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OIL SPILL CLEAN-UP

The Torrey Canyon wreck showed the immense problems of dealing with a large oil spill. 25 years later the spillage of Norwegian crude from the Braer on the Shetland Islands illuminates again the limits on our actual ability to mitigate the effects of massive oil spills - despite much research, development and contingency planning since 1967.

This briefing note reviews oil spill clean-up technology, its limitations and issues raised[1].

THE BRAER SPILL

The ten largest spills from ships around the world are listed in Table 1, together with other recent spills. In terms of size, it appears that the Braer spill will exceed that of the Exxon Valdez but will be less than the Torrey Canyon. The environmental impact is however determined by much more than size - by the nature of the oil, the rate of spillage, sea and weather conditions, the sensitivity of the environment, location of beaches, ports etc., and the marine life (seabirds, mammals, fisheries etc.) in the region.

Table 1 TEN LARGEST SPILLS AND SOME RECENT SPILLS

Date	Vessel Involved	Location	Amount Spilled ('000 tonnes)
1979	Aegean Captain	Off Tobago	280
1991	ABT	Off Angola	260
1983	Castillo De Bellver	South Africa	252
1978	Amoco Cadiz	France	227
1991	Haven	Italy	140
1988	Odyssey	Off Canada	132
1967	Torrey Canyon	England	124
1972	Sea Star	Gulf of Oman	125
1976	Urquiola	Spain	108
1977	Hawaian Patriot	North Pacific	101
(1989	Exxon Valdez	Alaska	37)
(1992	Aegean Sea	Spain	up to 70)
(1992	Braer	Shetland	up to 85)

TECHNICAL OPTIONS FOR CLEAN-UP

There is no one standard response to an oil spill - each method (e.g. mechanical recovery, dispersants) may have applications in different circumstances, while in some it may be least damaging to do nothing.

Mechanical Recovery

Over the last 20 years, hundreds of mechanical oil recovery devices have been developed and marketed. These include many varieties of booms used to contain or collect oil while an oil recovery system is operated. Booms are also used to protect sensitive areas such as estuaries and coastlines from oil spreading from offshore. Their main and critical weakness is that they are ineffective in currents much over 1 to 1.5 knots and wave heights over 6 to 9 feet. Successful use has thus tended to be limited to sheltered waters, harbours, etc.

There are a variety of devices which recover oil, including suction and weir skimmers, and skimmers with a moving surface such as a belt, oil-absorbent rope, mop or discs. These cannot recover useful amounts of oil from the thin layers encountered once the oil has spread, and generally have to work in conjunction with a boom, or in waters where relatively thick layers of oil have accumulated through wind or wave action. Again, these devices do not work in rough seas.

Mechanical recovery has been useful in certain circumstances, but primarily for relatively small spills in sheltered waters. Experience of large tanker spills in open seas is that generally much less than 10% of the oil spilt can be recovered; in the case of the Exxon Valdez, between 6 and 8% was recovered at sea, even though waters in Prince William Sound are sheltered and calm in comparison with UK waters.

Some specially designed oil spill recovery vessels capable of collecting oil from the open ocean have been developed mainly by Dutch and German companies; one design has a hinged split hull which opens and acts as two collecting arms, funnelling the oil into the vessel. These systems have the advantage of being complete, with significant on-board oil/water separation capability and storage capacity. Their disadvantages include their high cost and the time likely to be required to steam to the site of a spill. Experience in clearing up the Exxon Valdez spill emphasised the value of dual purpose vessels, where local vessels such as dredgers could be adapted for recovery purposes, and their storage capacity used for oil. The DTI's Warren Spring Laboratory (WSL) has developed an oil recovery device known as Springsweep which can be fitted to vessels to enable them to recover oil in a moderate sea; it consists of a boom which sweeps and concentrates oil into a skimmer head from where it can be lifted into the ship.

Dispersion

The Torrey Canyon was the first occasion on which dispersants were used on a large scale in UK waters.

1. This note restricts itself to oil spills; other spills (e.g. chemicals) raise quite different problems.

Since then, their use has remained controversial internationally, although they have remained the main plank of UK response. Dispersants act, like washing-up liquid, by reducing the cohesiveness of the slick so that the oil can be broken into small droplets by wind, wave and current action. The dispersant also stabilises the droplets so that they remain in suspension and disperse with currents and tides; the smaller droplets can break down faster through microbial action than would larger particles or undispersed oil.

Much of the controversy has arisen from the Torrey Canyon experience that many of the adverse ecological effects were caused by indiscriminate use of toxic dispersants rather than the oil. Dispersants of much lower toxicity were developed shortly afterwards, and MAFF operates a licensing scheme which requires that approved products be of low toxicity. Removal of oil from the surface reduces the threat to sea birds and mammals and the shore. On the other hand, dispersant use causes the concentrations of oil in the water column to increase. MAFF scientists conclude that under most conditions at sea, little if any ecological damage is likely to result from dispersant use, but that there may be risks of toxic effects on marine life with large spills where the scope for rapid dilution of the dispersed oil is limited by shallow water or by restrictions in lateral dispersion by nearby coasts etc.

Dispersants work best on oil which is relatively fresh, since as the oil is exposed to the weather, it becomes too thick to disperse effectively or forms a 'mousse' (water in oil emulsion), which is relatively unaffected by dispersant. The UK thus relies primarily on aircraft to mount the rapid response required if dispersants are to be effective.

Other Techniques at Sea

Burning can remove a high proportion of the oil; however, in order to ignite oil on water the oil must be relatively fresh, and the slick must be at least 3mm thick. This requires the oil to be contained by some means (e.g. the natural geography around the spill or a fire-proof boom). Various ignition systems are available including floating igniters that can be deployed by air (e.g. helicopter). Burning creates a highly visible sooty plume, but the air pollution from the oil itself entering the atmosphere will be reduced. Burning oil that is confined around the vessel may be undesirable on safety grounds and may preclude the possibility of pumping out remaining oil (most of the Exxon Valdez oil remained on the ship, and was successfully offloaded).

Other miscellaneous agents include gelling agents, herding agents and sinking agents, but these have not been widely used.

Shore Clean-up

Removal. Once the oil is stranded, a variety of techniques can be used to remove the oil. These range from manual mopping up with rags, mops, etc., through to the use of bulldozers to remove oiled sand to be disposed of elsewhere. The more drastic mechanical recovery techniques such as beach removal, steam and water jet cleaning can have more serious impacts on surviving intertidal flora and fauna than simple manual recovery, or no action at all.

The use of dispersants on beaches and shorelines is contentious, since the concentrations of oil and dispersant mixtures can be very high due to the limited water available for dilution in the intertidal zone. The case for dispersant use needs to balance the interests at stake. In some situations (e.g. amenity beaches) the economic case for clean-up may be strong; in others, such as remote rocky foreshores, cleaning may be left to natural degradative processes, though depending on the type of oil, these may take months to several years.

Natural Degradation. Oil degrades naturally because there are bacteria in the environment that can use the oil as a food supply (these bacteria are particularly likely to be present in regions where oil is regularly found , as would be the case in the Shetlands). The rate at which the bacteria can grow is, however, often limited by the nutrients available. Researchers have tried to either develop 'fertiliser' mixtures to increase the speed at which natural bacteria degrade the oil, or to develop proprietary mixtures of oil-eating bacteria and fertiliser to spray on the oil.

The Valdez spill gave US scientists an opportunity to evaluate some of these approaches (called **bioremediation**), and they concluded that applying a liquid oil-miscible fertiliser[2] caused the natural bacteria to grow faster, and made substantial differences to the rate of natural clean-up. In an expert review conference in Feb 1990, the consensus conclusion was that nutrients properly applied can increase the degradation rate of oil, leading to accelerated cleaning and removal of oil without any adverse ecological effects being detected; this may offer an alternative to existing beach clean-up methods, though practical experience is limited.

UK POLICY

UK response to oil spills is organised by the Marine Pollution Control Unit (MPCU) of the Department of Transport (DoT). Oil that reaches shore is primarily the responsibility of the local authority, who will be advised by the MPCU as required. In large pollution incidents such as the Braer, the MPCU sets up a Joint Response Centre which coordinates an integrated at-

2. Traditional fertiliser formulations are water soluble and would thus be washed away before they could enhance the growth of bacteria on the oil.

sea and on-shore clean-up operation.

UK policy remains to rely on dispersants as the first line of response, with mechanical recovery where it is practicable. In view of the typical sea states in the North Sea and other UK waters, the potential role for mechanical recovery in offshore spills is seen as quite limited.

In 1974, a statutory licensing scheme was introduced to ensure that all dispersants met toxicological standards applied by MAFF (now under the Food and Environment Protection Act, 1985). WSL applies standards for effectiveness, safety, storage stability etc. and only those products which pass both WSL and MAFF criteria are licensed. Because of the different technical requirements for clean-up on the open sea and on different types of shore, products must be approved separately for use at sea, on sand and gravel beaches, and on rocky foreshores. Some dispersants are approved for only one use (e.g. at sea only) because they are either ineffective or unnecessarily toxic in other uses.

Research at WSL and experience in spraying the Eleni V spill in 1978 proved the practical ineffectiveness of dispersants on thick oils and led to the adoption of new technical guidelines to guide spill response. These take account of the initial type of oil released and the rate at which it weathers (and therefore becomes thicker) in deciding how long after the spill it is productive to spray. With heavy oils (such as heavy fuel oil) it is now accepted as futile to use dispersants; on lighter crudes, the time during which dispersants can be effective will depend on the weather and temperature, and may range from several hours to 1-2 days.

The realisation that spraying could rapidly become ineffective led to a move away from vessel spraying to aerial application which was seen as providing the necessary swiftness of response before the oil became difficult or impossible to disperse. MPCU currently has 8 aircraft under contract for applying dispersants, with 2 remote sensing aircraft to direct the response effort to areas with the most oil. The conditions of contract require them to be ready to fly within 30 minutes of notification during the day, and 2 hours at night. MPCU uprated its treatment capability in 1989 from 5,000 to 14,000 tonnes of oil over a 48 hour period; it is thus clear that where tens of thousands of tonnes of oil are released in a short time, dispersant spraying can only tackle a small proportion of the oil released.

The MPCU also has dispersant-spraying equipment fitted to a number of commercial tugs at strategic positions around the coast, a small amount of mechanical recovery equipment (including two Springsweep sets) to be used on chartered vessels, equipment to transfer cargo in lightering operations and beach-cleaning equipment.

Table 2 EQUIPMENT AT THE SOUTHAMPTON OIL RESPONSE CENTRE

Containment Booms (Offshore)	6 kms
Containment Booms (Inshore)	11 kms
Skimmers and transfer pumps	Around 100
Temporary oil storage facilities	Around 60 tanks of different sizes
Dispersant equipment	
Offshore spray units	10
Inshore spray units	20
Beach clean-up units	30
Planes	2

The UK can also ask for assistance from neighbouring countries under the Bonn Agreement (for Cooperation in Dealing with Pollution of the North Sea by Oil); there are also bilateral agreements with France (Mancheplan) and Norway (the NorBrit plan). In addition, the oil industry's major oil response base is at Southampton, and contains large stocks of oil spill equipment (Table 2), some of which was used in the response to the Exxon Valdez spill. Although no formal agreement exists between industry and the MPCU, the MPCU can ask for assistance.

ISSUES

The Role of Dispersants

Although dispersant use has remained the main plank of UK oil spill response policy since it was first applied at the Torrey Canyon, it remains contentious and many countries remain reluctant to use dispersants except in special circumstances. The Royal Commission on Environmental Pollution (RCEP) questioned dispersant effectiveness in its eighth (1981) report and recommended that official policy to increase the capacity to spray dispersants should be reviewed to take proper account of their limitations. Some environmental groups and marine conservationists object to dispersant use on the grounds that it may make the oil more available to marine life by dispersing it into the water - including the lighter components which tend to contain the more toxic components of the oil and which would otherwise evaporate from the sea surface more swiftly. As already mentioned, MAFF scientific advice is that this is only likely to be a significant factor for fisheries in shallower waters, and since the removal of oil from the surface has benefits such as protecting seabirds and beaches from contamination, dispersant use can generally be justified in offshore waters.

Inshore, a balance may have to be struck between the wish to reduce the impact on birds and mammals and the amount reaching the shore, and the possibility that bottom dwelling organisms such as mussels and other filter feeders may be affected or tainted by increased amounts of oil in the water column. Current UK practice is for the MPCU to consult with fisheries departments and the appropriate conservancy body on the appropriateness of dispersant use in sensitive areas, and in water less than one mile from shore, or less than 20 metres in depth.

Regarding dispersant use to clean-up oiled foreshores, MAFF tests have shown that even with low toxicity dispersants, their use is likely to increase the mortality of intertidal organisms which have survived the oil. Deciding the best approach to beach cleaning may require a balancing of the pressure for a quick clean-up (e.g. for amenity considerations) and letting nature weather and disperse the oil. Natural cleaning depends on the type of coast, the type of oil and the amount of wave action, but is generally quickest in exposed well swept rocky foreshores (months rather than years) than in sheltered estuaries and salt marshes (a few to ten or more years).

Lessons for UK Response Policy

Every large spill has unique characteristics; the Braer spill is no exception. The oil was Norwegian crude, which is comparatively light and therefore contains a substantial proportion of volatile components. This, combined with the high wind created problems of land and air pollution on a scale which have not been reported before. The proximity to a rocky shoreline and the richness of the local marine life (including seabirds, mammals, sand eels, marine fisheries and fish farms) also create a number of special difficulties.

Mention has already been made of the guidance on the use of dispersants at sea and on the foreshore designed to minimise the risk of causing additional environmental effects. Although fisheries departments did give their approval for the use of dispersants within 1 mile of shore as required, the three brands of dispersants used by the MPCU aircraft[3] had all been given licences for sea use only, since they had either not been tested or had failed the MAFF tests designed to simulate toxicity in beach and rocky foreshore cleaning. The fact that these dispersants should not be used except at sea may have caused difficulty for aircraft having to spray oil emanating from a wreck close inshore with the danger of spray drift in strong winds.

The Shetlands fish farms have been threatened with oil contamination (similar problems were encountered by oyster farms near the Amoco Cadiz spill). The usual response is to try and prevent oil from entering by placing booms across the mouth of the farm inlet. Dispersant use nearby would be counter-productive since it would place oil into the water column where it could evade the boom and increase the amount of oil reaching the fish. Even the possibility of contamination has been sufficient to close the fishery, and Fisheries Departments are monitoring water and fish quality to establish the amount of any contamination.

Mention has already been made of the use of fertilisers to speed the natural recovery of soiled foreshores without adding any ecological stress due to dispersant or major mechanical disturbance. This was recognised as an important option for reducing oil residues in Alaska in early 1990. In the UK, WSL are compiling a report on bioremediation jointly funded by MPCU and the EC, but bioremediation does not comprise part of the UK response capability at the present. In an area where amenity pressures for rapid clean-up may be less than elsewhere, accelerating natural recovery might be attractive to those concerned to minimise further environmental impact on the foreshore.

The DoT continues to fund research into oil spill clean-up (see Table 3), and development work on a larger scale recovery system using special 'nets' is underway at WSL. Oil absorbent straw is also being evaluated for possible use in offering some protection to shores.

Table 3 RESEARCH AND DEVELOPMENT SUPPORTED BY THE DEPARTMENT OF TRANSPORT

Budget Year	Funds (£M)	Current Projects
1991/92	0.7	Aerial remote sensing of oil thickness
1990/91	1.0	Emulsion formation and dispersion
1989/90	0.7	Cleanup of salt marshes and mudflats
1988/89	1.1	Effectiveness of Demulsifiers
1987/88	1.0	Burning off slicks
		Measurements of oil dispersion in sea
		Review of sorbents

The RCEP noted in 1981 the contrast between the limitations of clean-up technology and the optimistic tone of much official thinking. Although the RCEP's views were taken into account, many see the Braer experience as reinforcing lessons from other large spills - i.e. that whatever the contingency arrangements, there is limited ability in practice to significantly restrict the natural spread of the oil or to prevent environmental damage caused by the spilt oil. Many experts conclude that further refinement of oil spill treatment technology and contingency planning are likely to yield only incremental benefits, and that the most effective form of environmental protection is to improve the measures which minimise the risks of major spills occurring.

FURTHER READING

Additional details and background information are available from POST, 2 Little Smith St., London SW1P 3DL, tel: (071)-222-2688.

3. The three dispersant concentrates used were Dispolene 34S, Dasic Slickgone LTSW, and BP Enersperse 1037. Dispolene 34S is not approved by the Norwegian Authorities; its UK licence expired in 1992, although its composition remains the same as before and dispensation to use existing stocks was given by MAFF.