media/Oil-Spill-Prevention/spillprevention/r-and-d/inland/sunken-oil-ops-guide.pdf

IMO (2016). *Operational guidelines on sunken and submerged oil assessment and removal techniques.* https://wwwcdn.imo.org/localresources/en/publications/Documents/Flyers/Flyers/I583E.pdf

National Research Council (1999). *Spills of nonfloating oils: risk and response.* Washington, DC: The National Academies Press. https://doi.org/10.17226/9640

NOAA (2020). *A response guide for sunken oil mats (SOMs): formation, behavior, detection and recovery.* https://response.restoration.noaa.gov/sites/default/files/SOM_Report_03-30-2020_508b.pdf

Piraino, E., Owens, E., Rios, J., Graham, A. (2017). 'Oil behaviour and the response to a sunken oil spill of slurry in Quintero Bay, Chile.' In *International Oil Spill Conference Proceedings,* Vol. 2017, pp. 124–133. https://doi.org/10.7901/2169-3358-2017.1.124

uSCAT (2018). *Technical manual: underwater cleanup assessment technique for sunken oil.* http://www.uscat.ca/

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