Sampling Objectives

- To identify and assess pathways for sunken oil resulting from spills of heavy oils
- To identify resource exposure and summarize potential impacts from this exposure

Definitions

Sinking is the mechanism by which oil masses that are denser than the receiving water are transported to the bottom. The oil itself may be denser than water, or it may have incorporated enough sand to become denser than the water. Sedimentation is the sorption of oil to suspended sediments that eventually settle out of the water column and accumulate on the seafloor. There is a significant difference in the relative amount of oil between the two processes: mass sinking oil may contain a few percent sediment, whereas the accumulation of oil-contaminated sediments on the seafloor generally contain less than 1 percent (10,000 ppm) oil. This protocol deals with sunken oil.

Oil Behavior and Fate Pathways

- Non-floating oil spills can have complex behavioral patterns, depending on the API gravity of the oil, the density of the receiving water, and the physical setting of the spill site. However, only heavy refined products and crude oils have the potential to accumulate on the bottom.
- Oils with an API gravity less than 10 will be denser than fresh water; oils have to have an API gravity less than about 7 to be denser than seawater.
- For releases in areas subject to tidal and riverine flow, currents will generally keep the oil in suspension by currents as small droplets in the water column.
- For oils heavier than the receiving water: Sinking to the bottom is only likely in areas of very low (<0.1 knot) currents; currents will usually keep oil droplets suspended in the water column.
- For oils that are lighter than the receiving water: Sinking can occur by: 1) adhering onto sand-sized particles while being mixed in the surf zone; 2) after stranding on shore, picking up sand, then being eroded from the beach by waves and deposited in the nearshore zone; and 3) by adhering to the substrate during low water, then not re-floating when the water level rose. This last mechanism is more likely in rivers and streams where water levels can rapidly change.
- It is important to note that, when the sunken oil is still lighter than the surrounding water (i.e., it sank by mixing with sand), the buoyant oil can re-float if the sand separates from the oil. Sunken oil can also re-float when warmed; not because it becomes lighter (warmer water is also lighter), but because it becomes less viscous and more able to flow and separate from adhered surfaces and sediments. Increased wave energy (e.g., storm waves or land-sea breezes that freshen in the afternoon) or river flow rates (e.g., thaws after a freeze, stormwater runoff) can trigger re-floating by breaking part of the oil away from the submerged oil mat.
- Oil that is heavier than water can temporarily accumulate in low-flow zones:
  - In rivers, potential accumulation areas include backwaters, sloughs, inactive scour pits, and in the lee of point bars, wing dams, and other man-made obstructions.
  - In estuaries, potential accumulation areas include man-made depressions (e.g., dredged channels, marinas and boat slips, prop scour pits, turning basins), natural scour pits active during periods of high flow, and abandoned channel meanders.
  - Along the outer coast, potential accumulation areas include the troughs between offshore bars, lagoons or pools protected by offshore rocks or coral, reef flats protected by reef crests, and in the lee of any obstruction of currents along the coast (e.g., rocks, jetties, breakwaters).
- Sunken oil can be buried by silt in harbors or sand in offshore areas within days to weeks. Once buried, it can remain for years, only to be exposed by storms or dredging operations.
- Water-column and water-surface impacts can persist where sunken oil re-floats due to exposure to both the soluble fraction and floating oil droplets. Sunken oil weathers slowly, therefore the toxic components can persist and be a source of exposure during re-floating or benthic transport.

- Where sunken oil accumulates in thick patches or mats, impacts are mostly related to smothering or coating. Oil can adhere to seagrass blades and sunken detritus, providing a pathway of exposure to animals feeding in these areas.

Survey Methods (NRC, 1999)

Visual Observations: Trained observers in aircraft or on vessels look for and photo-document visual evidence of oil on the bottom; high coverage rate for aircraft, low coverage rate for vessels; rapid turnaround for survey results (hours); high probability of false positives due to water clarity and bottom geometry/ vegetation, seagrass beds, cloud shadows, etc.; easy to implement quickly using available resources.

Bottom Sampling from Surface: Sample device (grab/dip net) are deployed to collect samples from the bottom for visual inspection and photo-documentation; alternately, sorbents are attached to the end of a pole, chain, or weight and dropped or dragged over sediments and visually inspected and/or photographed; photo-documentation is very important to backup visual observations; sorbent sampling from the surface is difficult and even when you could see oil, it is hard to get the sorbent to pick it up unless you carefully weighted and dragged the pads slowly; this method has a low coverage rate; rapid turnaround for survey results (hours); significant logistical requirements (sampling gear, boat with workspace); low rate of false positives (Weems et a., 1997).

Underwater Dive Surveys: Divers survey the sea floor with video-documentation; low coverage rate; rapid turnaround for survey results; low probability of false positives; contaminated water divers and video equipment needed, maximum depth of survey is 60-80 feet (Castle et al., 1995)

Bottom Trawls: Fish nets/trawls towed and inspected/photo-documented for presence of oil; low coverage rates; requires trawl-capable boat, operator, and multiple nets; rapid turnaround for survey results; low probability of false positives, bottom substrates/obstructions can limit effectiveness (NRC, 1999)

Photobathymetry: Aerial stereo photography is obtained and interpreted to identify underwater features; requires specialized equipment and data interpretation expertise; turnaround for survey results is days/weeks; high probability of false negatives; water depth and water clarity limit operational effectiveness (Benggio, 1994).

Geophysical/Acoustic Techniques: Sonar system detects oil layer; requires specialized equipment and personnel; moderate coverage rate; turnaround for survey results is hours/days, high probability of false positives, requires calm seas, can produce high-quality quantitative results (Chivers et al., 1990).

Key References

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