| | Sonar Systems | Still, Video, and Acoustic Cameras | Diver Observations | Towed Sorbents | Stationary Sorbents | Visual Observations by Trained Observers | Grab or Core Sampler | Wading-Depth Manual Shovel Pits | Laser Fluorosensors | Water-Column Sampling | Oil Sorbent "Swab" Poling |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Probability of False Positives** | After ground truth of preliminary results, low false positive rates are obtainable. | Provides low false positive rates due to the ability of human interpretation of raw optical data. | Low probability since divers can verify observations. | Low: It is easy to detect oil versus other fouling materials. | Low: It is easy to detect oil versus other fouling materials. | High for aerial surveys. Boat surveys have few false positives because samples can be collected to confirm the oil. | Low: samples can be visually inspected, and samples collected for chemical confirmation. | Low: Teams can be calibrated to consistently identify the oil vs. other materials. | Low, once calibrated for the oil. | Low: the units can be optimized for the spilled oil. | Low: It is easy to detect oil sorbed to fabric versus other fouling materials. |
| **Operational Limitations** | Water depth of 10 feet or less establishes an operation limitation on acoustic techniques, although operations in shallower water are possible in certain situations. | Water turbidity limits the functionality of visualization devices with the exception of the acoustic camera that functions in 0 visibility with lesser resolution than optical devices. | Surface-supplied air diving is restricted to 190 fsw. Diving operations are limited by depth, bottom time, visibility, currents, and other environmental conditions. | Standard safety limits for boat operations. No use possible in the surf zone or where snagging on the bottom is of concern.<br>More difficult to deploy/retrieve in >100 feet water depths. | Standard safety limits for boat operations. No use possible in the surf zone or vessel traffic lanes. More difficult to deploy/retrieve in >100 feet water depths. | Can only be used during daylight periods. Standard safety limits for aerial and boat operations, including no surveys possible in the surf zone. | Standard safety limits for boat operations. No surveys possible in the surf zone. | Many safety limits. Requires wading water depth, low waves and currents, light wind, no lightning, and warm water. | Detection decreases with water turbidity, distance from the target, and wave height. Bright light can interfere. Water depths accessible by boat. | Standard safety limits for boat operations. No surveys possible in the surf zone. Water currents must be low enough to minimize transport of the plume. | Standard safety limits for boat operations. No use possible in rapids or the surf zone. Difficult to utilize in >20 feet water depths. |
| **Pros** | Sonar systems are easy to use and have a high area coverage rate for fast establishment of sunken oil locations on the bottom. | Visualization techniques and devices provide visual validation of the presence of sunken oil without the requirement for ground truth of images. | Accurate, immediate observations can be conveyed to the surface. If visibility permits, real-time video can be viewed in the dive control house. | Effective in low visibility conditions; can be used in vessel traffic lanes; can vary the tow length to refine spatial extent; can be used to confirm removal. | Proven effective at detection of oil moving at various depths in the water column; time-series data are useful to track trends; can be re-deployed as the oil migrates down current. | Aerial surveys can cover large areas quickly and can be adjusted once oil is found to get more detail. | Samples can be collected for confirmation; can detect buried oil and oil thickness; poling can indicate the relative risk of sheen generation. | May be best option to detect buried oil in the surf zone; can work closely with Operations to achieve rapid removal after delineation of treatment area. | Highly sensitive, few false positives; can be used day or night. | Can map at high spatial resolution and differentiate among oil sources in real time, allowing detailed mapping of targets. | Effective in low visibility conditions; can be used in vessel traffic lanes; can be used to confirm removal. Effective in areas that have occasional bottom obstructions. High resolution location data. |
| **Cons** | For absolute detection, sonar systems require a ground truth of the detected contact on the bottom to provide positive identification of sunken oil. Shallow conditions prohibit accuracy & definition. | Increasing turbidity creates decreasing visibility until the acoustic camera is required which provides images of lesser resolution than optical techniques. Muck/organic substrates are difficult to view oil. | Diving in contaminated water is considered "high-risk". The limitations above combined with diver decon requirements often result in a relatively high cost and time-consuming operation. | Do not know where along the tow the oil occurred or how much oil is present (one larger patch or lots of small patches); can not determine duration of bottom contact or efficacy of oil adhesion; labor intensive. Debris littered substrates poses snags & damage to equipment | Very time and labor intensive; can have high loss rates; no calibration of the efficacy of oil adsorption and changes over time; can not be deployed in active vessel traffic lanes; low temporal data on when the oil was mobilized during the deployment. | Cannot detect buried oil; effective only in clear water and daylight; aerial surveys require ground truth; boat surveys are slow; not safe for work in surf zone or strong currents. Organic soils/muck & bottom vegetation make observation difficult. | Slow, labor intensive, not effective for patchy oil; weather and sea limits. Soft depositional deposits require careful recovery methods for representative results. | Narrow operational limits, slow coverage rate, and limited to depth of digging. | Cannot detect buried oil; not proven operationally. | Only effective if there is oil in the water; currents can transport the oil away from source; MS requires special teams and gear. | Effective in turbid water. Considered effective in shallow water. Deep water with high currents may cause implementation difficulties. |
| **Considerations for Riverine Systems** | Water depth will be make implementation inefficient in small rivers systems, as depositional areas are often shallow, potentially resulting in very small coverage area. Could be effective in deeper rivers and in non-depositional areas. | The turbidity typical in rivers would be most significant variable. In most river systems, turbidity and water depth will likely limit the effectiveness of this technology. Most effective in shallow areas. | Current, bottom obstructions, snags are consideration for diver safety. Turbidity and depth of light penetration/water depth are key considerations. In most river systems, turbidity will likely limit the effectiveness of this technology to very shallow areas. Diver decompression issues are not likely. | Can be effective in areas of rivers that have limited bottom obstructions/snags/submerged large woody debris. High current areas may cause drag control issues. Depending on drag design, drag could "dig" into soft sediments that are typical of depositional areas, rendering high drag on boat. May be ineffective in areas that have bottom obstructions. | Can be effective in rivers in areas of low current speed. High current speed can undermine supports and cause foundation failure. | The turbidity typical in rivers would be most significant variable. In most river systems, turbidity will likely limit the effectiveness of this technology to very shallow areas. | Effective in turbid water. Considered effective in shallow water and water with limited current. Deep water with high currents may cause implementation difficulties. | Effective in turbid water. Effective in shallow water and water with limited current. Deep water and/or high currents will preclude use of this technique. | Bottom obstructions can limit applicability due to the fact that sensor must be towed close to bottom. Current could hamper location control of subsurface sensor. Turbidity can limit detection extent. In shallow water, under bright conditions, sunlight can interfere with readings. | Easily implemented, but in moving water may not be representative of underlying sediments. Likely limited to use as a screening method, and then only early in a response effort due rapidity of oil weathering. | Difficult to determine efficacy of oil adhesion; labor intensive. Could be limited by water currents/sea conditions, limited effectiveness at depths greater than 20 feet or shallower areas with very high current speeds. |

**Table 4 – Matrix to evaluate technologies for sunken oil recovery (API, 2016b)**

**Red = not likely effective; yellow = may be effective; green = most likely effective**

| | Suction Dredge | Diver-Directed Vacuuming | Diver-Directed Pumping | Excavator | Grab/Clamshell Dredge | Environmental Clamshell | Sorbents/V-SORS | Trawls and Nets | Manual Removal Shallow Water | Manual Removal with Divers | Agitation/Refloat |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Water Depth (ft)** | | | | | | | | | | | |
| - < 5 ft | | | | | | | | | | | |
| - 5-40 ft | | | | | | | | | | | |
| - 40-80 ft | | | | | | | | | | | |
| - > 80 ft | | | | | | | | | | | |
| **Water Visibility** | | | | | | | | | | | |
| - > 5 ft | | | | | | | | | | | |
| - < 5 ft | | | | | | | | | | | |
| **Water Current** | | | | | | | | | | | |
| < 1 (kt) | | | | | | | | | | | |
| -1-2 kt | | | | | | | | | | | |
| - >2 kt | | | | | | | | | | | |
| **Wave Height (ft)** | | | | | | | | | | | |
| -<2 ft | | | | | | | | | | | |
| ->2 ft | | | | | | | | | | | |
| Availability | | | | | | | | | | | |
| **Oil Pumpability** | | | | | | | | | | | |
| Fluid | | | | | | | | | | | |
| - Not fluid | | | | | | | | | | | |
| **Oil Distribution (%)** | | | | | | | | | | | |
| -<10% | | | | | | | | | | | |
| -10-50% | | | | | | | | | | | |
| ->50% | | | | | | | | | | | |
| **Oil Patch Size** | | | | | | | | | | | |
| - < 0.1 $ft^2$ | | | | | | | | | | | |
| - 0.1- 1 $ft^2$ | | | | | | | | | | | |
| - > 1-10 $ft^2$ | | | | | | | | | | | |
| - > 10 $ft^2$ | | | | | | | | | | | |
| **Substrate Type** | | | | | | | | | | | |
| - Sandy | | | | | | | | | | | |
| - Muddy | | | | | | | | | | | |
| **Bottom Obstructions** | | | | | | | | | | | |
| **Buried Oil** | | | | | | | | | | | |
| **Sensitive Habitat** | | | | | | | | | | | |
| **Removal Rate*** | | | | | | | | | | | |
| **Waste Generation**** | | | | | | | | | | | |
| **Environmental Impact**** | | | | | | | | | | | |
| **Cost **** | | | | | | | | | | | |

* classified as rapid, medium, or slow

**classified as low, medium, or high