Global dispersant regulations

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1. Background

The use of oil spill dispersants is one of a limited number of methods that have been found to be effective at reducing the damage that can be caused by spilled oil. In common with other response methods such as the use of booms to contain or absorb spilled oil or the use of skimmers to recover spilled oil or the controlled burning of spilled oil, the aim of using dispersants is to prevent the spilled oil coming into contact with the ecological resources that would suffer the most severe and long-lasting damage. Past experience has shown that spilled oil cases most damage when it drifts into oil-sensitive coastal habitats such as mangroves, mud-flats and salt-marshes. Spilled oil persists for a long time in such habitats, is very difficult to clean up without causing more damage and continues to cause damage long after the oil spill incident.

Oil spill response can be a ‘race against time’ to recover, burn or disperse the spilled oil before it impacts an oil-sensitive resource. Spraying dispersants from aircraft onto the spilled can be a more rapid way of dealing with large volumes of spilled oil than other response methods. However, like all other oil spill response methods, the use of dispersants has some limitations. As spilled oil ‘weathers’ (loses the volatile oil components by evaporation and incorporates water to form water-in-oil emulsions) the use of dispersants becomes less effective.

2. The IPIECA perspective

National governments have the right and responsibility to introduce laws and regulations as they see fit to protect their citizens and the environmental and ecological resources within their territories from the effects of pollution. The use of dispersants as an oil spill response method is regulated in several different countries around the world to similar broad principles, but often implemented in very different ways.

The international oil industry is dedicated to the prevention of oil spills, but when such incidents do occur it is in everybody’s interests that the damage that could be caused by spilled oil is minimized by effective and timely response. The international oil industry naturally respects national laws and regulations and seeks to work with national governments and the IMO so that the national governments and the oil industry can achieve the best possible oil spill response outcomes.

The international oil industry and its specialist response contractors need to know what response methods will be permitted in responding to oil spills that may occur in the national waters of many countries.

With respect to the use of oil spill dispersants, there are a series of questions that often need to be asked and answered during the pre-planning stages when undertaking offshore oil exploration and production in a nation’s waters:

- Is dispersant use on spilled oil permitted in the waters of the host country?

- Do dispersants have to be approved by the government?
    - Which dispersants have already been approved?

- Does the national government accept dispersants approved in other countries or are there specific national dispersant approval procedures?
- How is the national dispersant approval process organized?
    - Which national government departments need to be involved?

- Where and when can dispersants be used, and where and when dispersants cannot be used on spilled oil in national waters?
    - Which national governments regulate dispersant use?
    - In what form is this information presented?
        - Dispersant use and non-use zones defined by minimum water depths and minimum distances from shore, plus special areas on marine charts?

The standardization of such information would be very welcome for an international industry, but such 'standardization' has not proved to be possible so far. In fact, the trend has been for dispersant regulations in some parts of the world to diverge.

There are a growing number of national regulations about dispersant use in different countries that may share common aims, but which differ very significantly in scope and complexity. In some cases, this is because the conditions that exist in the marine ecosystems with nation's territorial waters are genuinely different, but in many cases the different regulations are driven by different points of view on what dispersant regulations seek to achieve.

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3. The origin of regulations about dispersant use in the UK

Dispersants are blends of chemicals that will not be recovered after they have been added to the spilled oil. There is therefore a reasonable requirement that dispersants should be of low inherent toxicity and there is an historical precedent to justify this requirement. The use of massive quantities of industrial detergents at the *Torrey Canyon* oil spill in the UK in 1967 demonstrated that the unregulated use of industrial detergents could do more harm than good. The industrial detergents contained a high proportion of highly aromatic solvents such as KEX, kerosene extract, which contain very high levels of the BTEX (Benzene, Toluene, Ethylbenzene and Xylenes) compounds. These are exactly the same chemical compounds in crude oils that are now known to be toxic to marine organisms. In addition, the industrial detergents were not particularly effective and were used at very high treatment rates.

The UK Government introduced regulations to prevent the use of such detergents by requiring oil spill dispersant to be **approved for use** following an assessment of their toxicity and effectiveness. The UK Government also introduced regulations about **where and when dispersants could be used** on spilled oil at sea.

A. Dispersant approval regulations

The original regulations introduced by the UK Government required that dispersants could only be used on spilled oil in UK waters provided that they had been tested to ensure that they were:

i. Reasonably effective

- The dispersant had to be more effective in a specified test method with a test oil than a specified minimum level.
- The original UK test method involved two small boats in a harbour. A test spray of the candidate dispersant was made onto a fuel oil mixture laid on the water surface from one boat. A ‘breaker board’ towed by the first boat provided agitation. The effectiveness visually assessed by observers in the second boat.
- Subsequently the Labofina rotating flask method was adopted and incorporated into the WSL (Warren Spring Laboratory) LR 448 method to conduct effectiveness tests under laboratory conditions.
- The required ‘pass marks’ for a UK Type 2/3 dispersant are 60% with medium fuel oil (with a viscosity of 2,000 cP at 10ºC) and 45% with a 500 cP at 10ºC.
- Such effectiveness testing only gives an indication of the relative effectiveness of dispersants and are **not** an indication of their performance on spilled oil at sea because there are many variables (sea state, oil weathering etc.) that control dispersant effectiveness at sea.

ii. Not too toxic

- The dispersant had to be less toxic to a specified test organism in a specified toxicity test protocol than a specified maximum level.
- A simple 96-hour LC_{50} (Lethal Concentration to 50% of test organism population) toxicity test procedures with brown shrimp was used until 1977.
- The purpose of any LC_{50} toxicity test procedure to determine the relative toxicity of the tested substances; the dispersants. The exposure regime used in any LC_{50} test method does **not** simulate the exposure conditions that might be produced with dispersant use on spilled oil at sea.

One aspect of the UK dispersant approval regulations that still persists that is not shared by many countries is the classification of dispersants into three types:

UK Type 1: hydrocarbon solvent-based dispersant applied undiluted.
UK Type 2: concentrates, diluted 1:10 with seawater before application.
UK Type 3: high efficacy concentrates applied undiluted.

This is partly due to historical reasons.

i. Type 1 dispersants were those developed immediately after the Torrey Canyon incident and consisted of low levels of (10% to 20%) of surfactant in 80% to 90% of solvent, normally odourless kerosene. They were recommended for use at 1 part of dispersant to 2 to 3 parts of spilled oil.
ii. Type 2 dispersants were "water-dilutable" to be used from boats and ships with dilution with seawater through and educator.
iii. Type 3 dispersants are modern dispersants that can be used undiluted from aircraft and ships.

B. Dispersant use regulations

Following the experience of the use of industrial detergents at the *Torrey Canyon* oil spill it became apparent that oil can be toxic to marine organisms.

Crude oils and some refined oil products contain some slightly water-soluble oil chemical compounds such as BTEX (Benzene, Toluene, Ethylbenzenes and Xylenes) and substituted naphthalenes. Most oils also contain small quantities of PAHs (Polycyclic Aromatic Hydrocarbons). BTEX will be slowly released into the water from a floating oil slick, but many of these compounds are also volatile and will evaporate rapidly into the air. BTEX and substituted naphthalenes can cause toxic effects to marine organisms when they dissolve into the water from the oil.

Dispersing the oil into small oil droplets in the water increases the surface area of oil in contact with the water. The transfer of BTEX and substituted naphthalenes into the water is more rapid if the oil is dispersed. The localised concentration of these compounds in the water column, and therefore the potential to exert toxic effects, is greater when the oil is dispersed than if it is not dispersed.

The initial concern was that spilled oil should not be dispersed into areas water where the dispersed oil would come into contact with the benthos that inhabits the seabed. Dispersed oil is maintained in approximately the top 10 metres of water depth in moderate sea conditions. It was therefore decided that spilled oil could be dispersed into water depths (as marked on the charts) of 20 metres or greater without the likelihood of dispersed oil reaching the seabed. Dispersing oil into water with depths of less than 20 metres requires specific prior permission from the relevant authority.

Subsequent studies concentrated on the dilution of the dispersed oil to low concentrations and the dilution of the potentially toxic water-soluble compounds (the BTEX and substituted naphthalenes) released from the dispersed oil droplets. These studies confirmed that dispersing oil into water that was 20 metres deep or more allowed the concentrations of dispersed oil and of the water-soluble compounds to be rapidly diluted to very low concentrations that would not cause significant effects to marine organisms.

4. Development of regulations about dispersants around the world

As the possibility of dispersant use became more widespread in some countries around the world, some countries began to develop their own national regulations about dispersants. Other countries, or regional groupings of countries, decided that local conditions made it unlikely that dispersant use would be an acceptable oil spill response method. Of the countries that have developed dispersant regulations, some chose to adopt the approach used by the UK authorities.

The details of the regulations and testing requirements for dispersant approval are available at various web-sires, including:

Australia

Australian Maritime Safety Authority, 2012. National Plan to Combat the Pollution of the Sea by Oil and Other Noxious and Hazardous Substances: Protocol for the Register of Oil Spill Control Agents. Available at http://www.amsa.gov.au/Marine_Environment_Protection/National_plan/General_Information/Dispersants_Information/OSCAgentsStandards.pdf.

China, **Russia**, **Japan** and **Korea** have developed their own regulations about dispersants:

http://dinrac.nowpap.org/documents/NOWPAP_MERRAC_Technical_Report_No3.pdf

European Summary

EMSA, 2010. Inventory of National Policies Regarding the Use of Oil Spill Dispersants in the EU Member States. (Country profiles) Available at http://www.emsa.europa.eu/opr-documents/opr-inventories/226-opr-inventories/618-inventory-of-national-policies-regarding-the-use-of-oil-spill-dispersants-in-the-eu.html.

France

Center of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE): http://www.cedre.fr/index-en.php. CEDRE handles the dispersant approvals process in France. (Dispersant specific web page: http://www.cedre.fr/en/response/dispersant.php.)

India

http://www.indiancoastguard.nic.in/Indiancoastguard/NOSDCP/NOSDCP%20Publications_files/OSD.pdf

Mediterranean

REMPEC

http://www.rempec.org/country.asp?IDS=2_0&daNme=&openNum=1

Regional Information System: Part D: operational guides and technical documents: section 2: guidelines for the use of dispersants for combating oil pollution at sea in the Mediterranean region which can be downloaded at:

http://www.rempec.org/rempec.asp?theIDS=2_130&theName=INFORMATION%20RE

New Zealand

http://www.cawthron.org.nz/coastal-freshwater-resources/downloads/oil-spill-dispersants-v2.pdf

Norway

Norwegian Climate and Pollution Agency. Oil Spill Dispersant Policy in Norway. Available at http://www.klif.no/no/english/english/Whats-new/Oil-Spill-Dispersants-Policy-in-Norway1/?cid=29292.

Norwegian Climate and Pollution Agency. Pollution Regulations Chapter 19 : Composition and use of dispergent agents and shoreline cleaning agents in combating oil spills. Available at http://www.klif.no/artikkel____34957.aspx.

United Kingdom

Marine Management Organisation (MMO), 2012. The Approval and Use of Oil Spill Treatment Products in the United Kingdom. (Approval process, required testing; includes links to Efficacy test protocol and Toxicity test protocols on page 5) Available at http://www.marinemanagement.org.uk/protecting/pollution/documents/approval_and_use.pdf.

Marine Management Organisation (MMO). Link to product testing requirements: http://www.marinemanagement.org.uk/protecting/pollution/approval.htm.

Marine Management Organisation (MMO), 2007. Protocol for UK efficacy testing- Report LR448. Available at http://www.marinemanagement.org.uk/protecting/pollution/documents/approval_lr448.pdf.

Marine Management Organisation (MMO), 1996. Protocol for UK toxicity testing- Fisheries Research Technical Report No. 102. Available at http://www.marinemanagement.org.uk/protecting/pollution/documents/tech102.pdf.

USA

Unites States Environmental Protection Agency (EPA). National Oil and Hazardous Substances Pollution Contingency Plan Product Schedule- Subpart J. (Information about listing dispersants and other chemicals) Available at http://www.epa.gov/oem/content/ncp/index.htm.

Unites States Environmental Protection Agency (EPA). Use of Dispersants and Other Chemicals – 40 CFR 300.900 – 300.920. (Rules related to dispersant use) Available at http://www.epa.gov/emergencies/docs/oil/cfr/900_920.pdf.

4.1 Dispersant approval regulations

The idea that a dispersant should (i) exhibit a minimum level of effectiveness, and (ii) a maximum level of toxicity before it could be used on spilled oil in national waters was generally accepted. However, the test methods that would be used to assess (i) dispersant effectiveness and (ii) dispersant toxicity - or alternatively the toxicity of dispersed oil - are different in different countries.

4.1.1 Different effectiveness testing of dispersants for approval purposes

The concept that a dispersant should exhibit a minimum level of effectiveness, as defined by testing in a nationally specified laboratory test method with a specified test oil, before it would be permitted for possible use in national waters is retained by several countries. What varies is the test method and test oil used for dispersant effectiveness testing.

The UK continues to use the WSL LR 448 rotating flask method with two test oils; a 2,000 cP at 10ºC medium fuel oil and the same oil diluted, or cut-back, to a viscosity of 500 cP at 10ºC. The mixing of the dispersant-treated oil (at a Dispersant to Oil Ratio, DOR of 1:25) into the 250ml of seawater is achieved by end-over-end rotation of a flask at 33 rpm for 2 minutes, followed by a 1 minute static period before 50ml of the oil and water mixture is withdrawn and the oil content of the water determined. This mixing method is not a simulation of any recognisable sea-state; a series of 66 plunging, breaking waves every 1.8 seconds followed by a calm period is unlike any open-sea conditions. The Labofina method, from which the WSL LR 448 method was derived, was never intended as a simulation of conditions at sea. It was a formalised 'bottle shake' test for oilfield chemicals with the shaking by hand replaced by end-over-end rotation to produce a standardised and repeatable level of mixing. Some people criticized the intense mixing followed by a static period as being 'unrealistic' and various test methods were developed to produce a more 'realistic' mixing regime that might simulate - to some degree - the mixing conditions caused by waves and experienced by a floating oil slick at sea. This poses an immediate problem; which sea state should be simulated?

The size of waves is determined by wind speed, wind duration, and fetch (the distance over which wind blows without changing direction). The sea state is the general condition, with respect to wind, waves and swell, at a certain location and moment. A sea state is characterized by various characteristics including the wave height, period, and power spectrum. Sea states vary with time, as the wind conditions and/or swell conditions change. The World Meteorological Organization sea state code characterizes different sea states.

WMO Sea State Code	Wave Height (meters)	Characteristics
0	0	Calm (glassy)
1	0 to 0.1	Calm (rippled)
2	0.1 to 0.5	Smooth (wavelets)
3	0.5 to 1.25	Slight
4	1.25 to 2.5	Moderate
5	2.5 to 4	Rough
6	4 to 6	Very rough
7	6 to 9	High
8	9 to 14	Very high
9	Over 14	Phenomenal

Several different dispersant effectiveness test methods have been developed:

- In Canada, the Mackay - Steelman - Nadeau (MNS) method was developed using air blown over water contained in a circular tank. This produces a wave and dispersant-treated oil will be dispersed into the water by the wave action. This method is not used for dispersant approval in Canada since national dispersant approval regulations do not currently exist in that country, but is used as part of a comprehensive testing regime required for dispersant use to be permitted in Norwegian waters.

- In France, the IFP (Institut Francais du Pétrole) dilution method was developed and is used in the French dispersant approval procedure. This method uses a hoop that oscillates just below the water surface to provide agitation without breaking waves. For approval for use in French waters, a dispersant must produce an effectiveness of at least 60% when tested with the specified test oil; BAL 110ºC+, a lightly 'topped' Arabian Light crude oil. The IFP method is also used as part of the required testing regime in Norway.

- In the USA, the Swirling Flask effectiveness test method with Prudhoe Bay and South Louisiana crude oils is used. This protocol was developed by Environment Canada to provide a relatively rapid and simple testing procedure for evaluating dispersant effectiveness. It uses a modified Erlenmeyer flask to which a side spout has been added for removing subsurface samples of water near the bottom of the flask without disturbing a surface oil layer. A dispersant must attain an effectiveness value of 45% or greater to be added to the NCP Product Schedule. Manufacturers have to submit test results and supporting data to the EPA.A development of the Swirling Flask method, the Baffled Swirling Flask method has been developed as possible replacement for the is used for dispersants, but this has yet to be implemented in the appropriate regulations

- Other dispersant effectiveness test methods such as the EXDET test have been developed.

The different dispersant effectiveness test methods employ different levels of mixing energy to cause dispersion of the dispersant-treated oil into the water.
It is difficult to reliably quantify the mixing energy because other factors of the test methods are also different, but it seems that the methods could be ranked according to mixing energy as:

Most energetic

Baffled Swirling Flask
MNS
WSL
EXDET
IFP
Swirling Flask

Least energetic

It is not possible to assign a simulated sea state to the tests, but it is feasible that effectiveness results from the most energetic test methods (MNS and Baffled Flask methods) might be more representative of dispersant performance in rougher seas and effectiveness results from the less energetic test methods (IFP and Swirling Flask methods) might be indicative of dispersant performance in calmer seas.

When used for national approval, or listing (as in the USA), purposes the tests are carried out with the specified test oils. The most energetic test method used for approval test purposes is the WSL method used in the UK and one of the specified test oils has a viscosity of 2,000 cP at 10ºC. The lowest energy test, the Swirling Flask method used in the USA uses two unweathered crude oils. The IFP test used in France uses a lightly weathered crude oil. The mixing energy produced by the test method and the viscosity of the test oils used viscosity of counteract each other; the highest viscosity test oil is used in the most energetic test method and the lowest viscosity test oils are used in the least energetic test method. The required dispersant effectiveness for approval is therefore similar in tests used by the different countries; 60% in the UK and France and 45% in the USA.

It is very important to understand that the dispersant effectiveness results obtained during approval testing only indicate the relative performance of dispersants <u>under the conditions of the test</u>. The dispersant meets a certain minimum level of performance under these conditions. The performance at sea of a dispersant that is approved for use in a particular country, and which has therefore produced a dispersant effectiveness result above the minimum required, will entirely depend on the characteristics of the spilled oil and the prevailing conditions. No inference should be made from being approved that the dispersant will likely disperse 45% or 60% of the spilled oil. Under some conditions, the dispersant could disperse substantially all of the spilled oil, while in other conditions it could be much less.

4.1.2 Toxicity testing of dispersant or dispersed oil for dispersant approval

The industrial detergents used at the *Torrey Canyon* had LC_{50} values of around 6 ppm as assessed by the LC_{50} test procedure with brown shrimp (*Crangon crangon*). The low-toxicity UK Type 1 dispersants introduced in the early 1970s typically had 48-hour LC_{50} values of >3000 ppm. It became impossible to generate the range of dispersant concentrations in water necessary to establish the LC_{50} value because at the very high concentrations in water required, the dispersant formed a layer on top of the water. It was decided that the toxicity of the dispersant alone was not the relevant factor to consider. Dispersants would only be used on spilled oil and it was known that the toxic effects of dispersed oil would be greater than that of the dispersant. A new ‘at sea’ toxicity test procedure using dispersant and Kuwait crude oil was developed in 1977.

In some other countries, the emphasis of concern also moved away from that about inherent toxicity of the dispersant to the possibility of toxic effects being caused to marine organisms by the dispersed oil. Current toxicity testing of dispersant for approval (or listing) purposes is carried out in two different ways around the world

i. **Toxicity testing of “dispersant alone”**

   Some countries continue to specify a maximum permitted toxicity for a dispersant to be approved. For example:

   - In France, the toxicity of the dispersant to shrimp must be at least ten times lower than the toxicity of a reference toxicant (*Noramium DA50*).

   - In Norway, a toxicity test method determines the acute toxicity of the dispersant alone, by testing it on a planktonic algae (*Skeletonema costatum* test, ISO/DIS 10253). This is one of the standardised internationally accepted ecotoxicity tests used by the “OSPAR” Convention. The use of dispersants with EC_{50} < 10mg/l is prohibited.

   This approach retains the argument originally used by the UK Government prior to 1977. Any dispersant to be used in national waters must have a low inherent toxicity.

ii. **Toxicity testing of "dispersant plus oil"**

It has long been known that the real concern about toxicity with dispersant use should be the potential toxicity of the dispersed oil, not the toxicity of the dispersant itself. It is often stated that "Dispersants are less toxic than the oil they are used to disperse". Some countries test for toxicity by using a combination of dispersant and a test oil. For example:

- In the UK, the currently used "Sea Test" toxicity test procedure exposes shrimps to a mixture of oil (a lightly weathered Kuwait crude oil) and dispersant. The mixture is 1 part of dispersant to 10 parts of oil. The dispersant will be approved if the dispersant and oil mixture causes no more mortality than that caused by mechanically dispersed oil alone.

- In the USA, the current standard toxicity test for dispersants and other products involves exposing two species (Menidia beryllina (silversides fish) and Mysidopsis bahia (mysid shrimp)) to five concentrations of the test product and No. 2 fuel oil alone and in a 1:10 mixture of product to oil.

  To aid in comparing results from assays performed by different workers, reference toxicity tests are conducted using dodecyl sodium sulfate (DSS) as a reference toxicant. The test length is 96 hours for Menidia and 48 hours for Mysidopsis. LC_{50}s are calculated based on mortality data at the end of the exposure period.

This approach recognizes that any inherent toxicity of the dispersant is likely to be eclipsed by that which could be caused by the dispersed oil.

At first sight, it might seem reasonable that testing with "dispersant plus oil" is the more relevant approach. The potential for toxic effects when modern dispersants are used on spilled oil at sea is caused by the dispersed oil, not by the dispersant, so it is the "dispersant plus oil" approach that should be preferred. However, the "dispersant alone" toxicity testing approach is a 'gate-keeper' to prevent a repeat of the use of the inherently toxic detergents that occurred at the *Torrey Canyon* incident.

The "dispersant plus oil" approach to toxicity testing seems to provide some simulation of dispersant use at sea because dispersed oil is present in the test, while the "dispersant alone" approach simulates dispersant use with no oil present. However, the <u>presence</u> of dispersed oil in a toxicity test procedure is not the relevant point. The basis of all toxicology is that "*The severity of negative effects caused by a substance to an organism is related to the <u>exposure</u> of the organism to the substance*." Exposure is a function of the concentration of the substance that the organsism is exposed to and the time for which it is exposed. For most marine organisms, the severity of the toxic effects depends on the concentration of the BTEX and substituted naphthalenes in the water and the period of time for which the organism is exposed to these compounds.

The exposure regimes used in the UK and USA "dispersant plus oil" toxicity tests are much more severe than would ever be encountered at dispersant use on spilled oil at sea, if dispersants were used on spilled oil in accordance with dispersant use regulations (i.e. in water depth of 20 metres or more).

- The UK "Sea Test" toxicity test procedure exposes shrimps to a mixture of lightly weathered Kuwait crude oil and dispersant at 1000 ppm in water for 100 minutes.
- The USA toxicity test procedure exposes fish for 4 days (96 hours) and shrimp for 2 days (48 hours) to sufficiently high concentrations of dispersed No. 2 fuel oil to kill 50% of the test organisms; it is an LC_{50} test procedure.

The purpose of conducting toxicity testing for dispersant approval purposes is to cause measurable negative effects to the test organisms and the exposure regime used does this. The exposure regime to dispersed oil experienced by marine organisms is of an elevated dispersed oil concentration in the seawater that rapidly decreases as the dispersed oil is diluted. Exposure regimes that do resemble exposure to dispersed oil at sea (as was done in the CROSERF (Chemical Response to Oil Spills: Ecological Effects Research Forum) produces only minor effects, or no effects at all to some species.

Despite seeming the more reasonable approach at first sight, the use of the "dispersant plus oil" testing approach has several drawbacks:

i. "Dispersant plus oil" toxicity testing does **not** simulate actual dispersant use on spilled oil at sea.
   - The exposure regimes of very high dispersed oil concentrations, sometimes maintained for prolonged periods, do not simulate dispersant use on spilled oil in water more than 10 or 20 metres deep.
   - The exposure regimes used might inadvertently simulate dispersant use on spilled oil in shallow water, but this is not their intention.

ii. Different oils have different potential toxicities depending on their chemical composition.
   - The toxic effects caused by dispersed test oils in the "dispersant plus oil" toxicity tests will most likely be very different from oils dispersed at sea.
   - Both the UK and USA toxicity tests use oils of relatively high potential toxicity.
   - Dispersant use on spilled No. 2 fuel oil is specifically not recommended because

iii. "Dispersant plus oil" toxicity testing inevitably discriminates against highly effective dispersant and towards less effective dispersants
   - A more effective dispersant will cause more of the oil to be dispersed as smaller oil droplets. This will aid the transfer of toxic oil compounds into the water.

The potential for negative effects being caused to marine organisms by dispersed oil are already addressed, in general terms, in dispersant use regulations that specify minimum water depths and distances from shore for dispersant use on spilled oil. The rationale of these minimum water depths is that past experience has shown that any effects caused by dispersed oil on marine organisms will be very localized and of short duration. The marine ecosystem has the ability to recover more quickly from damage than the oil-sensitive coastal resources that dispersant use is designed to protect.

More specific concerns about the potential for toxic effects caused by dispersed oil should be addressed during a Net Environmental Benefit Analysis (NEBA) process during the preparation of location-specific oil spill contingency plans. These can take into account the specific factors such as the water depths, currents and the identity and location of oil-sensitive marine and coastal resources.

4.1.3 Choice of test species for toxicity testing for approval purposes

The UK and France use brown or grey shrimp as the test species in toxicity testing for dispersant approval. The UK also uses limpets in the ‘Rocky Shore’ toxicity test procedure that aims to simulate dispersant use on spilled oil in intertidal areas. Such use of dispersant is unlikely to be justified by a NEBA process since there is very little water for the oil to be dispersed into.

Shrimp are not very sensitive test organisms and were chosen for easy availability and hardiness in laboratory test conditions and are used in other toxicity tests for different purposes. The use of shrimp may be relevant to the conditions that prevail around the British and French coasts, but might be less relevant top other parts of the world, for example the Tropics or the Arctic. For this reason, some countries use other test species, or consider that other test species should be used. Should a test species for dispersant (or dispersed oil) toxicity testing be selected on the basis of sensitivity or as a representative of species that might be affected by oil dispersed in the national waters?

It is well known that some species are more sensitive to dispersants or dispersed oil than other species and that some life-stages, such as eggs or larvae, are more sensitive to dispersant or dispersed oil than adult organisms. Small crustaceans (amphipods) are known to be amongst the most sensitive organisms to dispersant toxicity. Comparisons of the toxicity of numerous species have confirmed that the relative sensitivities of different species and different life stages are similar, irrespective of the habitat locations around the world. There seems to be no habitat where a specific species is much more sensitive to dispersant than in other habitats. With respect to the potential effects of dispersed oil, the important factor of any toxicity test procedure is the exposure regime (concentration and duration) of dispersed oil to which the test organisms are exposed. And the exposure regime required depends on the purpose of the testing:

- If the aim of toxicity testing is to discriminate between the effects caused by different dispersants so that some can be approved and some not approved, then the exposure regime should be one that generates such a distinction. The acute EC_{50} (Effects Concentration, 50%) and LC_{50} (Lethal Concentration, 50%) values are often determined to do this. By definition, these dispersed oil concentrations, sustained for the duration of the test (48 hours or 96 hours) are those which cause measurable non-lethal effects or lethality. However, these exposure regimes are unlikely to occur with dispersant use on spilled oil at sea.

- If the aim of the toxicity testing is to simulate the exposure regime that might be encountered by marine organisms when dispersants are used on spilled oil at sea, a suitable exposure regime should be used. The outcome might be that with relatively non-sensitive test species only minor or no measurable effects are observed. This would indicate that such species are unlikely to be significantly affected by dispersed oil at a real oil spill incident.
  Selecting a particularly life stage or a particularly sensitive test organism might enable effects to be measured at exposure regimes that might be encountered, but this would not be representative of the effects to other species, or the cumulative effects to the entire ecosystem that might be caused.

Studies of sufficient complexity to determine the likely outcome of dispersant use before an oil spill are unlikely to be able to consider all of the relevant variables; there are too many combinations and permutations of possible factors. Post-spill studies, such as those conducted after large oil spills such as the *Braer* and *Sea Empress* spills in the UK and as part of the NRDA (Natural Resource Damage Assessment) process in the USA might be able to reveal information that is specific to the incident that had occurred.

4.1.4 Consequences of different effectiveness and toxicity tests used in different countries

It might be thought that the different methods used to test dispersant effectiveness and dispersant (or dispersed oil) toxicity in various would result in lists of different approved dispersants for different countries because of the different requirements. To some extent this is true.

However, the different dispersant effectiveness test methods and the different toxicity test methods (of dispersant or dispersed oil) generally measure relative, not absolute, values. In order to 'calibrate' the results from testing so that reasonable 'pass / fail' criteria can be established for dispersant approval purposes, it has been common practice for the performance of a well-established dispersant such as Corexit 9527 to be used as a "yardstick" of the effectiveness or toxicity to which other dispersants are compared.
Therefore, despite the obvious differences in the testing requirements of national dispersant approval regulations, some dispersants that are approved for use in the national waters of one country are also approved in other countries. For example:

- Dasic Slickgone NS is approved for use in French and UK waters and is specified in many Norwegian oil spill contingency plans.
- Finasol OSR 52 is approved for use in French and UK waters and is listed in the US Federal Register.
- Corexit 9500 is now approved for use in UK waters more than 12 nautical miles from the shore (as an "offshore dispersant"), is approved for use in French waters and is listed in the US Federal Register.

However, there are many instances of individual dispersants that are only approved for use in one nation's waters. This is most often because the dispersant manufacturer (who has to pay for dispersant testing for approval purposes) finds no commercial reason to get approval for dispersant use in any other than the 'home' countries waters. Many dispersants approved for use in French waters are manufactured in France, many dispersants approved for use in UK waters are manufactured in the UK and many dispersants listed in the Federal Register in the USA are produced in the USA. There is no particular reason to believe that many dispersants would not be approved in several countries, if the manufacturers chose to submit them for additional testing, although some of the dispersants listed on the Federal Register in the USA are unlikely to be effective enough for approval in France of the UK. The result is that many dispersants are only approved for use in one country's waters, simply because they have not been submitted for approval in other countries. Although this situation is readily explained on commercial and bureaucratic grounds, this situation produces an apparent national exclusivity and multiplicity of dispersants approved for use only individual countries.

Some countries seek to avoid the complications of carrying out accept dispersants for use in their own waters that have already been tested and listed in other countries without further testing. For example, in Europe, Germany would permit the use of any dispersant that is approved for use in French or UK waters. In the Persian Gulf, the ROPME organization accepts the dispersant listed as being accepted or approved in two out of three of France, the UK and the USA.

4.1.5 Misconceptions about toxicity testing of dispersants

Using a "dispersant plus oil" toxicity testing method may initially seem to be more reasonable than using a "dispersant alone" approach because it appears to be at least a partial simulation of dispersant use on spilled oil, but actually causes confusion in the mind of regulators and the public.

Toxicology is a difficult area to understand for a non-expert. The fact that dispersants are tested for toxicity has caused the commonly-held misconception that dispersants are toxic. The phrase "toxic dispersants" became a common short-hand description of dispersants during the media coverage of the response to the *Deepwater Horizon* incident.

The reality is that toxicity testing was originally carried out on dispersants to ensure that they were not too toxic to be used - that was the point of introducing the LC_{50} testing on dispersants. Practically everything is toxic at a high enough treatment or dose rate and the concentrations required to cause lethality to half the test organsism population, the LC_{50} test result, has little to do with the exposure regime to dispersant, or to dispersed oil, that any organsism would actually experience when dispersants are used on spilled oil at sea. Experience and experimentation has shown that the actual exposure regimes to spilled oil that is dispersed by the use of dispersants in water greater than 10 metres deep are very localized and of short duration. The dispersed oil is likely to cause effects in only a very limited volume of the water and the populations of affected marine organisms such as plankton will recover very quickly from such exposures.

But the subtleties of this argument; the purpose of LC_{50} testing, the significance of LC_{50} results, the difference between exposure regimes in test methods and exposure regimes experienced by marine organisms at sea et., are difficult to convey to a media and public outraged by the presence of a large oil spill close to their coastline. The availability of toxicity test results made on dispersants has now become 'proof' in some people's minds that dispersants are toxic. The introduction of "dispersant plus oil" toxicity testing methods has added further confusion. The results of toxicity testing of dispersant with oil are commonly misinterpreted that "*the dispersant makes the oil more toxic*". These misconceptions are not confined to the media or the general public, but can also be held by politicians and senior regulators.

This was demonstrated at the *Deepwater Horizon* incident when the US EPA demanded in their May 20, 2010 Dispersant Monitoring and Assessment Directive – Addendum 2 that:

- *"… lower toxicity dispersants should be used."*

- "*The less toxic dispersant product(s) shall be used by BP for surface application and subsurface application as directed by the FOSC. Within 72 hours after submitting the list of alternatives, and after receiving EPA approval, BP shall immediately use only the approved alternative dispersant."*

- *"Monitoring data on the use of the less toxic dispersant product(s) shall be reported by BP to the FOSC and the EPA RRT Co-chair on a daily basis. This reporting shall include a sample tracking table. Daily data reports shall thereafter be provided by BP to the FOSC and the EPA RRT Co-chair as soon as practicable on the day following use of the less toxic dispersant product(s) by BP, but in no event later than 24 hours after use."*

These now widely-held misconceptions about the toxicity of dispersants and the toxic effects that could be caused by dispersed oil will be a legacy of the *Deepwater Horizon* incident for some time.

4.2 Dispersant use regulations around the world

Many countries have developed dispersant use regulations that are based on dispersant use being permitted on spilled oil on water greater than a minimum depth, for example 10 or 20 metres, and outside a minimum distance from the shore, for example 1 or 3 nautical miles.

The permission to use dispersants on spilled oil in deeper water may be automatic, with no prior consultation with the relevant national authorities required (as in the UK), or take the form of specific pre-approval for dispersant use (as in some regions of the USA). Dispersant use on spilled oil on water that is less deep may be permitted with specific, prior permission on a case-by-case basis or may be prohibited.

These "water depth / distance from shore" dispersant use regulations are based on the tacit acceptance that the dispersed oil is unlikely to cause significant negative effects to marine organisms in relatively deep water because the dispersed-oil-in-water concentration will be rapidly diluted to very low levels.

4.2.1 The "knowns" and "unknowns" about dispersant use and the NRC 2005 report

Despite the acceptance that dispersant use on spilled oil in relatively deep water is unlikely to cause significant negative effects to marine organisms, this rationale has often been questioned when dispersants have been used, or have been contemplated to be used, on a large scale. The rationale has been criticized as being too simplistic, or that the full extent of potential effects of dispersant use is not known.

The precautionary principle, or precautionary approach, is sometimes invoked to question the use of dispersants. The precautionary principle states if an action has a suspected risk of causing harm to the public or to the environment, in the absence of scientific consensus that the action or policy is harmful, the burden of proof that it is *not* harmful falls on those taking the action. In the context of dispersant use, such a precautionary principle revolves around "*the suspicions of the risk of harm that might be caused by dispersant use*", or "*the presence or lack of scientific consensus*" that such harm will be, or will not be, caused by dispersant use.

Whose suspicions should be taken into account? Such suspicions might be based on ignorance or on the basis of other agendas. Which group or organizations of scientists should be included in the establishment of a scientific consensus? The views of many scientists, from a wide variety of disciplines, are often sought by the media to express their views at the time of an oil spill. Some will be unaware of the detail in which the specific issues regarding dispersant use have been considered in the past and will often claim that 'little is known'. But are the facts really unknown, or just unknown to them? A true scientific consensus is rare about many subjects.

During the response to the *Deepwater Horizon* incident in 2010 many people selectively quoted statements from the 2005 publication by the NRC (National Research Council) "Oil Spill Dispersant: Efficacy and Effects" to support the idea that there were many unknowns about the consequences of using dispersants.

The context in which the report was written and its purpose needs to be considered. The NRC report was prepared after the US Coast Guard had proposed regulations that mandated dispersant use capability for ports and terminals over a certain size. (These US Coast Guard rules were finally introduced on February 22, 2011).

The NRC 2005 report accepts that pre-approved dispersant use in waters deeper than 20 metres was, and is, almost without significant issues. For example:

> **Pages 48 / 49**
> *D5* ***Will the effective use of dispersants reduce the impacts of the spill to shoreline and water surface resources without significantly increasing impacts to water-column and benthic resource?***
> *In open, offshore waters, physical mixing processes tend to rapidly dilute a plume of dispersed oil droplets, reducing the potential for significant impacts on organisms in the water column or associated with the seafloor. The effective use of dispersants, therefore, reduces the threat posed by a surface slick to organisms on the surface or, eventually, nearer the shore by altering the fate of that oil. As a consequence, a more limited and less robust set of information is needed to support the decision to use dispersants in such offshore conditions. Use of dispersant in treating near-shore spills, however, raises many questions that are difficult to answer with current understanding of the dispersed oil fate and effects.*
>
> **Chapter 5, (Toxicological Effects of Dispersants and Dispersed Oil) on page 271:**
> *When spills occur offshore, where the potential magnitude and duration of impacts on organisms in the water column or seafloor can assumed to be minimal, a decision to use dispersant can be made with the information that is generally available.*

The effects of dispersant use were extensively studied following the *Sea Empress* incident in the UK in 1996. The effects of naturally dispersed oil were studied after the *Braer* incident in the UK in 1993. These incidents involved oil tankers with 72,000 and 84,000 tonnes respectively of oil released into the sea. The release of crude oil occurred over approximately one week at the *Sea Empress* incident and sporadically during the course of two weeks at the *Braer* incident. Slightly more than 400 tonnes of dispersant was sprayed at the *Sea Empress* incident. Many studies have been published about both the *Sea Empress* and *Braer* incidents and they are discussed and referenced in the NRC 2005 report.

> The NRC 2005 report (as described in the **Preface, page ix**) specifically addressed issues that had become apparent *"during US Coast Guard workshops comparing the ecological consequences or response options, especially in nearshore or estuarine situations. During these workshops, it became clear that there were significant gaps in the knowledge needed to make sound decisions regarding the use of dispersant in areas that were nearshore, shallow, or with restricted flushing rate. In these areas, the simplifying assumptions that were used in risk analysis for open water setting were insufficient."*

The NRC, 2005 report clearly accepts that the use of the "water depth / distance from shore" dispersant use regulations (as used in the different regional regulations within the USA and around the world) is a reasonable way of ensuring that the potential negative effects caused by dispersed oil will be slight. The report addressed issues of using dispersants on spilled oil in shallow water.

4.2.2 “Trade-offs” of dispersant use

Dispersant use apparently has two sides:

i. The successful use of dispersants will transfer the spilled oil from the sea surface and into the water column. The benefit of using dispersants on spilled oil is that the oil that has been dispersed will not drift ashore as the spilled oil on the sea surface could.

ii. The potential disadvantage of dispersant use is that marine organisms inhabiting the upper water column will be exposed to an elevated concentration of dispersed oil droplets in the water column, compared to the situation if dispersants were not used.

The decision to use, or not to use, dispersants is sometimes portrayed as a simple ‘trade-off’; accept damage to the coastal resources if dispersant is not used, but cause damage to marine organisms is dispersant is used.

The implication of the ‘trade-off’ is that it is a choice between an amount of damage being caused on the coast by drifting oil, or <u>the same amount of damage</u> being caused by dispersed oil in the water column. In game theory, this would be known as a “zero sum game”; the total amount of damage caused by the spilled oil remains the same and the use of dispersants simply redistributes the damage from the coastal resources to the marine resources. If this was true using dispersants would only altered the location of damage caused by the oil without any reduction in the total amount of damage caused by the spilled oil.

This is one of the most-often misunderstood aspects of dispersant use. While the spilled oil is transferred from the sea surface and into the water column by dispersant use the potential for damage in the two ecological compartments’ is not equivalent, so the simple ‘trade off’ concept breaks down.

Past experience at several major oil spill incidents has shown that any negative effects on marine organisms caused by the elevated dispersed oil concentrations in relatively deep water due to dispersant use were often localized and of short duration. Ecological studies and monitoring following major oil spills have repeatedly shown that the populations and communities of water column organisms (the algae and zooplankton, larger invertebrates and fish) can recover much more quickly from brief exposure to dispersed oil in the water than the populations and communities of birds, mammals, sea-grasses, or mangroves that may be exposed to oil that comes ashore. It can take years to decades for some of these shoreline communities to recover from oiling, whereas many water column communities can recover in weeks to months. The marine environment is, in general, more resilient that the coastal environment and natural recovery will take far less time.

Any ‘trade-off’ consideration of dispersant use has to consider the amount of severe and long-lasting damage to oil-sensitive coastal habitats and resources that can probably be <u>prevented by dispersant use</u> and compare that with highly localized and short-lived effects that might be <u>caused to the marine environment by dispersant use</u>.

4.2.3 NEBA (Net Environmental Benefit Analysis)

NEBA (Net Environmental Benefit Analysis) is a process of consideration and judgement to compare the likely outcomes of using different oil spill response methods. It should be used instead of simple 'trade-offs' about dispersant use. NEBA typically involves the following steps:

1) The first stage of NEBA during an oil spill is to consider where the spilled oil is and where it will drift. It is also useful to know how an oil will 'weather' as it drifts.

2) The next stage is to assess what is likely to be affected by the spilled oil. If this includes oil-sensitive coastal habitats, the role of oil spill response at sea is to try and prevent the spilled oil from reaching these habitats.

3) Previous experience should then be used to assess which oil spill response methods are likely to be effective. Pragmatic, operational considerations should form a very important part of the NEBA process applied to all feasible response methods. A simplified decision matrix as to the suitability of all response methods would be:

Response method	Response effective in prevailing conditions?	Capability of response to significantly affect outcome in time available?	Sufficient equipment and personnel that could be made available?
Booms and skimmers used at sea	Yes / No	Yes / No	Yes / No
Protective booming	Yes / No	Yes / No	Yes / No
Controlled, or in-situ, burning	Yes / No	Yes / No	Yes / No
Dispersant use	Yes / No	Yes / No	Yes / No

The apparent "luxury of choice" between different response methods often causes confusion and unnecessary debate, but often a realistic choice does not exist because the type of oil spilled or the prevailing conditions will dictate the response method that should be used.

- If the sea is cold and a very high viscosity oil such as Mazut M-100 (a heavy fuel oil for power station use) has been spilled, such as happened at the *Prestige* spill off the Spanish coast in November 2002, the use of dispersants is not likely to be effective and all efforts should be devoted to recovery at sea and shoreline protection.

- If the spill is of a crude oil and the sea is too rough for the effective use of booms and skimmers, then dispersant use - and the possible consequences - should be considered. Protective booming of especially oil-sensitive areas should also be considered as 'back-up' since no at-sea oil spill response method is likely to be 100% effective.

4) The consideration about dispersant use is to estimate the amount of severe and long-lasting damage to oil-sensitive coastal habitats and resources that can probably be prevented by dispersant use and compare that with highly localized and short-lived effects that might be caused to the marine environment by dispersant use.

5) The final stage is to compare and weigh the advantages and disadvantages of possible responses with those of no response and natural recovery.

The effective use of NEBA requires the appropriate expertise and experience.

5. Regulation of sub-sea dispersant use

The sub-sea use of 771,288 US gallons (2,920m^3) of dispersant on the oil being released 1500 metres underwater at the *Deepwater Horizon* incident was the first time such a method of dispersant use had been conducted. Although the regulatory position regarding sub-sea dispersant use was not clear, as such a use had not been anticipated prior to the event, the US EPA issued Directives concerning the use of dispersants in this way. To understand the concerns raised by sub-sea dispersant use, it is useful to consider the aims and consequences of dispersant use in the two situations.

The aims of dispersant use

The purpose of 'conventional' dispersant use (spraying dispersant onto spilled oil on the sea surface) is to transfer the spilled oil from the surface of the sea and into the water column. The aim is to prevent the spilled oil from drifting ashore and possibly contaminating oil-sensitive coastal habitats. The purpose of sub-sea addition of dispersant to an oil release is to prevent the oil from reaching the sea surface. The aim is the same - to prevent the released oil from eventually drifting ashore and possibly contaminating oil-sensitive coastal habitats.

The consequences of dispersant use

While the aim of using dispersants is identical in both cases, there are some differences between the consequences of dispersant sprayed onto spilled oil on the sea surface and the sub-sea addition of dispersant to released oil.

<u>Dispersant sprayed onto spilled oil on the sea surface</u>

Spilled oil on the sea surface changes its location as it drifts with the wind and currents. In rougher seas there may be some natural dispersion caused by the wave action, but the rate of natural dispersion often decreases and eventually stops as the oil 'weathers', unless the sea is very rough. After dispersant is sprayed onto an oil slick the oil will start to disperse, but this does not happen instantaneously or at the same time in all of the oil slick. Small individual 'plumes' of dispersed oil are created as breaking waves pass through the dispersant-treated oil and these will be formed at different locations and at different times after the dispersant has been applied. These small individual plumes of dispersed oil typically reach a peak dispersed oil concentrations in water of 10 to 20 ppm (parts per million), or less, and rapidly dissipate to 1 ppm or less as they are diluted into the underlying water column by the turbulence present in the upper ocean.

<u>Sub-sea dispersant use</u>

A sub-sea release of oil will occur from a single, fixed location - a 'point source'. Not all of the released oil will reach the sea surface. Some partially water-soluble oil components will dissolve into the sea as the larger oil droplet rise towards the sea surface. Some oil will be mechanically dispersed by the turbulence created at the release into oil droplets that are small enough to be retained in the water column and be permanently dispersed. If the oil is being released with associated gas, there could be a high degree of mechanical dispersion of the released oil resulting in, for example 25% of the total oil flow being permanently dispersed into the water close to the release point. The other 75% of the oil flow would only be temporarily dispersed as larger oil droplets and would float towards the sea surface. The dispersed oil in water concentration very close to the release point will initially be very high, possibly hundreds of ppm. A high-volume, high-velocity oil and gas release will entrain water into the rapidly rising plume and the dispersed oil in water concentration will rapidly decrease with vertical distance from the release point.

The addition of dispersant will cause an increase in the proportion of permanently dispersed oil and a reduction in the proportion of temporarily dispersed oil. The addition of dispersant may cause 75% of the total oil flow to be permanently dispersed, leaving only 25% as temporarily dispersed larger oil droplets that would float towards the sea surface. The dispersed oil in water concentration very close to the release point will be higher with dispersant addition than without, and could be several hundreds of ppm. The dispersed oil in water concentration will rapidly decrease with the vertical distance and horizontal distance from the release point. The plume of rising permanently dispersed oil will slow as the momentum created by the flow of oil and gas decreases and may become trapped under any pycnocline (density discontinuity) that exists in the water column.

At the *Deepwater Horizon* incident, a subsurface plume of dispersed oil droplets was formed at 1,000 and 1,400 m depth. The highest recorded dispersed oil concentration measured at 1 km from the source was 10 ppm while at 10 km from the source the highest mean dispersed oil concentration was 3 ppm, with most measured concentrations being in the ppb (parts per billion) range.

Comparison of the consequences of dispersant use

Dispersant sprayed onto spilled oil on the sea surface will create small, individual plumes of dispersed that are scattered in location under the drifting, dispersant-treated oil slick and are produced over a period of up to one hour after dispersant addition. The dispersed oil concentration in the upper 1 metre of the water column may locally be up to 10 ppm, but will decrease rapidly to less than 1 ppm as the dispersed oil is diluted into the water column.

Sub-sea addition of dispersant to a continuous sub-sea oil and gas release will produce a much higher dispersed oil concentration in the water in the immediate locality above the release point. This dispersed oil concentration in water may already be very high, several hundreds of ppm, due to mechanical dispersion of the oil, but will be even higher by several times due to the action of the dispersant. The dispersed oil (both mechanically dispersed and dispersed by the addition of dispersant) will then be diluted into the surrounding water column and the dispersed oil concentration in the water column will decrease with vertical distance and horizontal distance from the oil release.

The concern about sub-sea dispersant use stems from the localized, small volume of very high dispersed oil concentration created very close to the oil release. Regulations are being developed in several countries, including the USA and the UK plus others, to ensure that sub-sea dispersant use can be demonstrated to be effective and to ensure that it does not cause significant adverse impacts on the deep sea marine ecosystem. This presents technical challenges.

6. Conclusions

1) The regulations that exist about dispersants in individual countries around the world today grew from common roots. The experience of the use of massive quantities of industrial detergents at the *Torrey Canyon* spill in 1967 led the UK Government to introduce regulations on (i) dispersant approval and (ii) dispersant use.

    - The UK dispersant approval regulations required that any dispersant had to conform to a minimum permitted level of effectiveness and a maximum permitted level of toxicity before it could be used in UK waters.

    - The UK dispersant use regulations stated approved dispersants could be used on spilled oil in deeper water, but that prior permission from the relevant authorities had to be obtained for dispersant use on spilled oil in shallow water, legally defines as 20 metres depth as marked on charts or within 1 mile of such depth.

2) Over the years some other countries have developed their own dispersant regulations. Some have adapted the UK regulations and testing for their own use; while others looked at the issues again and have develop their own regulations.

    - A variety of different laboratory methods have been devised for testing the effectiveness of dispersants for dispersant approval purposes in different countries. The level of 'mixing energy' employed by different laboratory methods for dispersant effectiveness varies over a wide range. However, differences in the properties of the specified test oils and in the specified effectiveness 'pass mark' for approval means that many modern dispersants could be approved for use in several countries on the basis of their effectiveness.

    - One major difference in dispersant approval regulations is the approach used to toxicity testing. As it became apparent that the toxicity of the dispersant itself was an irrelevant issue and that the potential for toxic effects to be caused by the dispersed oil was the more valid issue for concern, some countries, including the UK and the USA, introduced toxicity test procedures that used oil plus dispersant instead of dispersant alone, while other countries such as France retain a dispersant alone toxicity test for approval purposes. The exposure regimes used in the UK and USA toxicity test procedures are more severe than would be experienced by marine organisms at sea if the oil were dispersed in water greater than 10 or 20 metres deep and therefore cannot be considered as simulations of the probable effect of dispersed oil on marine organisms if dispersants are used on spilled oil at sea.

    The profusion of different effectiveness test methods and toxicity test protocols in different countries, plus the arguments and counter-arguments put forward by supporters and critics who consider that one particular method or protocol is superior to another, gives the impression that the different testing requirements for dispersants to be approved in different countries consider different aspects of dispersant use.

    This conceals a commonality that is rarely acknowledged. Several dispersants have been approved in multiple countries with different approval testing regimes. Most modern dispersants would be approved under the different existing national testing regimes, although some products that are listed in the USA would not be approved for use in the UK, Norway or France because they exhibit only a low level of effectiveness.

3) The significance (or otherwise) of the results of toxicity testing of dispersants, or particularly of the test results obtained from testing dispersant plus oil, have been widely misinterpreted by many people. The fact that dispersants are tested for toxicity in order to establish that they are not too toxic to be used has been, and probably will continue to be, misconstrued as indicating that the dispersants are toxic. "Toxic dispersant" became the generally accepted way of describing dispersant in the media during the *Deepwater Horizon* incident response. Similarly, the results from toxicity testing with dispersant plus oil for approval purposes are often misconstrued as being simulations of dispersant use at sea and are taken to indicate that "*dispersants make the oil more toxic*". These misconceptions are not confined to ill-informed members of the public or media, but are shared by politicians and regulators.

4) Several countries have developed <u>dispersant use regulations</u> that specify where dispersants can be used on spilled oil on the basis of a minimum water depth, typically 10 or 20 metres, and a minimum distance from the shore, typically 1 or 3 nautical miles. These "water depth / distance from shore" dispersant use regulations are based on the tacit acceptance that the dispersed oil is unlikely to cause significant negative effects to marine organisms in relatively deep water because the dispersed-oil-in-water concentration will be rapidly diluted to very low levels. Extensive testing over 30 years has shown that the exposure of marine organsism to dispersed oil after dispersant use at sea does not cause significant negative effects.

   Nevertheless, when dispersants have been used on a relatively large scale, the validity of this assumption is often questioned. The validity of dispersant use as a reasonable response method was extensively questioned during the *Deepwater Horizon* response on the basis that 'little is known' about the consequences of dispersant use. While it is true that little is known about the consequences of long-duration sub-sea dispersant use, because it had not happened before nor been studied, there is a substantial body of literature from studies on the 'conventional use' of dispersants on oil spilled from damaged oil tankers. These studies have repeatedly confirmed that negative effects of dispersed oil to marine organisms in water that is more than 10 or 20 metres deep, if any, are very localized or short duration and subject to rapid natural recovery.

   The decision to use, or not to use, dispersants is often simply and incorrectly portrayed as a 'trade-off'. This implies that when the spilled oil is transferred from the sea surface to the water column by dispersant use, the potential damage that the oil could cause is also transferred in equal measure. This 'shorthand' consideration ignores past experience of dispersant use and the essential elements of NEBA (Net Environmental Benefit Analysis).

5) The sub-sea use of dispersants at the *Deepwater Horizon* incident appeared to be successful and seemed to prevent a lot of the oil from reaching the sea surface. Until all the facts are known, it is not possible to describe a mass balance that was altered by dispersant use or assess the damage to coastal resources that was prevented by dispersant use. Similarly, until the NRDA (Natural Resource Damage Assessment) studies are complete it is not possible to provide quantitative information about the negative effects, if any, that were caused by dispersant use.

   Several national regulators have felt it appropriate to introduce regulations that entitle a national authority to grant or deny permission for sub-sea dispersant use. That is the sovereign right of any nation to develop regulations that it considers protect the marine environment within its territorial waters.

   The regulations may require that sub-sea dispersant use is monitored for effectiveness and for potential negative effects that could caused by dispersed oil. This presents technical challenges that are still to be solved.