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Factors in the Dispersant Use Decision-Making Process: Historical Overview and Look to the Future

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The decision to use chemical dispersants in a particular marine oil spill response revolves around an evaluation of the potential costs and benefits. Decision-makers must consider the potential effectiveness of dispersant treatment as well as the potential for environmental benefits or harm. The safety and effectiveness of dispersant use depend on: the type of oil or product spilled, the amount of oil spilled, proximity to the shore and to sensitive habitats and populations, the weather and sea conditions at the time of the spill and during the response, the types of dispersant chemicals on the market at the time of the spill, and the potential efficacy of other cleanup methodologies available. Spill response coordinators must evaluate these complex factors as well as follow the local and national regulations in place at the time and in the location of the spill, and evaluate the relative financial costs involved in use of the different methods.

Over 37% of the marine oil spills recorded in the *Oil Spill Intelligence Report* International Oil Spill Database for which there are detailed records of the cleanup response involve the use of dispersants during the cleanup operations. Records indicate that the use of dispersants has changed over the last 35 years with changes in the availability of new dispersant formulations as well as improvements in other recovery techniques, implementation of local and national laws, the efficacy and costs of the different cleanup methodologies, the assessment of natural resource damage costs, and research developments on the effectiveness and safety of chemical dispersants.

This paper reviews the history of dispersant use through data and a review of case histories to shed light on the political, technical, and financial issues that have influenced the decision-making process and are likely to influence dispersant use in the future.

Introduction

The decision to use or not use chemical dispersants in response to a particular oil spill involves consideration of four key factors:

- *Potential effectiveness*, depending on the oil type and condition, prevailing conditions, location, and dispersant formulations available;
- *Potential environmental impact* of the oil, dispersant, and dispersed oil;
- *Regulatory policy* in the jurisdiction within which the spill occurred; and
- *Operational feasibility*, including logistical considerations and cost.

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The manner in which response officials have evaluated these factors and made decisions on dispersant usage have varied over the last 35 years depending on lessons learned from actual experiences and research. The decision-making process today still varies considerably from one spill incident to another, as it does from one nation to another. The information (and misinformation) on which officials base their decisions continues to be confusing, contradictory, and difficult to interpret.

History of Dispersant Use

The earliest recorded use of dispersant chemicals on an oil spill occurred on an offshore tanker spill in Germany in 1966 with favorable results and little environmental impact (Lewis and Aurand 1997). This success and others encouraged the use of this technique. In fact, an evaluation of data from 408 oil spills in the *OSIR* International Oil Spill Database for which the cleanup method is known shows that 90% of major spills involved the use of dispersants in the response during 1966-1969.

But in 1967, response crews applied an estimated 420,000 gallons (nearly 1.6 million liters) of various dispersants on the oil slicks and on the shoreline following the spill of 38.2 million gallons (130,000 tonnes) of crude oil from the tanker Torrey Canyon off Land's End, United Kingdom, with devastating results that became apparent in later evaluations (Smith 1968). The Houghton, BP1002, and Gamlen dispersants formed stable detergent-oil emulsions that persisted for weeks (NRC 1989). In addition, the highly toxic hydrocarbon-based dispersants and dispersed oil were reported to have caused wildlife damage that far exceeded damage the undispersed crude oil would have caused.

Much of the notoriety of chemical dispersants stems from the high toxicity of the formulations and improper application techniques used in the response to the Torrey Canyon spill. The toxicity of dispersants of this era was due primarily due to the carrier solvents (aromatic hydrocarbons) rather than the dispersant surfactant themselves (US NRC 1985).

After the Torrey Canyon spill, the oil spill response community became concerned that the dispersants themselves were very toxic and that effective dispersants made oil constituents more available to biota enhancing the toxicity of oil components (US NRC 1989). Dispersant usage dropped precipitously. During 1970-1979, 52.2% of spills involved the use of dispersants in the response.

The environmental impact concerns led to the development of newer, safer formulations. So-called “second-generation” dispersants developed in the 1970s were less toxic but also considerably less effective. Again, dispersant usage began to drop even further in favor of mechanical and manual recovery methods. During 1980-1989, 38.0% of spills involved the use of dispersants in the response, according to *OSIR* data.

In the 1980s and into the 1990s came the advent of a variety of “third-generation” dispersants, which consisted of concentrated solutions of surfactant with little solvent designed to be diluted with seawater before application. These formulations presented a answer with significant improvements in both safety and effectiveness.

Despite the availability of the new generation of dispersants, dispersant usage is at an all time low. During 1990-1998, only 28.4% of spills have involved the use of dispersants in the response, according to *OSIR* data. While some of the reduction in dispersant usage in the last two decades may be attributed to improvements in mechanical and manual recovery technologies, many observers feel that lingering concerns about dispersant toxicity still override recognition of the potential benefits of dispersant usage in many situations. Coupled with increased environmental awareness and responsibility among officials and the public, these concerns often lead to what may be an overly restrictive stance on dispersant usage.

National Dispersant Policies

Over 73% of the 150 nations worldwide specifically allow dispersant usage, albeit often with restrictions, while only 8 nations (5.3%) specifically prohibit it under any circumstances (see Table 1). Another 32 nations (21.3%) have an unknown status with respect to dispersant usage, in many cases due to lack of experience with major spills.

Many nations now have an official policy on dispersants which outlines both prohibitions and restrictions as well as the procedures to follow in an oil spills response. In many cases this procedure includes a mandatory official approval or permitting process as well as reference to an approved list of dispersant chemicals. This approval procedure generally involves a careful evaluation by officials and technical and scientific experts on the factors of potential effectiveness, environmental impact, and operational feasibility, as well as cost.

Evaluating Potential Dispersant Effectiveness

Officials must consider the following points concerning the potential effectiveness of the dispersant(s):

- Oil composition (amounts of aromatic and aliphatic hydrocarbons, asphaltenes, and metalloporphyrins);
- Dispersant composition (hydrophilic-lipophilic balance) of surfactant(s), type of surfactants, and type of solvents;
- Dispersant-to-oil ratio;
- Mixing energy (breaking waves, subsurface turbulence, and mechanical mixing);
- Water salinity;
- Water temperature;
- Oil viscosity;
- Slick thickness and distribution on water surface; and
- Oil weathering (evaporation of volatile hydrocarbons, photooxidation, and mousse formation (NRC 1989).

Different phases of a response often require re-evaluation of the dispersant question. For example, during the response to the 1979 Ixtoc I well blowout, in which at least 140 million gallons (476,000 tonnes) of crude oil spilled into the Gulf of Mexico over the course of 10 months, Mexican response teams relied heavily on dispersant usage with considerable success. But US officials opted to deny permission to use dispersants in the response in offshore US waters because the oil was already too weathered at that point for any reasonable expectation of success.

In some cases, the decision to use dispersants turns out to be in error due to factors related to the oil condition or type. For example, in the response to the 20-million-gallon (68,000-tonne-)

spill from the tanker Khark 5 off Morocco in 1989 response crews applied dispersants which were largely ineffective due to the weathered state of the oil. Crews that applied dispersants to the No. 6 fuel leaking from the sunken Vista Bella barge in the Caribbean Sea in 1991 found that the chemicals were ineffective on the heavy oil. Officials blamed cold temperatures on the ineffectiveness of dispersants on a 1992 crude oil pipeline spill in Cook Inlet, Alaska, USA. Knowledge of current research findings and advance consideration of oil-related factors can assist officials in making appropriate choices.

Concerns Over Environmental Impact

In addition to evaluating the dispersability of the oil, officials must also consider the potential for environmental damage to nearby sensitive resources. This requires a detailed knowledge of the ecosystems involved both in space and time. The proximity of the spill to sensitive economic sources, such as tourist beaches, fisheries or industrial water intakes, must also be considered. Many nations have prohibitions and restrictions related to sensitive environmental and economic resources incorporated into their official dispersant policies. Other nations consider environmental impact issues on a case-by-case basis. In some nations, such as Guinea, Micronesia, and Palau, dispersant use is an unlikely option due to the preponderance of sensitive coral reefs and mangroves.

The federal on-scene-coordinator at the response to the 1989 World Prodigy tanker spill in Block Island Sound, Rhode Island, USA, vetoed the use of dispersants due to concern over the sensitivity of spawning species. The appropriateness of this decision was borne out in a research study showing that subtidal organisms suffered no damage because dispersed fuel oil was kept out of the water column (Peckol, Levins, and Garrity 1990).

In the 1991 fishing vessel Tenyo Maru fishing spill in Juan de Fuca Strait, Washington, USA, US and Canadian response officials decided to deny permission dispersant use due to concerns over fishing areas.

Evaluation of Logistical Problems

Logistical concerns, such as the availability of chemicals, application equipment, and trained personnel, are also of importance, and may change a decision from positive to negative even in the face of the most favorable environmental conditions. Costs can also play a role at this stage. In some nations, such as Liberia, Gambia, and Ukraine, dispersant use is an unlikely response option due to unavailability of equipment. In Uruguay, although dispersants are not prohibited per se, application with anything other than hand-held sprayers would be difficult due to the geography of the coastline.

Even weather can cause logistical problems. In the response to the 1997 tanker Nadhodka spill in Japan, responders were forced to delay dispersant applications due to stormy weather conditions that made flights by dispersant-applying airplanes dangerous.

In some cases logistical considerations sway decisions in favor of dispersant usage. In the response to the 1987 freighter Pacbaroness spill off California, USA, responders opted to use aerial dispersant applications because high seas and winds made it difficult to bring in and use mechanical recovery equipment.

Dispersants as a Primary Response Tool

Less than one-third of nations that allow dispersant usage recognize the methodology as a primary response tool to be considered along with mechanical and manual cleanup as “just another tool in the response toolbox.” Many of these nations have various restrictions, including prohibitions against use in nearshore areas or near sensitive resources, such as mangroves or coral reefs (see Table 2). Some nations, such as South Africa, which officially list dispersants as a primary response option are becoming more strict in their dispersant approval process and are leaning more towards mechanical recovery techniques, perhaps due to an acquisition of more equipment and improvements in logistical situations.

Fifty-seven nations regard dispersants as a secondary response option to be used only if mechanical containment and recovery or manual techniques are not likely to be effective or are impractical for logistical reasons. Again, many of these nations have restrictions on usage (see Table 3).

A few nations allow dispersant usage only as an absolute last resort option, i.e., when all else fails. A synopsis of dispersant response policy by nation is shown in Table 4.

Dispersants Vs. Other Methodologies

Analysis of the *OSIR* data show that 37.5% of spill responses over the last three decades involved the use of dispersants, as opposed to 60.5% which involved mechanical containment and recovery and 43.4% of responses which involved manual methods (see Table 5).

In 17.2% of all spill responses, and in 45.8% of dispersant-inclusive responses, chemical dispersion was the only methodology employed, often with remarkable results. In a 1997 spill from a floating storage offloading vessel in the North Sea, immediate application of dispersant from an oilfield standby vessel dispersed the oil so quickly that oil company officials initially reported the spill as only 44,000 gallons (150 tonnes) when as much as 200,000 gallons (680 tonnes) had actually spilled. They reported that the oil had dispersed so quickly that their visual estimations were grossly inaccurate.

Prudent use of dispersants on offshore oil spills has been credited with keeping oil off of shorelines, reducing environmental and economic impact and reducing cleanup costs in many cases. In the response to the 1989 spill from the tanker Philips Oklahoma off Hull, UK, chemical dispersion played a key role in keeping oil off the shoreline, eliminating the need for shoreline cleanup.

In some cases, dispersants play an important role in reducing shoreline impact but do not totally eliminate it. In 1998, the Sea Empress Evaluation Committee (SEEC) reported that 3.2 million to 4.7 million gallons (11,000-16,000 tonnes) of oil emulsion stranded on UK beaches as a result of the 1996 spill of 21.2 million gallons (72,360 tonnes) of light crude oil from the tanker Sea Empress. According to SEEC, “without dispersants there could have been 60,000-120,000 tonnes (17.6 million-35.3 million gallons) of emulsified oil on the beach.” The spill response did require nearshore mechanical containment and recovery operations as well as some shoreline cleanup, though recovery figure here were only about 3%.

In over half of spill responses in which dispersants are employed other methods are used as well (Table 6). This is particularly true of nearshore spills in which dispersants can disperse as much as 65-75% of the oil but the remaining oil still hits the shoreline (Clark 1998, personal communication). Often manual shoreline cleanup is still required to some extent.

Mechanical recovery can also be employed in conjunction with dispersants as well.

According to response experts, the industry-wide edict about the mutual exclusivity of dispersants and mechanical recovery is a myth. The use of dispersants does not preclude the use of mechanical recovery later, except in some specific circumstances, such as the temporary problems that occur with disc skimmers. Historically, response crews have used mechanical recovery in conjunction with dispersants in nearly 38% of spills involving dispersant use. The Sea Empress spill is an example of such a situation.

In some cases dispersants and application equipment are put on standby while officials evaluate the progress of natural dispersion through wave action and natural weathering. In 1994 South African officials made such a choice after the tanker Tochal broke up of the coast in the Indian Ocean. The oil dissipated naturally with no environmental impact while the dispersant spray vessels remained on standby.

Spill Response Costs

Oil spill response costs can be formidable. Although response officials, and often the responsible party as well, are most concerned with maximizing the effectiveness of an oil spill response in order to minimize environmental, property, and economic damages, response costs are an important consideration as well. While publicly responsible parties rarely proclaim the virtues of selecting their cleanup techniques with cost in mind, privately it is a primary concern, and rightly so. Cleanup costs are often directly correlated with spill impact, particularly shoreline impact, so that reducing the spill impact can result in reducing the spill response costs (Etkin 1998a,b). Likewise, money well spent on an effective cleanup can significantly reduce later damage claims and natural resource damage assessments.

Keeping the oil off the shoreline and employing the most effective cleanup methodology for the situation at hand are prudent financial considerations as well as prudent environmental decisions.

Cost factors are significant in the use of dispersants as shown in Table 7. While costs vary widely within each response method category depending on logistical and other factors, a general trend can be detected. Oil spill responses that involve dispersants only or dispersants as the primary response method are less expensive than those that involve a variety of methods. This trend is, to some extent, influenced by the fact that an offshore oil spill, which is treatable by dispersants only or by dispersants with minimal backup of manual and other methods, is generally less complicated to clean up than one which occurs nearshore.

But, further analysis shows that offshore spills in which dispersants might have prevented major shoreline impact would have been less expensive to tackle on this front rather than on the shoreline. An example of this is the 1984 spill from the Tanker Alvenus off the Louisiana, USA, coast in the Gulf of Mexico. After a controversial decision not to use dispersants offshore, the shoreline, including large areas of tourist beaches, were significantly impacted necessitating $67.6 million (1997 $) in shoreline cleanup.

One study showed that the cost of removing oil offshore (by either dispersants or mechanical recovery) averaged $25/gallon ($7,350/tonne), whereas shoreline cleanup ran as high as $500-$1,000/gallon ($147,000-$294,000/tonne) (Franken 1991, personal communication). With the reduced costs of dispersants compared to mechanical recovery, the cost reduction in offshore vs. shoreline cleanup would be even greater if dispersants were used.

The cost benefits of dispersant use have been described by other researchers, notably

Allen and Ferek (1993) and Moller, Parker, and Nichols (1987), as well as the British Oil Spill Control Association (BOSCA) (1993). BOSCA estimated the cost of dispersant treatment at $0.59-$1.19/gallon ($173.46-$349.86/tonne), whereas physical containment and recovery costs averaged $9.52-$11.90/gallon ($2,798.88-$3,498.60/tonne) and shoreline cleanup costs were even higher at $23.81/gallon-$95.24/gallon ($7,000.14-$28,000.56/tonne).

Changes in the Approval Process

While the financial cost advantages of a successful dispersant application are remarkable when compared side-by-side with other technologies, response officials and other decision-makers have always had to bear in mind that environmental benefits and costs were the primary concern in an oil spill response. The choice has always been a difficult one and officials have always only had the knowledge of the history of spill response experiences, including the Torrey Canyon, along with varying degrees of exposure to current research findings at their disposal in making this decision.

Because the window of opportunity for effective dispersant usage can sometimes be small and there are so many complex factors to consider, many officials have historically denied dispersant use requests by responders, choosing to err on the side of caution. This caution has not always led to favorable results as in cases where large amounts of oil have impacted a shoreline because the oil was not dispersed offshore, such as in the Alvenus spill.

In recent years, there has been a greater push towards more responsible environmental decision-making. In some cases, there has been what some observers view as a "backlash" against dispersant use as more parties with special interests have become involved in the decision-making process. UK officials have complained that disputes between wildlife and fishery interests have resulted in problems making dispersant decisions. Others have argued that the inclusion of greater numbers of interests in dispersant decision-making has unnecessarily complicated the process leading to valuable time lost in the aftermath of a spill. But in many cases, this increased concern over environmental responsibility has led to careful evaluations of the dispersant use decision factors.

Ideally, dispersant use policies have been incorporated into oil spill contingency plans with some forethought as to logistical concerns and sensitive resources. Some nations which have a cautious approach to dispersant usage, such as the US, are going one step further and are working on implementing "pre-approval" procedures in many areas. These "pre-approvals" are usually location-specific decisions on dispersant usage made by a committee of technical experts and officials, along with various potentially impacted interests. Discussions of relevant issues and interests ahead of time eliminate the lengthy approval procedure and hence increase the opportunity for effective usage of dispersants. In some locations, such as California, USA, the pre-approval process has been overturned in favor of a "quick approval" process that results in a decision within two hours.

Education is also key to improving the decision-making process. In the US, the National Oceanic and Atmospheric Administration, which administers scientific and technical advice to on-scene-coordinators, has begun holding educational workshops with regional response teams to bring decision-makers up to speed so decisions are made in hours even if there is no memorandum of understanding (pre-approval).

New Considerations Due to Research Advances

Recent research on dispersant effects and advances in dispersant technology have changed the overall picture on dispersants enough that officials may need to reconsider the conventional guidelines followed in the dispersant decision-making process.

In January 1998, in a closely monitored field experiment during the response to an offshore pipeline spill in the Gulf of Guinea off Nigeria, responders successfully used Corexit 9527 on a 150-hour-old parch of crude oil. According to the experimenters, a 2,500-gallon-(8.5-tonne-)-slick shrank to about 5 gallons (0.02 tonne) in just over 2.5 hours. This suggests that perhaps the window of opportunity for dispersant use is not as small as once believed.

Decisions based on oil type may also need to be reconsidered. Response officials have often hesitated to use dispersants on No. 2 fuel because of concerns that the technique is ineffective for a product which evaporates so quickly and is high in aromatic compounds. However, recent experiments have shown that if temperature and evaporation rates are considered there may be better results (Lewis 1997, personal communication). At lower temperatures evaporation occurs more slowly adn the dispersant can be quite effective. Prohibitions against nearshore use have been based on concerns over inadequate dilution in shallow water. But modern dispersants require less mixing energy. While conventional dispersants require physical dispersive energy, newer “concentrate” formulations have a “self-mix” action when applied to oil because they contain high concentrations of surfactant molecules per unit of dispersant (US NRC 1985).

In the Baffin Island oil spill project (BIOS), Sergy and Blackall (1987) showed that despite unusually severe conditions of exposure to chemically dispersed oil, the impact on a shallow-water benthic habitat was of minor ecological consequence. Oil company response teams, working in conjunction with government officials, have used dispersants in shallow water/intertidal zones in the Persian Gulf in large spills. Visual monitoring has indicated favorable results on major recreational beaches and shallow beaches in Bahrain (Brown 1997, personal communication).

Currently, researchers are addressing concerns over nearshore dilution and exposure effects by new efforts to measure realistic exposure, including short-term pulse exposures to dispersant chemicals (Clark 1998, personal communication).

The common prohibition against the use of dispersants in mangroves may also need to be re-evaluated. Ballou, et al. (1989), Lai and Feng (1985), and Teas, et al. (1987) showed that chemically dispersed oil had only minor effects on mangroves, while fresh untreated oil had severe long-term effects on the survival of mangroves and associated fauna. But the same experiments showed that coral reefs, which are often associated with mangroves, were adversely impacted by chemically dispersed oil. Ballou, et al. (1987) concluded that:

- Dispersant use nearshore in a mangrove area could expose subtidal organisms to more oil and result in greater coral and seagrass damage, while protecting the mangroves;
- No action would cause mangroves and intertidal organisms to suffer, while the corals would remain unaffected;
- The effects of the dispersed oil are dose-related; and
- Dispersants may be beneficial in mangrove areas if used in deep waters or areas

with high energy that would promote rapid dispersal.

The lesson here is that once an oil spill occurs any decision that officials make, whether it is to apply dispersants, to mount a full-force mechanical containment and recovery effort, or to do nothing and allow nature to take its course, will have both positive and negative consequences. Nothing can undo the fact that the oil has spilled. But wise decision-making can reduce the consequences to a great extent.

Net Environmental Benefit Analysis

Increasingly, researchers and officials are concluding that the key to coming up with a wise decision is through a net environmental benefit analysis. Response officials, in conjunction with their scientific and technical advisors, must evaluate whether the net benefit of dispersant application overrides the potential damages associated with this treatment. During a net environmental benefit analysis (IPIECA 1993), the following questions need to be considered:

- What concentrations of dispersed oil may be expected under a dispersant-treated slick?
- What is the dilution potential in different types of waterbodies?
- What is the toxicity of the likely concentrations of dispersed oil to local flora and fauna?
- What is the distribution and fate of the dispersed oil in water, sediments, and organisms?
- What is the distribution, fate, and biological effects of the oil if it is not treated with dispersant?

When dispersant use is an option as dictated by local policy and logistics, officials should make the dispersant use decision by considering the entire ecosystem and not just the individual resources of interest to particular groups. Understanding and modelling important ecosystems can be an important aid in this process. Sensitive resources must be evaluated and prioritized and integrated into oil spill contingency plans.

Dispersant use is a series of tradeoffs that need to be carefully evaluated. As David Salt, of Oil Spill Response Ltd., Southampton, UK, told 1997 International Oil Spill Conference attendees, “Cleaning up oil is a series of bad alternatives. We need to figure out what will cause the least or shortest term effect. Dispersants can shorten the exposure to oil <197> that's a benefit. If we could clean up all oil with mechanical recovery we'd do it, but it doesn't happen that way. Sometimes dispersant use is the best alternative when considering short-term vs. long-term problems.”

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Table 1 National Dispersant Use Policies

Policy	Number Nations	% All Nations	% Nations Allowing Dispersant Use
Allow dispersants	110	73.3%	--
Prohibit all dispersant use	8	5.3%	--
Unknown dispersant use status	21	21.3%	--
Official dispersant use policy	69	46%	62.7%
Allow dispersant use as primary response option	35	23.3%	31.8%
Allow dispersant use as secondary response option	57	38%	51.8%
Allow dispersant use only as last resort	9	6.0%	8.2%
Approved dispersant list	24	16.0%	21.8%
Requirement for official approval procedure	45	30.0%	40.9%
Nearshore use restriction	26	17.3%	23.6%
Sensitive resource proximity restrictions	24	16.0%	21.8%
Dispersant use unlikely option due to logistics	7	4.7%	21.9%
Dispersant use unlikely option due to sensitive resources	9	6.0%	28.1%

Table 2 Policies in Nations With Primary Option Use

Policy	Number Nations	% All Nations	% Nations Allowing Dispersant Use	% Nations with Primary Option
Dispersant use as primary response option	35	23.3%	31.8%	--
Restrictions or prohibition for nearshore use	13	8.6%	11.8%	37.1%
Official permit/approval requirement	14	9.2%	12.7%	40.0%
Approved dispersant chemical list restrictions	9	6.0%	8.2%	25.7%
Other restrictions	2	1.3%	1.8%	5.7%
No official policy	12	8.0%	10.9%	34.3%

Table 3 Policies in Nations With Secondary Option Use

Policy	Number Nations	% All Nations	% Nations Allowing Dispersant Use	% Nations with Secondary Option
Dispersant use as secondary response option	57	38.0%	51.8%	--
Restrictions or prohibition for nearshore use	13	8.7%	11.8%	22.8%
Official permit/approval requirement	12	8.0%	10.9%	21.1%
Approved dispersant chemical list restrictions	15	10.0%	13.6%	26.3%
Other restrictions	13	8.7%	11.8%	22.8%
No official policy	14	9.3%	12.7%	24.6%

Table 4 Basic Dispersant Response Policy By Country

Country	Dispersants Allowed?	Policy in Place?	Option	Guidelines/Restrictions
Albania	YES	NO	secondary	REMPEC policy probably applied
Algeria	YES	NO	secondary	--
Angola	YES	NO	primary	--
Anguilla	YES	YES	secondary	Local stockpiles absent; consultation with authorities required
Antigua & Barbuda	YES	NO	secondary	Consultation with authorities required
Argentina	YES	NO	secondary	Consultation with authorities required
Aruba	YES	YES	secondary	Restrictions near sensitive resources
Australia	YES	YES	secondary	Use limited to damage mitigation
Bahamas	YES	NO	primary	Use unrestricted in ports
Bahrain	YES	YES	secondary	Use in minor spills common; ROPME guidelines
Bangladesh	YES	NO	secondary	--
Barbados	YES	YES	secondary	Use restricted to water depth over 10 meters; limited shoreline use
Belgium	YES	NO	secondary	Official approval required
Benin	YES	NO	secondary	Use restricted in fishing areas and lagoons
Bermuda	YES	YES	secondary	--
Brazil	YES	NO	primary	Restricted to water depth over 20 meters; approved list
Brunei Darrussalam	YES	YES	primary	Restricted to over 1 km offshore; official approval required; restricted near coral reefs and fisheries
Bulgaria	YES	YES	primary	Use restricted in breeding areas during some seasons and nearshore
Cameroon	YES	NO	primary	Used near oil installations with no restriction
Canada	YES	YES	secondary	Official permit required; restricted in Great Lakes and St. Lawrence R.; pre-approved list
Cape Verde	UNKNOWN	NO	--	--
Cayman Islands	YES	YES	secondary	Use restricted in shallow waters near coral reefs; used in minor terminal spills
Chile	YES	YES	secondary	Use restricted to offshore areas with strong currents; official approval required

China	YES	YES	primary	Official approval required; approved list
Country	Dispersants Allowed?	Policy in Place?	Option	Guidelines/Restrictions
Colombia	YES	YES	secondary	Rapid approval process in ports
Congo-Brazzaville	YES	NO	primary	--
Congo, Dem. (Zaire)	UNKNOWN	NO	--	--
Cook Islands	UNKNOWN	NO	--	--
Costa Rica	YES	NO	secondary	Restricted near coral reef reserve; official approval required
Côte d'Ivoire	UNKNOWN	NO	secondary	--
Croatia	YES	YES	primary	Restricted near sensitive areas; approved list; official approval required
Cuba	UNKNOWN	NO	secondary	--
Cyprus	YES	YES	primary	Restricted near sensitive areas; approved list from EC; official approval required
Denmark	YES	YES	secondary	Official approval required; use limited to preventing damage to birds or mechanical removal impractical
Djibouti	UNKNOWN	NO	--	--
Dominica	UNKNOWN	NO	--	--
Dominican Rep.	YES	NO	primary	Used in ports
Ecuador	YES	NO	primary	Use restricted to offshore; in spills over 4,200 gal (14 t) need official approval
Egypt	YES	YES	secondary	Official approval required; restricted in sensitive areas
El Salvador	UNKNOWN	NO	--	--
Eritrea	YES	YES	primary	Restricted nearshore unless official approval; approved list
Estonia	YES	YES	secondary	Use restricted according to Helsinki Convention; use by permit only
Falkland Islands	YES	YES	primary	Restricted to offshore; approved list; impractical nearshore
Fiji	YES	NO	primary	Use decided on ad hoc basis depending on currents and water depth
Finland	YES	YES	last resort	--
France	YES	YES	secondary	Use permitted in some areas; official approval required; approved list
French Antilles	YES	YES	secondary	Use permitted in some areas; official

				approval required
French Guiana	YES	YES	secondary	Restricted in nearshore and estuarine waters

Country	Dispersants Allowed?	Policy in Place?	Option	Guidelines/Restrictions
French Polynesia	NO	YES	prohibited	--
Gabon	YES	NO	primary	Used by oil industry in port
Gambia	NO	NO	unlikely	Impractical due to logistics
Georgia	NO	NO	unlikely	Impractical due to logistics
Germany	YES	YES	secondary	Restricted in waters under 20 meters deep; use according to Bonn Agreement
Ghana	YES	YES	secondary	Use possible logistically
Greece	YES	YES	secondary	Use permitted if mechanical recovery impossible; approved list
Greenland	NO	YES	prohibited	--
Grenada	YES	YES	primary	Official approval required
Guatemala	UNKNOWN	NO	unlikely	Probably impractical option logistically
Guinea	NO	NO	unlikely	Use not probable due to mangroves and swamps
Guinea Bissau	YES	NO	secondary	Restricted to use with caution due to fisheries
Guyana	UNKNOWN	NO	secondary	Unlikely option due to mangroves
Haiti	UNKNOWN	NO	--	--
Honduras	UNKNOWN	NO	--	--
Hong Kong	YES	YES	secondary	Use restricted near mariculture, water intakes, and sensitive areas
Iceland	YES	YES	secondary	Use restricted with caution; approved list
India	YES	NO	primary	Restricted to offshore; probably not option nearshore
Indonesia	YES	YES	secondary	Restricted to use with caution due to coral reefs; approved list
Iran	UNKNOWN	UNKNOWN	--	--
Ireland	YES	YES	last resort	Restricted nearshore and in rivers and estuaries
Israel	YES	YES	secondary	Policy for Mediterranean coast only; official written authorization required; restrictions near areas of national importance and by water depth; pre-approved list
Italy	YES	YES	secondary	Official approval required; restricted in sensitive areas; approved list

Country	Dispersants Allowed?	Policy in Place?	Option	Guidelines/Restrictions
Jamaica	YES	YES	last resort	--
Japan	YES	YES	secondary	Official approval required; local fishing cooperative approval required
Jordan	YES	YES	secondary	Restricted in sensitive areas; official approval required; approved list
Kenya	YES	NO	primary	--
Kiribati	YES	NO	primary	Consultation with authorities required for use near sensitive areas
Korea, Rep.	YES	YES	last resort	--
Kuwait	YES	NO	secondary	Consultation with authorities required; use decided on ad hoc basis; ROPME approved list
Latvia	YES	NO	secondary	Use limited; official permit required
Lebanon	YES	NO	primary	--
Liberia	UNKNOWN	YES	unlikely	Use unlikely due to logistics
Libya	UNKNOWN	NO	--	--
Lithuania	YES	NO	secondary	Use limited; Helsinki Commission guidelines followed; approved list
Madagascar	UNKNOWN	NO	--	--
Malaysia	YES	YES	secondary	Official approval required
Malta	YES	UNKNOWN	primary	--
Marshall Islands	UNKNOWN	NO	unlikely	Unlikely option due to mangroves, lagoons, and coral reefs
Mauritania	UNKNOWN	NO	--	--
Mauritius	YES	YES	last resort	Prohibited near coral reefs, in lagoons, and in shallow water
Mexico	YES	UNKNOWN	secondary	--
Micronesia	UNKNOWN	NO	unlikely	Unlikely option due to mangroves, fisheries, and coral reefs
Monaco	YES	NO	secondary	Consultation with authorities required
Montserrat	YES	NO	secondary	--
Morocco	YES	YES	secondary	Official approval required
Mozambique	YES	NO	primary	--
Namibia	YES	YES	primary	Official approval required
Netherlands	NO	YES	prohibited	--

Netherland Antilles	YES	YES	secondary	Use restricted

Country	Dispersants Allowed?	Policy in Place?	Option	Guidelines/Restrictions
New Zealand	YES	YES	secondary	Prohibited in water depths less than 10 meters and near mariculture; approved list
Nicaragua	UNKNOWN	NO	--	--
Nigeria	YES	YES	secondary	Prohibited nearshore; approved list
Norway	YES	YES	secondary	Official approval required for spills over 1 tonne; approved list
Oman	YES	YES	secondary	Except primary option in Mina al Fah where pre-approved; official notification required; restricted in water depths under 25 meters; ROPME approved list
Pakistan	YES	NO	primary	Restricted to offshore; unlikely option nearshore
Palau	UNKNOWN	NO	unlikely	Unlikely option due to mangroves, coral reefs, and fisheries
Panama	NO	YES	unlikely	Occasional use on ad hoc basis with official approval
Papua New Guinea	YES	YES	primary	Resticted to over 7.4 km offshore; prohibited near coral reefs and fisheries; consultation with authorities required
Peru	UNKNOWN	NO	unlikely	Unlikely use near fish spawning areas
Philippines	YES	YES	secondary	Official authorization required; use restricted near sensitive resources; accredited list
Poland	YES	YES	secondary	Use limited in accordance with Helsinki Convention; official permit required
Portugal	YES	YES	last resort	--
Qatar	YES	YES	secondary	Except primary option in some offshore areas; prohibited in shallow water, near industrial water intakes, areas with poor water exchange; official approval required; ROPME approved list
Romania	NO	YES	prohibited	Prohibition except for extreme circumstances where official approval granted
Russian Fed.	YES	YES	secondary	Requires official approval

Country	Dispersants Allowed?	Policy in Place?	Option	Guidelines/Restrictions
St. Kitts & Nevis	UNKNOWN	NO	unlikely	Unlikely due to lack of chemicals and equipment
St. Lucia	UNKNOWN	NO	--	--
St. Vincent & Grenadines	UNKNOWN	NO	unlikely	Unlikely use nearshore due to sensitive resources
Samoa (Western)	YES	NO	secondary	Official approval required
Sao Tome & Principe	UNKNOWN	NO	--	--
Saudi Arabia	YES	YES	primary	Use prohibited near aquaculture and desalination intakes
Senegal	YES	NO	secondary	Unlikely option nearshore due to sensitive resources
Seychelles	YES	NO	primary	Mostly used for small harbor spills
Sierra Leone	YES	YES	secondary	Official written authorization required; approved list; use restricted to dispersable persistent oils when damage to sensitive resources likely
Singapore	YES	YES	primary	Restricted to offshore and on beaches after manual removal; official approval required
Slovenia	NO	NO	umlikely	--
Solomon Islands	UNKNOWN	NO	--	--
South Africa	YES	YES	primary	Restricted to offshore; restricted in waters less than 9.2 km offshore and with depth under 30 meters; official approval required; approved list
Spain	YES	YES	secondary	Official approval required; approved list
Sri Lanka	YES	YES	primary	Restricted to offshore
Sudan	UNKNOWN	NO	unlikely	Unlikely use due to coral reefs
Sweden	YES	YES	last resort	--
Syria	UNKNOWN	NO	--	--
Taiwan	YES	NO	primary	Best option due to lack of mechanical equipment
Tanzania	YES	NO	secondary	Restricted to favorable conditions
Thailand	YES	NO	primary	Unlikely option offshore due to logistics; primary option by oil companies in harbors; companies

				follow international use guidelines
Togo	UNKNOWN	NO	--	--
Tonga	UNKNOWN	NO	--	--
Country	Dispersants Allowed?	Policy in Place?	Option	Guidelines/Restrictions
Trinidad & Tobago	y	y	2	Restricted to offshore; official approval required
Tunisia	y	n	2	--
Turkey	y	n	2	Have been considered in previous spills
Turks & Caicos Islands	y	y	1	Official approval required
Ukraine	u	n	unlikely	Unlikely use due to logistics
United Arab Emirates	y	n	1	Restricted to offshore; prohibited near seawater intakes and in some ports; approved list
United Kingdom	y	y	1	Approved list
United States	y	y	2	Restrictions in nearshore and near sensitive resources; pre-approval in some states according to strict criteria; official authorization of regional response team required in all cases; approved list
Uruguay	y	n	unlikely	Impractical except with hand-held sprays on shoreline due to geography
Vanuatu	u	n	--	--
Venezuela	y	y	last resort	--
Vietnam	y	n	2	Possible use; policy unknown
Yemen	u	n	unlikely	Unlikely option due to prevalence of coral reefs and mangroves
Sources: ITOPF (1997); Etkin (1990); *OSIR* archives				

Table 5 Cleanup Methodologies Used in Past Marine Spill Responses

Response Methodology	Percent All Responses[1,2]
Dispersants	37.5%
Bioremediation	2.2%
In-situ burning	3.4%
Manual (sorbents, shovels)	43.5%
Mechanical containment/recovery	60.5%
Other methods (including natural dispersion)	5.2%

Dispersants exclusively	17.2%

[1]Based on data from *OSIR* International Oil Spill Database for 408 spills between 1967-1998

[2]Many spill responses involved the use of more than one methodology

Table 6 Dispersant Usage With Other Methodologies In Marine Spill Responses[1]

Response Methodology	Percent All Responses[1]
Dispersants Only	45.8%
Dispersants + Bioremediation[2]	2.0%
Dispersants + In Situ Burning[2]	2.0%
Dispersants + Other[2]	5.2%
Dispersants + Mechanical[2]	37.9%
Dispersants + Manual[2]	33.3%
Only Dispersants + Manual + Mechanical	16.3%
Only Dispersants + Manual + Mechanical + Other[3]	2.0%
Only Dispersants + Mechanical + Other[3]	1.3%
Only Dispersants + Bioremediation + Mechanical	1.3%
Only Dispersants + In Situ Burning + Manual	0.7%
Only Dispersants + In Situ Burning + Mechanical	0.7%
Only Dispersants + Bioremediation + Manual + Mechanical	0.7%
Only Dispersants + Manual + Other[3]	0.7%

[1]Based on data from *OSIR* International Oil Spill Database for 408 spills between 1967-1998
[2]Many spill responses involved the use of more than one methodology
[3]Other methodologies includes intentional natural dispersion and “do nothing” strategies.

Table 7 Oil Spill Cleanup Cost Comparison[1]

Methodology	Mean Cost/Gallon	Mean Cost/Tonne	Standard Deviation	Sample Size
Dispersants Only	$7.27/gal	$2,137.38/t	$6.37/gal $1,872.78/t	5
Dispersants Primary Method	$8.51/gal	$2,501.94/t	$8.99/gal $2,143.06/t	11
Dispersants Secondary/Tertiary	$47.37/gal	$13,926.78/t	$44.95/gal $13,215.30/t	16
Other Methods Only (No Dispersants)	$42.61/gal	$12,527.34/t	$134.31/gal $39,487.14/t	65

[1]Based on *OSIR* International Oil Spill Database; all costs in US dollars (1997 $)