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THE SEA EMPRESS OIL SPILL

- *Technology of oil spill clean-up*
- *How these apply in the Sea Empress case.*

The Torrey Canyon wreck showed the immense problems of dealing with a large oil spill. Almost 30 years later the spillage of North Sea crude from the Sea Empress off Milford Haven illuminates again the limits on our ability to mitigate the effects of massive oil spills - despite much research, development and contingency planning since 1967.

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

OIL SPILLS WORLDWIDE

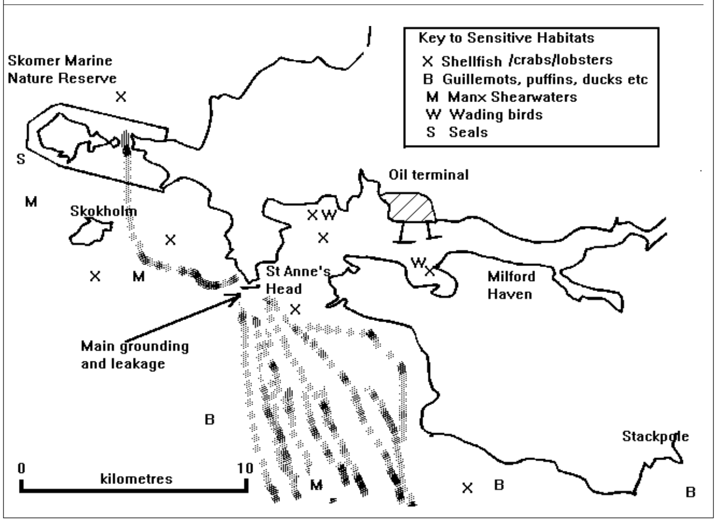
Large oil spills are a familiar but highly variable occurrence - the worst year recorded by the International Tanker Owners Pollution Federation (ITOPF) was 1979, when 615,000 tonnes (tes) were spilt worldwide. In contrast, last year (1995) only 5,000 tes were spilt. The ten largest spills from ships around the world are listed in **Table 1**, together with other recent substantial spills. In terms of size, the Sea Empress spill is between that of the Exxon Valdez and 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 in the region. As shown in the case of the Braer, given the right combination of high winds and waves in open and deep waters, large amounts of light oil can be rapidly removed by natural processes, limiting environmental damage. In the Milford Haven area, however, there are many sensitive areas from fisheries, marine environmental and wildlife standpoints. As can be seen from **Figure 1**, inshore shellfish and amenity areas within the Haven are particularly at risk, as well as the islands of Skomer and Skokholm with their bird and sea mammal colonies.

Table 1 TEN LARGEST SPILLS AND SOME RECENT SPILLS

Date	Vessel Involved	Location	Amount Spilled ('000 tonnes)
1979	Atlantic Empress	Off Tobago	280
1991	ABT	Off Angola	260
1983	Castillo De Bellver	South Africa	257
1978	Amoco Cadiz	France	227
1991	Haven	Italy	140
1988	Odyssey	Off Canada	132
1967	Torrey Canyon	England	119
1972	Sea Star	Gulf of Oman	125
1976	Urquiola	Spain	108
1977	Hawaian Patriot	North Pacific	99
1992	Aegean Sea	Spain	72
1989	Exxon Valdez	Alaska	37
1992	Braer	Shetland	85
1996	Sea Empress	Milford Haven	70+

Figure 1 SENSITIVE AREAS AROUND MILFORD HAVEN



UK POLICY ON SPILL RESPONSE

There are many possible technical responses to an oil spill situation, as described in the **Box** (page 2). Each method (dispersants, mechanical recovery etc.) has its own advantages, disadvantages and limitations, and the best approach needs to be assessed in the light of individual circumstances; in some cases it may even be least damaging to do nothing.

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 and Sea Empress, the MPCU sets up a Joint Response Centre which coordinates an integrated at-sea and on-shore clean-up operation.

UK policy relies on dispersants as the first line of response, with mechanical recovery where it is practicable (in view of the typical sea states in UK waters, offshore mechanical recovery is difficult). Experience in the past showed that to be effective, dispersants have to be applied when the oil is still fresh and before loss of volatile components and weathering makes it immune to dispersant and futile to spray. The realisation that spraying could rapidly become ineffective led to a move away from vessel spraying in the 1980s to aerial application to provide the necessary swiftness of response, and MPCU currently has 6 converted DC-3 aircraft under contract for applying dispersants, with light aircraft to direct the spraying effort to the oil.

TECHNICAL OPTIONS FOR CLEAN-UP

There is a whole spectrum of possible responses to an oil spill situation (including leaving it alone).

Oil Off-loading

The best environmental option is clearly to offload the oil before it can pollute the sea and foreshore. In calm waters, this can be a straightforward operation if smaller tankers can be brought alongside. Where seas are too rough or the tanker cannot be approached, safety considerations may rule against off-loading at sea. If aground on rocks near land, a land-based operation could be considered. This would require floating pipelines and pumping to temporary storage tanks (e.g. pillow tanks) or into road tankers. The main difficulty would be to assemble sufficient receiving capacity.

Recovery of Spilt Oil

Over the last 20 years, many mechanical oil recovery devices have been developed (e.g. suction and weir skimmers, skimmers with a moving belt, oil-absorbent rope, mop or discs). These cannot recover useful amounts of oil from the thin layers 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. Booms tend to be ineffective in currents much over 1 to 1.5 knots and wave heights over 6 to 9 feet. Successful oil recovery has thus tended to be limited to small spills in sheltered waters, harbours, etc. Experience of large tanker spills in open seas is that little oil can be recovered - in the case of the Exxon Valdez, 6-8% was recovered at sea, even in waters which were relatively sheltered and calm.

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 former Warren Spring Laboratory (WSL)[1] 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.

Dispersion

The Torrey Canyon was the first occasion on which dispersants were used on a large scale in UK waters. Since then, their use has remained controversial, although they have remained the main plank of UK response. Dispersants act 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 stabilises the droplets so that they remain in suspension and disperse with currents and tides, breaking down more swiftly through microbial action.

Much of the controversy arose from the Torrey Canyon experience that many of the worst ecological effects were caused by indiscriminate use of early types of toxic dispersants. Since 1974, all dispersants have been licensed by MAFF (currently under the Food and Environment Protection Act (1985)) to ensure effectiveness and low toxicity to marine life[2]. Because of the different technical requirements, products must be approved separately for use at sea, on sand and gravel beaches, and on rocky foreshores.

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. 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 threat to mussels, fish farms etc., through toxicity or tainting from oil in the water column. UK practice is for MPCU to consult with fisheries departments and appropriate conservancy bodies on dispersant use in sensitive areas, within one mile off shore, or in waters less than 20 metres deep.

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. Various ignition systems are available including floating igniters that can be deployed by air (e.g. helicopter). Arguments against burning are that the volatile components are swiftly lost anyway through evaporation, the difficulty of combining burning with other approaches, including salvage, and the tendency for the residues to sink to the seabed.

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

Shore Protection and Clean-up

Booms can also used to protect sensitive areas such as estuaries and coastlines, as well as to contain oil (e.g. around a leaking vessel) to enable oil recovery. The restrictions on current and wave height already mentioned apply. Once the shore is soiled however, the choice is between attempting to clean up the mess or, in sensitive environments such as salt marshes, leaving it to natural processes.

Removal. Once the oil is stranded, a variety of techniques can be used to remove the oil - from manual mopping up with rags, mops, etc., through to bulldozers to remove oiled sand to dispose of it 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 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 - in exposed coasts and with light oils, this may take weeks to months; with heavier oils in sheltered coves, up to several years.

Natural Degradation. Oil degrades naturally because there are bacteria in the environment that can use the oil as a food supply. 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 these approaches (**bioremediation**), and they concluded that applying a liquid oil-miscible fertiliser caused the natural bacteria to grow faster, and made substantial differences to the rate of natural clean-up. The general effectiveness of such approaches remain uncertain however, and bioremediation does not form part of the UK's response 'tool-kit'.

1. Now closed, but its oil pollution and related expertise was transferred to the National Environmental Technology Centre at Culham.
2. MAFF initiated a review in 1993 of the testing, approval and use of oil dispersants, which has just been published (Jan 1996).

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 - see Box) for use on chartered vessels, equipment for lightering operations and for beach-cleaning.

Because the MPCU has only a small permanent staff, it has agreements with the oil industry to respond to emergencies. A Memorandum of Understanding has been under negotiation with the United Kingdom Offshore Oil Operators Association (UKOOA), and the UK Petroleum Industries Association (UKPIA) since the Braer incident, whereby the industry supplies staff to help manage the clean-up operation. It is expected to be signed soon. Response is generally according to the system of three tiers. Tier One (T1) deploys the equipment used for local operational spills at the port itself; T2 pulls together equipment available at centres within the immediate area; T3 is where the national resources are mobilised - including stocks at the oil industry's (international) base at Southampton (Oil Spill Response Ltd - OSR), with equipment listed in **Table 2.**

Table 2 EQUIPMENT HELD BY THE OIL SPILL RESPONSE LTD.

Containment Booms (Offshore)	6 kms
Containment Booms (Inshore)	11 kms
Skimmers and transfer pumps	Around 100
Temporary oil storage facilities	Around 50 tanks: total 600 tonnes
Dispersant equipment	
Offshore spray units	7 (3 aerial, 4 offshore)
Inshore spray units	20
Beach clean-up units	40
Planes (for transport and spraying)	1

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).

THE SEA EMPRESS EXPERIENCE

The major problem encountered initially with the Sea Empress was the failure to offload the oil from the vessel until it had been badly damaged and lost over half its cargo. Offloading to tankers was thwarted by the heavy weather and the inability of the tugs available to prevent the Sea Empress from repeated grounding. The tanker was removed from the rocks and berthed to allow off-loading the remaining oil on February 21/22, but not before 70,000 tes had been spilt.

The oil was Forties (North Sea) crude, which is comparatively light and therefore contains a substantial proportion of volatile components. This is amenable to dispersant spraying provided it can be attacked within several hours, after which 'mousse' (water in oil emulsion) can be formed, rendering it less amenable to dispersion. In view of the richness of the local marine life (including seabirds, mammals, marine fisheries), MAFF withheld approval for the use of dispersants within Milford Haven, in a coastal strip 1 nautical mile from the shore and within 1 nm of Skomer. The MPCU's 6 aircraft (joined by OSR's C-130) were able to spray[1] the bulk of the slick as it moved into the outer Bristol Channel, and report success (combined with the generally active sea conditions) in dispersing much of the oil in open water. After the vessel was moved inside the Haven on 23 Feb, spraying was discontinued because there was no oil outside the Haven amenable to dispersion. By this time, some 440 tes had been sprayed - perhaps dispersing 4-8,000 tes of oil. With evaporation removing perhaps 30-40% of the oil, many thousand tonnes of weathered oil and mousse remain to contaminate seabirds and shores. Remnants in the form of sheens and weathered oil/mousse are widespread, affecting waters and shores from North Devon to north of Skomer, and as far as Porthcawl into the Bristol Channel. Oil is also affecting the islands of Skomer, Skokholm and Lundy.

1. Four dispersant concentrates are being used: Dasic Slickgone NS and LTSW, and Finasol OSR 51 and 52. These are all licensed by MAFF. In addition, a small amount of demulsifier has been used on oil mousse.

As shown in Figure 1, the main resources at risk are:
Marine birds and waders. Bird counts by the RSPB, Countryside Council for Wales (CCW) and other groups revealed 12-13,000 birds in the Haven estuary on 13 February. Outside the Haven, guillemots are returning 2-3 weeks early to their colonies of which Skomer, Stack Rocks and Ramsey Island are the largest. There are also over 60,000 gannets and 10,000 seaducks (scoters) in the adjoining bays and sea areas. Manx shearwaters have yet to return and are still generally beyond the range of the oil. Birds in the area are very vulnerable to the many patches of oil remaining, to oil which has come ashore, and to oil within the Haven. So far (Feb 27), over 1,200 oiled birds are in treatment and some 400 bodies have been picked up (some experts consider these are likely to represent only 10% of the total number so affected). In addition, some 5,000 of the birds still flying have been seen to be oiled to some degree. The final impact on the bird population will thus be substantial. Scoters have been particularly badly hit, and deaths have included rare species such as divers and grebes.

Sea mammals. The Dyfed coast is home to 4% of the UK grey seal population. Adults are not so susceptible to oil as birds, although they can be poisoned by the components in fresh oil, and 45 seals have been seen oiled to some degree. The pupping season is from August, so the more vulnerable pups will not be present. Dolphins have also been reported in areas of slicks.

Fisheries. The main commercial resources at risk outside the Haven are coastal crab and lobster fisheries and offshore finfisheries - both from the reality and perception of contamination. Most vulnerable are the Haven's shellfisheries (mainly mussels) which may be tainted even when not killed; fish farms adjoin the Haven, and there are seabed environments of conservation value. Oil has spread some 10km up the estuary. Fishermen have applied a voluntary ban on sales from the area.

Coastline and Foreshore. The whole area is one of National Park and Heritage Coast, with over 30 SSSIs, 2 of the UK's 3 marine nature reserves (Skomer, Lundy), and sites of European conservation importance. Mortality of intertidal fauna has been 100% near the main spill and oil has also spread over wide areas of coast to the north and south of the Haven entrance; additional contamination is likely with onshore winds. Potentially sensitive estuaries have been boomed by the NRA, but the foreshore cannot be so protected.

The next stage will be to monitor the effects of the 70,000 tonnes spilt on the marine environment. A number of environmental impact assessments will shortly be underway. For instance, MAFF has sent its Research Vessel (*Corystes*) to measure the extent of contamination of the water, fish, shellfish and sediments, and the condition of marine life in general following the spill. The Welsh Office will be funding a £250,000 investigation of environmental impact by CCW. There is a good database of the pre-spill state (particularly for Skomer) which will allow longer term effects to be judged.

LESSONS FOR UK RESPONSE POLICY

The Royal Commission on Environmental Pollution noted in 1981 the contrast between the limitations of clean-up technology and the optimistic tone of much official thinking. The Sea Empress reinforces lessons from other large spills - that booms, spraying, etc., offer at best only limited protection against environmental damage; indeed the extent of damage can depend as much on the weather as human intervention. Despite the large amount of research worldwide over the last 20-30 years[2], the most effective form of environmental protection remains to minimise the spills occurring.

It is too early to draw firm lessons from the Sea Empress experience, but observers draw attention to a number of relevant factors beyond those (e.g. tug availability) directly involved in the vessel's salvage. One technical option for lightering offered by a Norwegian shipowner which was not pursued, was for a dynamic positioning tanker which could remain stationary (without the need to anchor) while off-loading up to a mile away from the grounded vessel. Had the Sea Empress remained fast on the rocks, it might have been technically feasible to take advantage of the tanker's proximity to land to offload oil into temporary storage tanks or to road tankers.

As far as the spill response is concerned, even though conditions were favourable for aerial spraying-assisted dispersion, substantial amounts of mousse and weathered oil remain; quantities in the Haven itself are being removed by local oil recovery craft and by additional (including French) vessels. As already mentioned, of particular concern is the amount of oil reaching the breeding islands, and the impact on estuarine and coastal shellfish, crab/ lobster fisheries, where contamination is a potential long term problem.

The Sea Empress also illustrates the potential difficulties of organising the clean-up with so many interested parties involved. As far as the vessel itself is concerned, as soon as the salvage contract is let, all actions related to that vessel become the responsibility of the salvor. On the spill response, while MPCU maintains a lead role, its main equipment is the spraying aircraft, and it relies very much on the oil industry for additional equipment needed for containment, physical recovery, shore clean-up and supplementary aerial spraying. While much of this (Tier-1 and Tier-2) equipment may be deployed swiftly, access to T-3 (e.g. OSR) required Texaco (the owner of the cargo) to decide unilaterally to commit these resources. Subsequent attempts to share the responsibility with others (e.g. insurers) can divert attention from the needs of clean-up, or in the event of a failure to agree, lead to premature reduction in effort.

The current policy emphasis on relying on the oil industry to conduct the clean-up is consistent with the polluter pays principle, but some remain concerned that the necessity of debate between all the different parties involved and their insurers can make swift action more difficult to achieve than where a central organisation (e.g. MPCU) acts first and recovers costs later. In either case, there are well-established compensation schemes for recovering clean-up costs under the International Oil Pollution Compensation Fund, whose limits are to be increased in May 1996.

As already mentioned, bodies from County Councils, the Port Authority, MAFF, NRA, and conservation and wildlife organisations are involved in consultations on spill response. Conflicts can arise between environmental and operational interests - e.g. the salvage interest was to move the leaking tanker into the relative safety of the Haven; from an environmental and shellfisheries point of view this was a worse option because it introduced more oil into a particularly sensitive and constrained environment - better could have been offloading in more open areas where spillages could have been dispersed into open water. It remains MPCU's role to attempt to resolve such conflicts, and to make decisions where consensus cannot be reached; however, the salvor remains the prime decision-maker on the fate of the vessel once the salvage contract has been let.

2. DoT's research budget is ca £1M p.a. and has supported a number of projects; e.g.aerial remote sensing of oil thickness,emulsion formation and dispersion, cleanup of salt marshes and mudflats, effectiveness of demulsifiers, review of sorbents and burning of slicks.