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THE TORREY CANYON DISASTER

A review of methods employed to combat large scale oil pollution

by

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INTRODUCTION:

In this review an attempt has been made to collate the central points of the most important of the multitudinous reports which have appeared in connection with the Torrey Canyon oil pollution. The content has been limited to the biological aspects of a large-scale oil spillage and its subsequent treatment, although the importance of tourist amenities also receives consideration in the discussion. Consequently, several related topics which lie outside the scope of the biologist have either been omitted or just mentioned in passing: they include the technical problems of the salvage of oil from a crippled tanker, the control or collection of floating oil, and the administrative organisational requirements for effective action in an emergency of this kind.

There are four sections:

I The Problem

II The Treatment

A. In England

B. In France

III Discussion

IV Conclusions

Bracketed numbers in the text refer to the list of publications at the end.

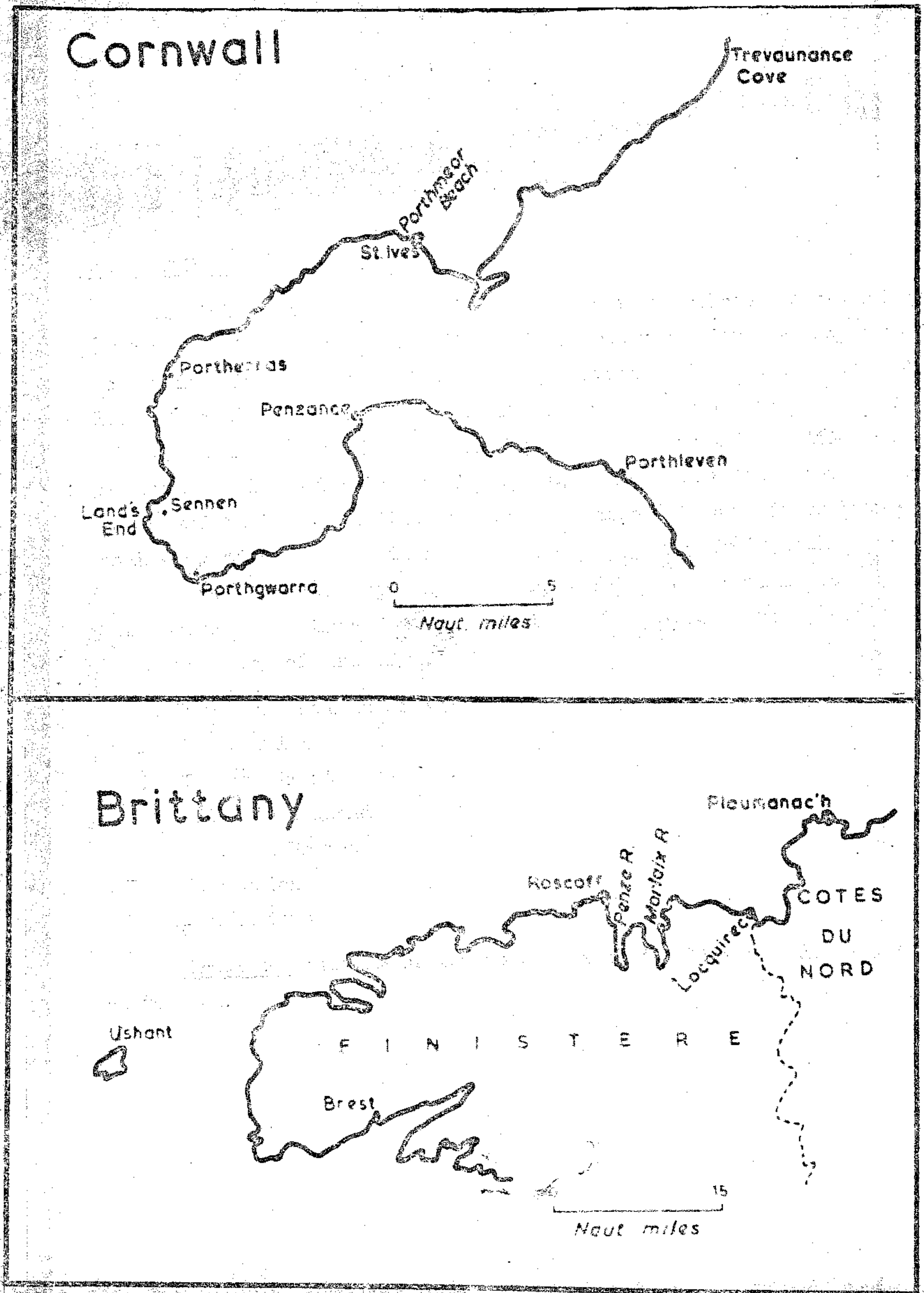

Fig. 1. Maps showing places mentioned in the text.

N.B. 1 nautical mile = 2,000 yards.

I The Problem

The Torrey Canyon was carrying 119,000 tons of Kuwait crude oil [1] at the time of running aground on 18th March, 1967, on the Seven Stones Reef, some 15 miles west of Land's End. The fate of the cargo was estimated as follows[1]:-

30,000 tons released on grounding;
20,000 tons released during next 7 days;
50,000 tons released on breakup, 8 days after grounding;
19,000 tons destroyed by bombing, 12 days after grounding.

About 18,000 tons reached the Cornish beaches[2], the first oil coming ashore on 25th March and continuing for four or five days although it was withdrawn and redeposited with every tide for some time afterwards. The oil which reached the French coast[2] comprised about 15,000 tons on the Cotes du Nord from the oil released when the tanker grounded, and about 50,000 tons from the break-up on 26th March. This second batch passed to the west of Ushant, together with an unknown, but probably small, quantity of unburnt oil released during or after the bombing from 28th - 30th March. Most of it was successfully sunk, and a small quantity came ashore in Finistere.

II The Treatment

A. In England

1. At Sea. It was found that the rate of movement of oil patches in the direction of the wind could be predicted with a fairly high degree of accuracy. When well away from land, the velocity can be calculated as 3.3% of wind speed[3], with subsequent vectorial adding or subtracting of residual surface currents. Where the wind drift flows closely parallel with a coast on the right the factor is about 4.2% and when the coast is on the left it falls to about 2.5% of wind velocity.

Treatment of the oil at sea was confined to spraying with detergent, followed by agitation with the ships' screws and high-pressure hosing. Up to 6th April, 592,000 gallons of detergent (mostly BP 1002 and Dasic) had been issued for use in this way[1]. By the end of April, the crude oil content of surface water samples[4] in the Western Channel was still appreciable, even though the sampling was carried out well away from visible slicks. In the Torrey Canyon wreck area the surface contamination was 11-20 parts oil in 10^9, and in other parts of the Western Channel the range was 3-14 parts oil in 10^9. Surface water taken at a point off Portland Bill and not contaminated by Torrey Canyon oil contained 3 parts crude oil in 10^9. These figures are maximal and were obtained by spectrofluorimetry.

2. On the beaches. Attempts to control the oil movements by means of booms met with little or no success. Of the designs given a fair practical test, the best was the Warne design[1], a 16" diameter foam-filled neoprene flotation cylinder with a 22" skirt and weighted lower cylinder. This boom excluded oil from Porthleven harbour in spite of a 7' swell, but it was defeated by wave heights greater than about 18" or 2', and by tidal currents in excess of 2 knots.

Treatment on the beaches was generally by detergent application or physical removal. The first was perhaps the most widely used, and up to 6th April 1,164,000 gallons (again mostly BP 1002 and Dasic) had been issued[1]. By 17th April a further 500,000 gallons of detergent had been issued for shore use and it is estimated that a total of $2\frac{1}{2}$ million gallons was issued during the whole operation, at sea and on the shore. The recommended application rate was 1 part detergent to 4 parts oil, timed if possible so that the incoming tide agitated the mixture shortly afterwards, but otherwise it was to be hosed down.

At Sennen Cove the Local Authority cleaned the rocks by what has been claimed[5] to be the most efficient method seen in Cornwall. A special vehicle was equipped with a large detergent tank, a pump and three high-pressure sprayers with pistol grip on/off controls. The hoses were on powered reels. When the rocks had been sprayed the detergent was washed off with water hoses. This system was not so successful on the sand, where spraying was accompanied by furrowing and ploughing with bulldozers so as to let the rising tide mix the oil and detergent for better dispersal; by May the concentration of oil 18" below the surface, was still very high (up to 30.9 fl. ozs., per cu. ft. sand). Bulldozing was continued up to early June. By August the beach appeared to have been cleaned satisfactorily but there was a 12"-18" layer of blue-black sand covered by 3'-6' of new sand. This had a very bad appearance but in view of its low oil content (0.5 - 0.7 fl. ozs. per cu. ft.) it did not appear to inconvenience visitors. It was later confirmed that this blue-black zone was a harmless sulphide layer which is naturally present on many beaches, and in this case was probably the product of biodegradation of the oil.)

Another heavily polluted beach at Portherras was treated only partially successfully with detergent. By August there was no pollution, but the natural situation of the beach was such that 3' - 4' of sand, together with the oil and detergent, had been removed by tidal action.

Physical removal of contaminated sand was somewhat more successful. At Porthmeor Beach, St. Ives, the pollution was very heavy, and although earlier attempts to get rid of the water-in-oil emulsion (40% - 50% oil) by detergent had only made matters worse (see page 7) the top 6" - 9" layer of sand was bulldozed to low water level and there treated with detergent.

Within 8 days the oil concentration in the sand was only slightly above acceptable limits - 0.2 to 2.5 fl. ozs. oil per cu. ft. sand[5]. Initial concentrations of oil, before any decontamination exercises, had been up to 33 fl. ozs. per cu. ft. By August 6" of new sand covered the beach, and the slight oiliness of the black underlay was easily removed from human skin by rinsing with water.

At Trevaunance Cove, 4-5 acres in size, the owner refused to allow detergents to be used and instead scraped off the top layer of polluted sand which he dumped down an old mine shaft. The oil content of the beach afterwards was less than 0.2 fl. ozs. per cu. ft.[5].

In Guernsey, sewage tanker lorries sucked up 3,000 tons[2] of oil and oil emulsion for discharge into a quarry. Up to seventeen tankers of 800-1,000 gallon capacity were used to pump the oil from the sea surface, where a fresh wind at high water built up the oil to a layer thicker than the minimum 2" required by the pumps. When the wind dropped or changed, pumping had to stop.

B. <u>IN FRANCE</u>

1. <u>At sea</u>. Initial attempts to sink the oil with sawdust and powdered chalk were unsuccessful[6], but Craie de Champagne was used to good effect after a trial on 18th April. This is finely ground calcium carbonate containing 1% sodium stearate to render the chalk hydrophobic and oleophilic. Although the only effective way to apply it was to slit the bags and pour it over the side of the boat, followed by steaming through the oil/chalk mass, the French were able to sink between 20,000 and 30,000 tons of water-in-oil emulsion with 3,000 tons of this treated chalk[2,3]. No oil/chalk mixture came ashore subsequently, nor did this treatment interfere with fishing[7]. By May a system of pumping the oil aboard an adapted petrol coaster had been worked out but by that time most of the oil had been sunk or dispersed. In the two days that this system was functional it pumped up 1,200 tons of oil[2].

2. <u>On the beaches</u>. Roscoff harbour was successfully protected [2,6] by two kinds of boom. The first, which was the more satisfactory was made from straw and jute fibres buoyed up with tractor inner tubes, while the second, which was heavier, had an expanded polyurethane core surrounded with straw and covered with jute fibres. Other booms protected the oyster beds in the Morlaix and Penzé rivers to the east. To the west in Finistere the types in use were a plastic apron 1 m. deep weighted with shingle in pockets along the bottom edge and another (better) one of canvas weighted with lead and supported with rods of Duralumin; both were kept up by fishing net floats.

It is calculated[2] that 300 tons of emulsified oil came ashore in Finistere in west Brittany and 15,000 tons in the Cotes du Nord. Sandy beaches were successfully cleaned by repetitively placing a line of straw or gorse along the shore at low tide, and as the tide rose the oily sand was collected by the straw or gorse rolling up towards high water mark. It was then collected and burned.

Detergents were sprayed on polluted holiday beaches in north Brittany, but only on those well away from estuarine oyster beds. Oxane and Fina-sol were used. At other places the top layers of sand were bulldozed off, since the oil had sunk in to a depth of 6". At Locquirec, on the north coast, steam was used to clean oiled rocks on 20th June. The machines required a large supply of fresh water, and delivered steam at 140°C and 8kg/sq.cm. pressure (114 lbs/sq.in.) through spray nozzles. This was followed by rinsing the rocks with 0.3% Teepol solution, the whole operation cleaning about 30 sq. metres of rock surface per hour per machine.

By mid-July only insignificant traces of oil pollution were apparent on treated beaches(6) and holiday activities were not interrupted. One rocky beach (at Ploumanac'h) which had not been treated had black layers on the rocks, a distinct smell of oil and thin oily layers on the rock pools. Detergent spraying, if properly carried out, can remove oil that has been on rocks for up to two months(2), but oil, if left indefinitely without any attempts to remove it, will remain as a hard black film around high water mark for at least one and probably for several years(7).

III. DISCUSSION

When one examines the methods used to combat an oil spill of the size of the Torrey Canyon disaster, it becomes clear that no single method is perfect - nor can it be fairly expected to be, especially in situations where there is a conflict between the interests of tourism and those of fisheries. At best one must be adaptable in taking steps to remove oil pollution, either on the sea or on the shore, and be aware of the drawbacks as well as the advantages inherent in each method.

Detergents were reasonably successful in dispersing floating oil from the Torrey Canyon, bearing in mind the vast quantities involved. (Here it is worth pointing out that a detergent does not destroy oil - it merely disperses it into very fine particles which facilitate bacterial breakdown.) However, there were three main disadvantages associated with attempts to disperse oil on the beaches. They were (i) inefficiency in achieving the object of the exercise, (ii) the toxic effects of the detergents on a large number of marine animals, (iii) instability of the sand on treated beaches.

The first disadvantage resulted partly from over-zealous application of the detergent - in some places it was just poured out of the drums instead of being sprayed - and partly from the nature of the oil coming ashore. Where the oil arrived as a relatively thin fluid, detergent treatment was reasonably successful (although difficulty of access by spraying machinery to rocky coves resulted in inefficient application in these situations), but in many places the oil was in the form of a sticky brown mass, a water-in-oil emulsion which became known as "chocolate mousse" from its appearance. (After 24 hours, a fresh oil spill has lost 25% by weight of volatile matter, and 30% after 3 days. Because of the increased viscosity which results from this evaporation, weathered oil is formed into an emulsion by wave action much more easily than fresh oil and the "chocolate mousse" was in fact a water-in-oil emulsion containing up to 80% water. Where the emulsion coming ashore contained less than 40% water it was coloured black.) Treatment of the "chocolate mousse" with detergent was largely unsatisfactory; it had to be worked into the emulsion with great agitation; the normal spraying and hosing was not very effective. Another source of inefficiency (on sandy beaches, e.g. Porthmeor) was the way in which the detergent reduced the viscosity of the oil and caused it to soak deeply into the sand(5). This made further attempts to remove it very difficult.

The second disadvantage - the toxic effects of detergents - was observed on the shores of Cornwall(8) and investigated in laboratory tests (2, 9), both during and after mopping up operations. At Sennen Cove, which had been sprayed with detergent, the rocky part of the shore held dead or dying individuals of many species - fish in the rock pools, worms, crustaceans, molluscs - but at Porthgwarra, a small rocky creek where oil had come ashore as an emulsion and had not been treated, animal life appeared to be quite healthy with gastropod snails crawling on oil-covered seaweed. The day after Porthgwarra had been sprayed with detergent the conditions of the intertidal species were similar to those seen at Sennen Cove. Laboratory investigations showed that the concentration of BP 1002 required to kill the majority of experimental shrimps (Crangon vulgaris) in 24 hours was 2 parts per million. For the limpet (Patella vulgaris) the figure was 5 p.p.m., for the sea anemone (Actinia equina) 25 p.p.m., for the shore crab (Carcinus maenas) 25 p.p.m. and for the periwinkle (Littorina littorea) 100 p.p.m. Meat from lobsters taken up to 800 yards offshore from a treated beach was found to be tainted(9).

The third disadvantage - the production of temporary quicksands - was very pronounced in cleaned areas of Porthmeor beach(5). These conditions were reproduced in the laboratory(2) where it was found that 10 p.p.m. of detergent was sufficient to markedly reduce the cohesiveness of the sand particles, and that it required numerous tidal cycles to flush out the solvent part of the detergent which becomes adsorbed on to the sand grains.

Since the time of the Torrey Canyon grounding several detergents have come on the market which are said to be either more effective or less toxic than BP 1002. The I.C.I. product Cirrasol was much better at emulsifying oil under laboratory test, and Esso's Corexit has been shown to be much less harmful to marine life,[10,11] but the former is still relatively toxic and the latter is not such an effective emulsifier as either Cirrasol or BP 1002 when subjected to the same laboratory test.[12] Until such time as the perfect oil dispersant is produced - an effective but non-toxic emulsifier - the large scale use of these materials should be confined to spills on the open sea, using the most efficient emulsifier available. If a spill is to be dealt with close inshore and in circumstances where the use of detergents is unavoidable, then the detergent chosen should be the least toxic available.

Two further methods are available for use at sea - absorbing and sinking.

Straw is adequate for absorbing small quantities: depending on the type of oil the amount absorbed varies from 8-30 times the weight of the straw.[13] An expensive method, but one which might be worth while in valuable shallow waters is to coat and absorb the oil with a cob-web like raft of sprayed plastic/acetone solution. Polyurethane foam has also been tried successfully, although not on Torrey Canyon oil. This is a hydrophobic material which can be used as a roller mounted on the bows of a collecting barge or cut up into chips and broadcast over the floating oil. However, there are two drawbacks to the use of absorbing agents. Firstly it is difficult to apply the material to the oil slick under rough sea conditions without a lot of waste, and secondly the recovery of the oil-soaked agent presents considerable practical problems. With straw, for example, one of the difficulties is that about 40% of the oil runs off when lifted at sea, although it can be used to absorb oil on beaches (see page 6) where these conditions do not apply.

Several sinking agents are available; apart, however, from its physical properties, a sinking agent must be both cheap and readily available if its use is to be a practical proposition. The French used blackboard chalk - Craie de Champagne - with 1% sodium stearate to render it hydrophobic and oleophilic. The chalk itself was powdered calcium carbonate of the kind which in this country is found only in Co. Antrim under the basalt (our blackboard chalk is made from gypsum). Powdered limestone (another form of calcium carbonate), which occurs widely throughout Ireland, is also satisfactory when treated with stearate, but it is not as absorbent as chalk. Pulverised fuel ash from electricity generating stations has the same hydrophobic and oleophilic properties when it has been treated with chloro-silane vapour at the rate of 0.2% by weight.[13] I.C.I. market a gypsum residue called Stucco which is similar to Plaster of Paris, and when it is applied to an oil slick it sinks, taking the oil with it, and sets to a fairly hard cake on the sea bed.[13]

The principal difficulty with a sinking agent is to get the material on to the sea surface without most of it blowing away. The French found that it was impossible to work from naval vessels because the fine powder clogged up the radar and armaments and they were reduced to slitting the bags of Craie de Champagne and pouring the contents over the side of fishing vessels. Even under these circumstances it sank the oil very well, although it must be pointed out that in France they were dealing with emulsified oil that had been at sea for several weeks. The Warren Spring Laboratory in England are working on a system of injecting the powder into a boat's fire pump and pumping it out as a slurry: the water spray then seems to form a curtain and allows the powder to reach the sea surface.(14) They have also found, however, that it requires an equal weight of sinking agent to sink a given quantity of fresh oil (in France the ratio was 1 part chalk to 7 or 8 parts emulsified oil) and this brings us to the problem of bulk.

If one thinks in terms of a fresh oil spill of 100,000 tons (which was the quantity lost from the Torrey Canyon) it will be seen that the logistics of moving 100,000 tons of powdered sinking agent to the disaster area would be enough to monopolise, if not overwhelm, most national transport systems since it would involve approximately 10,000 railway wagons. Even if a stockpile of the material was available the problem of bulk still applies when it comes to actually using it. As mentioned above, efficient scattering from boats is difficult; the use of helicopters or crop-dusting aircraft would appear to be the solution but their limited carrying capacity would hinder the necessary high rate of application of the sinking agent.

Finally, it is not certain that a sinking agent will actually bring the oil all the way down to the bottom. Because the water density increases with depth the oily particles of sinking agent might only travel part of the way down from the surface, but it is not difficult to envisage situations where this would be more favourable than complete sinking.

Booms had limited success in controlling the movement of oil slicks, and then only in harbours or estuaries where the wave height was lower than 18" or where the surface flow was less than 2 knots.

Burning of weathered or emulsified oil is difficult if not impossible, and this method of treating oil pollution did not get beyond the experimental stage. The most successful results were obtained when the emulsion was first broken down with detergent to release the oil, and burning was also assisted by the addition of finely divided solids such as powdered pumice.(1) Attempts to burn off black oil on a sea wall using oxy-acetylene equipment(5) caused considerable flaking of the rock surface and sprayed the operator with carbon-coated splinters; it is a slow method - about 150 sq. ft. per hour per man.(15) If the pollution is relatively light and in the form of semi-solid masses, the lumps can be collected by hand and burned in a drum supplied with compressed air at the base. But taken by and large, burning is an expensive and laborious process.

CONCLUSIONS

Bearing in mind the inherent drawbacks as well as the advantages of the methods used to combat the Torrey Canyon disaster and also the problem already referred to concerning the often conflicting interests of tourism and fisheries, one can draw up a preferential list of actions which can be taken to deal with oil pollution in different situations.

Away from land, the first and possibly the most important step is to keep the oil spill under observation. Since the rate of movement of a patch of oil before the wind can be predicted with reasonable accurary, its extent and position may be observed from the air without expensive and time wasting searching. Samples of the oil should also be taken periodically to determine the progress of its weathering and consequent increase in density, since this is one of the factors on which will depend the decision to use detergent, which is expensive, or a sinking agent, which is generally cheaper.

As long as the oil stays well away from land it should be just kept under observation, but if it starts to drift towards coastal waters while still fresh it should be sprayed with the most efficient detergents available. On the other hand if the oil is old and has increased in density to the stage where the use of a sinking agent becomes practical, then this method should be used in preference. The possibilities of sucking up the oil should not be overlooked.

Detergents should not be used where there are commercially valuable shellfish beds. If, however, a holiday beach of greater importance is threatened, and if there are shellfish nearby, then low toxicity should be the criterion when selecting a detergent if its use is considered unavoidable. If such treatment is not imperative in the amenity interest the oil should either be sunk or allowed to come ashore, either of which will cause less biological damage. Estuarine shellfish beds may be protected by booms, and this is about the only situation where conditions will permit their effective use.

If it has been impossible to prevent the oil coming ashore the course of action is largely determined by the type of beach to be dealt with and also, as before, by its importance as a holiday amenity. Secluded and inaccessible rocky coves should be left alone - they will be cleaned naturally in time and do not (contrary to popular belief in Cornwall at the time of the Torrey Canyon) constitute a source of pollution during this period of natural cleansing.(2) Rocky beaches frequented by tourists may be cleaned either by physical removal of the oil, or by the careful use of detergents. These must be scrubbed in with heavy brushes, particularly if the oil has started to harden, or if pollution is by "chocolate mousse" emulsion. Action should be delayed (also contrary to earlier ideas, this is possible) until conditions of wind and tide are favourable.

Detergents should not be used on a sandy beach, since at best they are ineffective and sometimes even make matters worse. Instead, an absorbing agent - straw, gorse, proprietary polyurethene foam - should be spread along the beach at low tide to absorb the oil and be rolled up the beach by the rising tide. As the tide starts to fall again the oil-soaked absorbing agent is collected for burning or dumping and the process repeated as often as necessary. Alternatively, the top layers of sand should be physically removed with earth-moving equipment.

Finally, it should be pointed out that, whatever the merits and demerits of the methods that have been mentioned, there are two things which are at best guaranteed to hinder and at worst to defeat the most comprehensive plans to combat large-scale oil pollution of the marine environment. One is lack of preparation, the other is panic.

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REFERENCES:

1. The Torrey Canyon: Report of the Committee of Scientists on the Scientific and Technological Aspects of the Torrey Canyon disaster. H.M. Stationery Office, London, 1967.

2. Smith, J.E. (ed.) 1968 'Torrey Canyon' Pollution and Marine Life. A report by the Plymouth Laboratory of the Marine Biological Association of the United Kingdom. Cambridge Univ. Press, London.

3. Cooper, L.H.N., 1968 Scientific consequences of the wreck of the Torrey Canyon.
Helgolander wiss. Meeresunters. 17 : 340-355.

4. Parker, C.A. et. al.,1967 Oil Contents of the Sea following the Torrey Canyon Incident.
Report No. A/70(M), Admiralty Materials Laboratory, Poole, Dorset.

5. Taylor, W.E.L., 1968 'Torrey Canyon' exercise 'Mop-Up'.
Report No. 52 Admiralty Oil Laboratory, Cobham, Surrey.

6. Wyllie, D., & Taylor, W.E.L., 1967 France and the 'Torrey Canyon'. Technical Note No. 31, Admiralty Oil Laboratory, Cobham, Surrey.

7. Bone, Q., & Holme,N.,1968 Lessons from the 'Torrey Canyon'
New Scientist 39: 613. pp. 492-3.

8. O'Sullivan, A.J., and Richardson, A.J., 1967 The Torrey Canyon Disaster and Intertidal Marine Life.
Nature 214 : 5087, pp. 448, 541, 542.

9. Simpson, A.C. 1968 The Torrey Canyon Disaster and Fisheries
Laboratory Leaflet (New Series) No. 18, Ministry of Agriculture, Fisheries & Food, Fisheries Laboratory, Burnham-on-Crouch, Essex.

10. Spooner, M.F., 1968 (Personal communication)

11. Griffith, D. de G. 1969 Investigations into the toxicity of Corexit.
Fishery leaflet No.6, Dept. of Agriculture and Fisheries, Dublin.

12. Jeffery,P.G.1968 (Warren Spring Laboratory,Stevenage,Herts.)-
Personal Communication.

13. Wardley Smith, J. 1968 Methods of Absorbing Oil Spills at Sea.
Warren Spring Laboratory, Stevenage, Herts.
(Paper given to Symposium on the Biological Effects of Oil Pollution. Field Studies Council, Orielton.)

14. Shuttleworth, F. 1968 (Warren Spring Laboratory, Stevenage, Herts.) - Personal communication.

15. Recommended Methods for Dealing with Oil Pollution.
Engineering and Information Services Leaflet LR 79. Warren Spring Laboratory, Stevenage, Herts.