SpillPrevention.org

INTRODUCTION TO **DISPERSANTS**

Things You **Should Know**

Mechanical recovery will always be the most widely used response option, because most spills are small and nearshore.

Dispersants remove oil from the water surface thereby protecting birds, mammals, and sensitive shorelines.

Dispersants can be used under a broad range of environmental conditions. For large offshore spills, the limitations of other response options may make dispersants the most effective response tool.

Modern dispersants are biodegradable and contain ingredients which are similar to, and in some cases less toxic than those found in many common household soaps, cosmetics, shampoos and even food (Fact Sheet 2).

All environments contain naturally occurring microbes that feed on and break down crude oil.

Dispersants are designed to break a slick up into tiny oil droplets, which enhances the rate of microbial degradation and ultimately removes the oil from the environment.

Dispersant use is always based on a net environmental benefit analysis (Fact Sheet 6).

Scientists have been studying the effects of dispersants on the marine environment for over 30 years, and are still actively engaged in dispersant research, development and innovation.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these tiny oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume (**Figure 3**).

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools — mechanical recovery and burning in place (also known as in-situ burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas et al., 1991; 1995).

This fact sheet summarizes what dispersants are, how they work, when their use is considered, and any associated environmental trade-offs and potential human health effects.

Fact Sheet Series

- **Introduction to Dispersants**
- Dispersants — Human Health and Safety
- Fate of Oil and Weathering
- Toxicity and Dispersants
- Dispersant Use Approvals in the United States
- Assessing Dispersant Use Trade-offs
- Aerial and Vessel Dispersant Operations
- Subsea and Point Source Dispersant Operations
- Dispersants Use and Regulation Timeline
- Dispersant Use in the Arctic Environment

Introduction

Unfortunately, when an oil spill occurs adverse impacts will occur. The goal of oil spill responders is to rapidly determine which options will reduce these impacts as much as possible given the conditions of the specific incident. The main categories of response options available for marine spills include:

- On-water (surface) mechanical recovery (boats, boom, skimmers, etc.).
- Surface or subsea applications of dispersants to enhance natural microbial degradation.
- Controlled burning, known as in-situ burning (burning in place on the water surface).
- Monitor and evaluate — allowing natural processes to take place with monitoring.

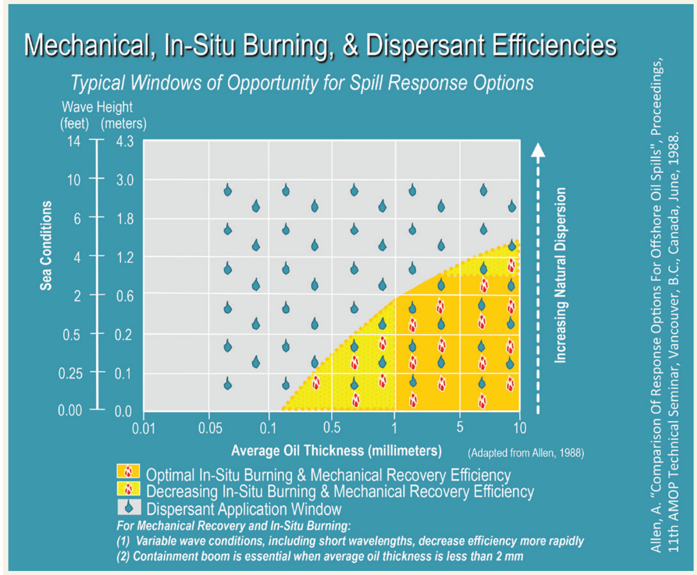
All of these options have their place in oil spill response because of the extreme variability of marine spill conditions. Mechanical recovery will generally be the most important and widely used oil spill response option because most spills are relatively small, close to shore, and often near locations where boats, boom, skimmers, and trained responders are available.

Dispersants become a critical response tool for larger spills far from shore, spills more distant from stockpiles of recovery and containment equipment, when weather and ocean conditions preclude the use of other options, or when weather conditions are predicted to become more severe. This is because in addition to vessel-based operations, dispersants can be rapidly applied from aircraft as well; they are efficient when wind and waves prevent vessel-based mechanical recovery or in-situ burning operations, and they are the only effective option when slicks have spread very thin (< 0.1 mm) (**Figure 1**).

Additionally, dispersant aircraft can typically travel to spill locations at speeds over 150 knots (170 mph; 275 kph) compared to 7 knots (8 mph; 13 kph) which is the typical speed of a response vessel transiting to a spill location. Arriving at the spill location quicker allows an effective response to start before slicks have spread, moved, or broken apart into smaller surface slicks. Additionally, aircraft are also able to travel between slicks located only a few miles apart in a matter of minutes, while vessel-based response options may require many hours to haul in the equipment, move to a new location, and redeploy the equipment.

Seas with breaking waves greater than 3-5 feet (approximately 1 to 1.5 meter) reduce the efficiency of both mechanical recovery and in-situ burning. This is because both options require containment boom to corral and contain slicks in an effort to thicken slicks for efficient operations. However, booms begin

FIGURE 1. Effectiveness limits of response options due to sea conditions and average oil thickness (Source: Coolbaugh, 2011, Modified with permission from A. Allen/Spiltec)



to lose the ability to contain oil in those conditions and become less efficient as wave heights increase, causing slicks to wash over or under booms. As depicted in **Figure 1**, potential wave-height and average oil thickness have an effect on the operating windows for the three main offshore response options.

Dispersants, however, retain their effectiveness when mixing energy in the form of waves increases, since the greater the mixing energy, the smaller the resulting dispersed oil droplets. This both reduces the potential for resurfacing of droplets (small droplets rise much more slowly) and creates additional surface for microbial degradation—tiny droplets have a greater surface area to volume ratio than larger droplets. In addition to this, larger waves cause greater mixing that helps to reduce the concentration of dispersed oil in the water column even more rapidly.

Containment boom also has limitations when attempting to collect thin oil slicks. As mentioned, oil slicks rapidly spread and become extremely thin within hours of a spill. Low-viscosity oils will eventually become as thin as 0.1 mm on average (Lehr et al., 1984) with sheen being even thinner (NOAA, 2007). Slicks and sheen this thin simply cannot be collected efficiently in boom because only a small volume of oil is encountered and collected within the boom at any time. For example, a boom with a 330 foot (100 m) opening (also known as "swath") width collects a 0.1 mm thick slick at approximately 19 m^3 per hour (120 barrels or about 5,000 gallons/hour) because vessels can only move forward at about 1 knot (1.2 mph; 2 kph) for most types of boom systems to keep the oil contained. There are boom systems that can move faster, but they do not have swath widths approaching 100 m. In contrast, a large dispersant delivery plane operates at 150 knots (170 mph; 275 kph) and has a swath width of 130 feet (40 m) allowing it to treat a 0.1 mm thick slick at a rate of approximately 525 m^3 per hour (about 3,300 bbls or 140,000 gallons/hour) which is a significant improvement of any boom system. More detail is provided in **Fact Sheet #7 – Aerial and Vessel Operations**.

Although dispersants have many operational benefits, dispersant use, as with any response option, is only justifiable when it is clear that it will provide a net environmental benefit; that is, its use does more good than harm (**Fact Sheet #6 – Assessing Dispersant Use Trade-offs**). The decision to use dispersants involves trade-offs between decreasing the risk that oil on the water's surface presents to surface animals and shoreline habitats while increasing the potential risk to organisms in the water column. Time-critical choices must be made regarding which options are best to manage potential impacts.

The goal of this Fact Sheet is to provide a clearer understanding of dispersants and the basis for their consideration in an oil spill response decision-making process.

How Dispersants Work

Dispersants generally contain surface active agents (surfactants) and solvents. Surfactants are the active ingredients in many common household products including soaps, cosmetics, detergents, shampoos, and even food (Fingas et al., 1991; 1995). Dispersants work because surfactant molecules have one end that is attracted to oil while the other end is attracted to water. They align themselves at the oil/water interface and reduce interfacial tension, thereby enhancing the breakup of a slick into tiny oil droplets (**Figure 2**). When mixing energy is applied (e.g., wind, waves, currents), the dispersant-treated oil slick will break up into many tiny droplets that are less than 100 microns in diameter (smaller than the size of a period on this page) (**Figure 3**). This means that effectively dispersed oil droplets are unlikely to ever resurface, and if they do, the next wave will likely re-transfer them into the water. When impacted by waves, untreated slicks on the water surface tend to form larger droplets that rapidly resurface and reform into a slick.

During surface applications, the tiny dispersed oil droplets

FIGURE 2. Dispersants are comprised of two parts. Dispersant molecules attract water on one end, and oil on the other. Dispersants reduce surface tension between oil and water so that oil slicks can break apart.

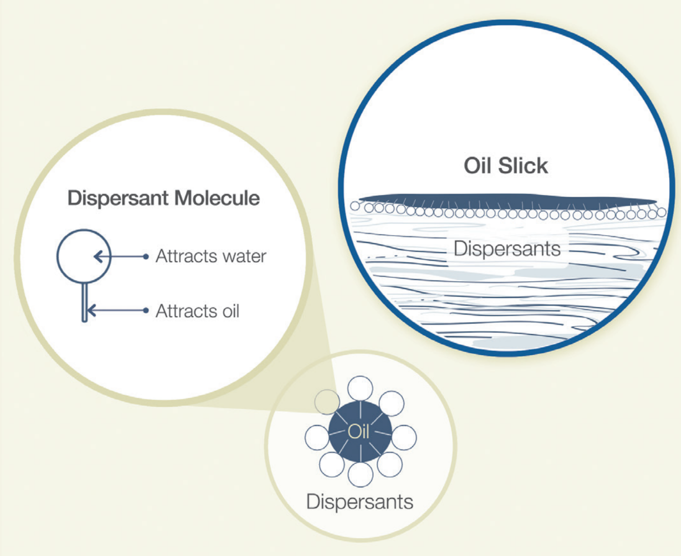
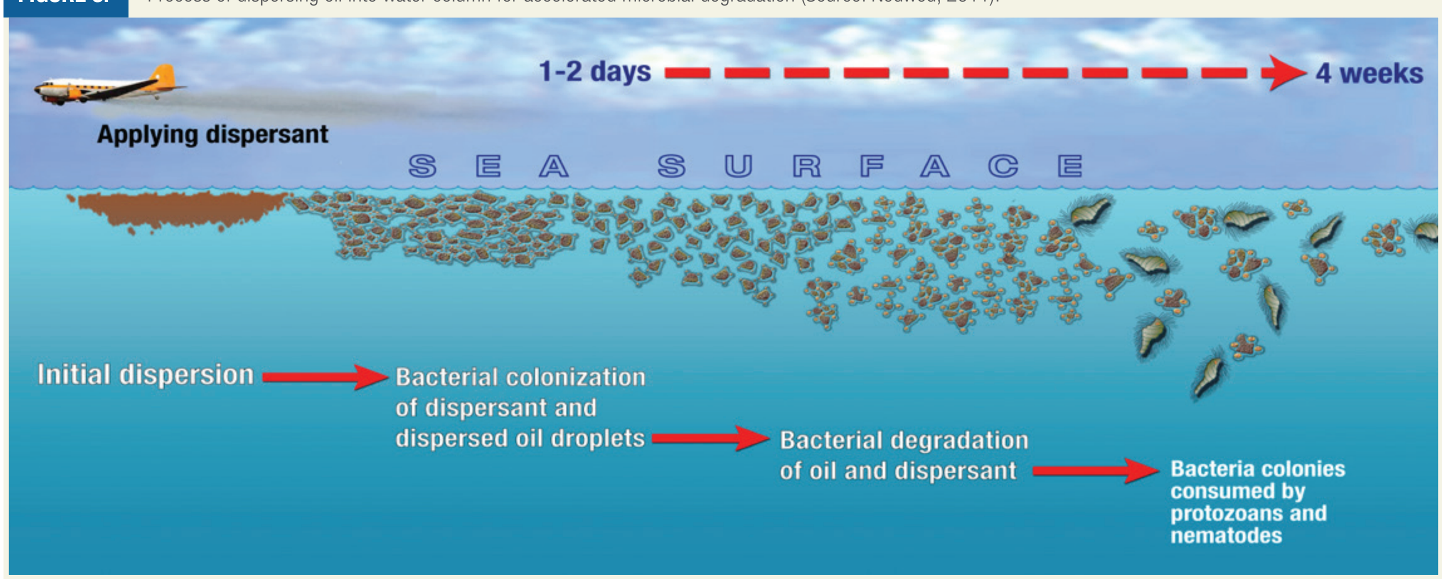


FIGURE 3. Process of dispersing oil into water column for accelerated microbial degradation (Source: Nedwed, 2011).



rapidly spread within the top 30 feet (~10 meters) of the water column and provide an easy target for microbial degradation. Oil-degrading bacteria are present everywhere in the marine environment, from the Arctic to the equator, from the sea surface to the seafloor and at all water depths in between. Thus, as mentioned above, dispersants enhance removal of oil from the environment through microbial degradation.

Dispersants work best on fresh oil that has not weathered significantly (e.g., become thicker) and are generally considered to be most effective on oils that have been on the water for less than 72-96 hours (NRC, 2005). Therefore, decision-makers must decide quickly whether to use dispersants during a spill in order for dispersant use to be the most effective. A batch (everything spilled at once) or a continuous (oil continues spilling over time) spill is also an important consideration because a continuous spill may require continuous dispersant applications.

Oils also vary in viscosity/thickness and composition and dispersants may work differently on different types. In general, the less viscous or lighter the oil is, the more easily it is dispersed. **Fact Sheet #3 – Fate of Oil and Weathering** provides more information on the types of oil and the changes oil undergoes after being spilled into the environment.

Research and experience has shown that dispersants work best on light oils and medium to heavy weight crude oils (**Table 1, Groups II and III**) (Nedwed and Coolbaugh, 2008). Dispersants can effectively disperse light products; however, these materials such as gasoline and diesel tend to rapidly evaporate and biodegrade when spilled, so the use of dispersants is not recommended. Conversely, due to the composition of very heavy oils like bunkers or asphalt-like products (**Table 1, Groups IV and V**), their components limit the dispersion action. However, research has shown that dispersants can be effective on more viscous oils and that dispersants should not be ruled out before being tested in the field with the understanding that thicker or heavier oils may disperse more slowly than light oils.

Initial elevated concentrations of tiny dispersed oil droplets will rapidly dilute and their impact will be very short-lived and localized. Field trials and wave-basin tests show that dispersed oil dilutes to concentrations below 1 ppm within hours after application of dispersants. These concentrations are below most toxicity thresholds for marine organisms that have undergone testing with constant exposures to dispersed crude oil for 48 to 96 hours. This rapid dilution explains why fish kills have never been observed in areas where there is significant water depth (10 meters or greater) after dispersants have been properly used.

The dispersed oil droplets will continue to dilute and are expected to have concentrations less than a few ppb within 2 days (Nedwed, 2011). Research indicates that microbes colonize dispersed oil droplets within 1 – 2 days (MacNaughton et al., 2003) at which point the microbial degradation process becomes rapid. By this time, the dispersed oil concentrations are too dilute to exhaust the available nutrients (primarily nitrogen and phosphorus) or available dissolved oxygen. As a result, aerobic microbial degradation proceeds much more efficiently than it would on a shoreline or in near shore sediments. In general, the components of oils that are of the most concern are typically the smaller, most soluble and volatile compounds that will tend to rapidly evaporate and dissolve. These also tend to be biodegraded first because they are easier for microbes to consume. As the oil droplets are biodegraded, they become less toxic over time.

Dispersants make it more difficult for oil droplets to stick back together or to other objects, like sediment, sand, wildlife, vegetation, rocks, or other hard surfaces in the nearshore environment. Because dispersed oil droplets do not reform

TABLE 1. Oil Type and dispersants effectivness

Group	Common Products	Specific Gravity	API	Natural Dispersion	Chemical Dispersion
I	Gasoline, Ker	< 0.8	> 45	Rapid	Not Recommended[1]
II	Diesel, Heating Oil	0.8—0.85	35—45	Moderate–Rapid	Rapid
III	Alaskan Crude Oil, Gulf of Mexico Crude Oil	0.85—0.95	17.5—35	Moderate–Slow	Rapid
IV	Heavy Fuel Oil, Venezuelan Crude Oil	0.95—1.0	10—17.5	Slow	Moderate
V	Oil Sand, Bitumen, Asphalt	> 1.0	< 10	Little or None	Not Applicable[2]

[1] As Group I oils, such as finished product gasoline evaporate rapidly, the use of dispersants is not recommended
[2] As the specific gravity of Group V products is heavier than fresh water, these oils may sink and the use of dispersants may not be applicable
Source: Nedwed and Coolbaugh, 2008

into slicks (or re-coalesce), it is unlikely that dispersed oil will have the capability to form tarballs. For more information on this topic, refer to **Fact Sheet #3 – Fate of Oil and Weathering.**

When Dispersent Use is Considered

Scientists have been studying the effects of dispersants on the marine environment for over 30 years, and are still actively engaged in dispersant research, development, and innovation. Dispersants are often considered a first response option in a number of countries around the world (ITOPF, 2010). In the US, dispersants are typically considered for offshore oil spills when surface slicks become too large for effective containment by boom, when the spill is located far from stockpiles of mechanical recovery equipment, or when the sea state prevents, or will soon prevent, the use of other response options.

One way to assess response tradeoffs is by the Net Environmental Benefit Analysis approach, also known as NEBA. NEBA is a process used to compare all response options, including natural recovery (no human intervention), with a goal to determine which combination of options can best minimize the spilled oil's overall long-term impact on resources and the environment (**Fact Sheet #6 – Assessing Dispersant Use Trade-offs**).

As already discussed, oil spilled at sea can be very dynamic – rapidly spreading to become extremely thin, moving with winds and currents, and breaking up into smaller slicks that can be separated by large distances. This dynamic nature combined with the potential for rapidly changing weather conditions means that all available response options should be considered to protect organisms, habitats, and human use areas.

In most marine environments, nearshore and shoreline areas are the most biologically rich and potentially most sensitive to oil spills. For this reason, keeping oil off of these areas is necessary to minimize environmental impacts. The use of dispersants is often the best option to help protect these sensitive areas but there are important factors to consider with the use of these materials.

Trade-offs in Decision-making

There is a general perception that the main trade-off associated with dispersant use is the protection of surface, nearshore, and shoreline resources at the expense of water column resources that otherwise would not have been impacted. Water-column organisms are not free of risk from undispersed surface slicks. Surface slicks also release the toxic components of oil into the water column, but potentially over an extended period of time. While evaporation of some oil components will reduce their level to some extent, some of these soluble components may find their way into the water column whether dispersants are used or not.

The application of dispersants serves to rapidly transfer these compounds into the water column. As a result, dilution is rapid, which tends to minimize any negative impact as scientific studies by the EPA and others have shown (BenKinney et al., 2011; Clark et al., 2001; Coelho et al., 2011; EPA online, 2011; Hemmer et al., 2010; Judson et al., 2010).

Another factor to consider regarding dispersant use is the potential negative effect that they may have if they are used in waters less than 30 feet (~10 meters) in depth. At these depths, dispersed oil droplets may not dilute as rapidly and could affect water column and bottom dwelling plant and animal communities. Dispersant use in such areas must take into account the associated trade-offs to water column species in relation to the potential benefits, such as preventing a slick from entering environmentally sensitive or economically important nearshore or shoreline areas.

Sub-lethal impacts from dispersed oil have been reported in recent studies (Whitehead, 2011) and are addressed in greater detail in **Fact Sheet #4 – Toxicity and Dispersants**.

Further, sub-lethal impacts are not limited to dispersed oil in the water column since untreated oil slicks can provide similar aquatic exposure to oil components. Further still, chronic impacts (those from long-term exposure to elevated concentrations) are more likely for untreated slicks that strand on shorelines or mix with the sediment in shallow near shore areas since they provide a potentially longer-term source of crude oil components to the near-shore areas. Appropriately applied dispersants can reduce the amount of stranded oil onshore A Net Environmental Benefit Analysis will often indicate that dispersants will provide the environment the best opportunity to recover.

Potential Human Health Effects

There are concerns about oil spills and the use of dispersants. While environmental risks have been the primary concern in the past, concerns about the potential for human health risks associated with dispersant use have recently increased. Risks to human health and community assets (e.g., beaches, shorelines, etc.) from the oil, dispersed oil, and the dispersant itself must be evaluated and communicated to all interested parties in an effective manner. It should be noted that the components of the most widely used dispersant in the U.S. (Corexit® EC9500A) were specifically chosen because they had previously been approved by the Food and Drug Administration for either human contact or consumption.

Each surfactant has alternative uses in such products as cosmetics, pharmaceuticals, and even food (Fingas et al., 1991; 1995). Further, the components of dispersants have been evaluated for bioaccumulation potential based on their persistence and the results indicate that the potential is low (Garcia et al., 2009; Prince et al., 2003). On-scene health hazard evaluations for all major offshore response activities (including dispersants) performed by the National Institute of Occupational Safety and Health (NIOSH) found that standard personal protective equipment with exposure monitoring (if deemed necessary) was adequate to protect oil spill responders (King and Gibbins, 2010; NIOSH, 2010). Dispersant use actually reduces public contact with oil by addressing it offshore and preventing oil from coming ashore. It also reduces the potential exposure of cleanup workers who could otherwise be exposed to oil and oil fumes while recovering it at sea or on the shoreline. For more information on this topic, refer to **Fact Sheet #2 — Human Health and Safety**.

References

BenKinney, M., J. Brown, S. Mudge, M. Russell, A. Nevin, and C. Huber. 2011. **Monitoring Effects of Aerial Dispersant Application during the MC252 Deepwater Horizon Incident**. In: *Proceedings of the 2011 International Oil Spill Conference*, 7 pp., Paper #2011-368. 23-26 May, 2011, Portland, Oregon. Available online at http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-2011-1-368.

Boyd, J.N., J.H. Kucklick, D. Scholz, A.H. Walker, R. Pond, and A. Bostrom. 2001. **Effects of Oil and Chemically Dispersed Oil in the Environment**. Prepared by Scientific and Environmental Associates, Inc., Cape Charles, VA. Prepared for the American Petroleum Institute, Washington, DC. 49 p.

Clark, J.R., G.E. Bragin, E.J. Febbo, and D. J. Letinski. 2001. **Toxicity of Physically and Chemically Dispersed Oils Under Continuous and Environmentally Realistic Exposure Conditions: Applicability to Dispersant Use Decisions in Spill Response Planning**. In: *Proceedings of the 2001 International Oil Spill Conference*, pp.1249 - 1255, 26-29 March, 2001, Tampa, FL. Available on line at http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-2001-2-1249.

Coelho, G, D. Aurand, A. Slaughter, L. Robinson, and B. Carrier Jones. 2011. **Rapid Toxicity Evaluations of Several Dispersants: A Comparison of Results**. In: *Proceedings of the 2011 International Oil Spill Conference*, 7 pp., Paper #2011-416. 23-26 May, 2011, Portland, Oregon. Available online at http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-2011-1-416.

Coolbaugh, T. 2011. **Presentation: Oil Spill Dispersants**. Presented at the 2011 Clean Gulf Conference Dispersant Workshop. October 2011, San Antonio, Texas.

Curd, H. 2011. **The Use of Dispersant for the Control of Volatile Organic Compounds.** In: *Proceedings of the 2011 International Oil Spill Conference*, 7 pp., Paper #2011-359. 23-26 May, 2011, Portland, Oregon. Available online at http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-2011-1-359.

"EPA Response to BP Spill in the Gulf of Mexico: Questions and Answers on Dispersants." Last modified on January 10, 2011. http://www.epa.gov/bpspill/dispersants-qanda.html.

Fingas, M. F., R. G. Stoodley, N. Stone, R. Hollins, and I. Bier. 1991. **Testing the Effectiveness of Spill-Treating Agents: Laboratory Test Development and Initial Results**. In: *Proceedings of the 1991 International Oil Spill Conference*. API. Washington, DC.

Fingas, M. F., D. A. Kyle, N. D. Laroche, B. G. Fieldhouse, G. Sergy, and R. G. Stoodley. 1995. "The Effectiveness of Spill Treating Agents." **The Use of Chemicals in Oil Spill Response**, ASTM STP1252, P. Lane, Ed. ASTM, Philadelphia, Pennsylvania.

Garcia, M.T., E. Campos, A. Marsal, and I. Ribosa. 2009. **Biodegradability and toxicity of sulphonate-based surfactants in aerobic and anaerobic aquatic environments**. *Water Res.* 43: 295-302. Available online at: http://www.sciencedirect.com/science/article/pii/S0043135408004697.

Hemmer, M.J., M.G. Barron and R.M. Green. 2010. **Comparative toxicity of Louisiana Sweet Crude Oil (LSC) and chemically dispersed LSC to two Gulf of Mexico aquatic tests**. U.S. Environmental Protection Agency, Office of Research and Development. Revised report dated August 31, 2010.13 p.

International Tanker Owner Pollution Federation (ITOPF). 2010. **ITOPF Handbook**. Available at http://www.itopf.com/information-services/publications/documents/ITOPFHandbook2012.pdf.

Judson, R.S., M.T. Martin, D.M. Reif, K.A. Houck, T.B. Knudsen, D.M. Rotroff, M. Xia, S. Sakamuru, R. Huang, P. Shinn, C.P. Austin, R.J. Kavlock, and D.J. Dix. 2010. **Analysis of Eight Oil Spill Dispersants Using Rapid, In Vitro Tests for Endocrine and Other Biological Activity**. *Environ Sci Technol*. 2010 August 1: 44(15): 5979-5985.

King, B.S. and J.D. Gibbins. 2011. **Health Hazard Evaluation of Deepwater Horizon Response Workers: Health Hazard Evaluation Report**. HETA 2010-0115 & 2010-0129-3138. August 2011. 24 pp.

Lehr, W. J., Cekirge, H. M., Fraga, R. J., and Belen, M. S. 1984. **Empirical Studies of the Spreading of Oil Spills**. *Oil & Petrochemical Pollution*, Graham & Trotman, Ltd. Vol. 2 No. 1.

Louisiana Universities Marine Consortium (LUMCON). 2006. ***Dispersants: An Electronic Bibliography on Effectiveness, Technological Advances, and Toxicological Effects***. 393 pp. http://www.lumcon.edu/library/dispersants.

MacNaughton, S.J., R. Swannell, F., Daniel, and L. Bristow. 2003. **Biodegradation of dispersed forties crude and Alaskan North Slope oils in microcosms under simulated marine conditions**. *Spill Science & Technology Bulletin*, 8, 179.

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (National Commission). 2011 update. **The use of Surface and Subsea Dispersants during the BP Deepwater Horizon Oil Spill: Staff Working Paper No. 4**. Originally released 6 October, 2010 and updated 11 January, 2011. 21 pp.

National Institute for Occupational Safety and Health (NIOSH). 2010. **Interim Report 1: Health Hazard Evaluation of Deepwater Horizon Response Workers**. Letter from A. Tepper to F. Tremmel. Date June 23, 2010. HETA 2010-0115. 21 pp. Available online at http://www.cdc.gov/niosh/topics/oilspillresponse/gulfspillhhe.html.

National Research Council (NRC). 2005. **Understanding Oil Spill Dispersants: Efficacy and Effects**. National Academy Press, Washington, DC. 248 pp.

Nedwed, T. 2011. **Presentation: Recent Dispersant Developments**. Presented at the 2011 Clean Gulf Conference Dispersant Workshop. October 2011, San Antonio, Texas.

Nedwed, T. and T. Coolbaugh. 2008. **Do Basins and Beakers Negatively Bias Dispersant-effectiveness Tests?** In: *Proceedings of the 2008 International Oil Spill Conference*, Savannah, Georgia, page 835 – 841.

NOAA Oil Budget. 2010. **A Lot of Oil on the Loose, Not So Much to Be Found**. *Science*, Vol. 329, pg. 734, August 13, 2010.

Operational Science Advisory Team (OSAT). 2011. **Summary Report for Sub-sea and Sub-surface oil and dispersant detection: Sampling and Monitoring**. Unified Area Command. December 17, 2010.

Office of Technology Assessment (OTA), U.S. Congress. 1990. **Coping with an Oiled Sea: An Analysis of Oil Spill Response Technologies**. OTA-BP-O-63. 70 pp.

Prince, R., R.R. Lessard, and J.R. Clark. 2003. **Bioremediation of Oil Spills**. *Oil & Gas Science and Technology*. Vol. 58, No. 4: 463-468.

Scholz, D.K, J.H. Kucklick, R. Pond, A.H. Walker, D. Aurand, A. Bostrom, and P. Fischbeck. 1999. **A Decision-maker's Guide to Dispersants: A Review of the Theory and Operational Requirements**. Prepared by Scientific and Environmental Associates, Inc., Cape Charles, VA. Prepared for the American Petroleum Institute, Washington, DC. API Publication No. 4692, 38 p.

Whitehead, A., B. Dubansky, C. Bodine, T.I. Garcia, S. Miles, C. Pilley, V. Raghunathan, J.L. Roach, N. Walker, R.B. Walter, C.D. Rice, and F. Galvez. 2011. **Genomic and physiological footprint of the Deepwater Horizon oil spill on resident marsh fish**. Proceedings of the National Academy of Sciences. PNAS Early Edition. http://www.pnas.org/cgi/doi/10.1073/pnas.1109545108. 5 p.

DISPERSANTS —
HUMAN HEALTH AND SAFETY

SpillPrevention.org

Things You Should Know

Toxicity is the potential of a chemical to cause adverse effects. Most substances are toxic at a high-enough dose.

Dispersants are less toxic than most crude oils and adding dispersant in low levels at the appropriate application rates does not increase the toxicity of the oil.

Most dispersants are biodegradable and contain ingredients which are similar to those found in many common household soaps, cosmetics, detergents, and shampoos and even food.

Personal protective equipment (PPE) is required when handling chemicals and basic PPE is required to protect responders while transferring and handling dispersants.

The general public will not come in direct contact with dispersants when dispersants are properly applied.

Concerns that human health might be affected from consuming dispersant tainted seafood are unfounded; the ingredients in most dispersants are not persistent because they biodegrade, therefore they don't move up the food chain for shrimp, fish, etc.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these very small oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume. For more information on Dispersants and microbial degradation refer to **Fact Sheet #1 — Introduction to Dispersants**.

All materials have some ability to cause toxic or adverse effects in living organisms that may be exposed; these effects are responses exhibited outside the normal range for healthy organisms. In fact, most substances are toxic at a high enough dose — even food and water. However, the ability of a material to cause adverse effects (its toxicity) is directly related to the concentration of the material and length of exposure (Rand, 1995; Capuzzo, 1987; Gilfillan et al., 1983). During an oil spill response, the challenge is to characterize the risk from the oil, chemically dispersed oil, and to a lesser extent, the dispersants themselves, to potential receptors (humans, wildlife, environment, etc.). Although dispersants increase the amount of dispersed oil in the water column, the trade-off is that they enhance the removal of oil from the water surface, increase the rate of microbial degradation, and reduce overall toxicity through rapid dilution within the water column. For more information on toxicity and the impacts to species in the water column, refer to **Fact Sheet #4 — Toxicity and Dispersants**.

This Fact Sheet summmarizes the potential human health and safety considerations for dispersant use for the public and response workers. This includes the likely routes of exposure and the relative exposure risks to the oil, and dispersed oil, and dispersant that may result when applying dispersants to spilled oil on the water surface and at depth.

Fact Sheet Series

Introduction

Dispersants are applied offshore (either to the surface of the water or injected at depth) and therefore the chances of the public being impacted by the dispersant or the dispersed oil are remote. The potential adverse effects to spill responders would need to be evaluated for the spilled oil itself, the dispersant itself, and from dispersed oil droplets that are mixed into the water column. The likely adverse effects of exposure to the oil, dispersants, and dispersed oil to humans are a function of both the **duration of exposure** and the **concentration** of the material during that exposure.

Exposure Routes

One of the greatest concerns during an oil spill response is ensuring the health and safety of the response workers and the public from the effects of the spilled oil, the response options, and cleanup efforts. An initial risk evaluation is conducted to clearly define how response workers and the public can be exposed during an oil spill response. Key government public health organizations, such as the Occupational Safety and Health Administration (OSHA, part of the U.S. Department of Labor), and the National Institute of Occupational Safety and Health (NIOSH, part of the Centers for Disease Control and Prevention (CDC)/U.S. Department of Health and Human Services) have defined the primary potential pathways for human exposure to spilled oil, dispersant and dispersed oil:

- **Inhalation** — with emphasis on volatile organic compounds (VOCs), especially, the toxic aromatic hydrocarbons, BTEX (Benzene, Toluene, Ethylbenzene and Xylene). Inhalation is the primary route of exposure to VOCs.
- **Dermal Contact** — also considered a significant route of exposure for Humans.
- **Ingestion** — with emphasis on polycyclic aromatic hydrocarbons (PAHs) contained in crude oil which are taken up by seafood and have the potential to be consumed by people.

Exposure Risks

The following are summaries of the exposure risks from spilled oil, dispersants, and the dispersed oil relative to human effects. Keep in mind that the requirements for dispersant use makes it unlikely that the public will come in contact with oil or dispersed oil by requiring applications be offshore so that the treated oil has mixed into the water column, preventing it from coming ashore. Dispersants also reduce exposures of cleanup workers to the oil and oil fumes while recovering it at sea or on the shoreline.

Spilled Oil

Crude oils are mixtures of thousands of different “chemicals” that may display different potential for adverse effects depending on the composition. For example, light, low viscosity oils have a higher level of the more toxic components of the oil (VOCs) that evaporate more readily and may be more likely to be inhaled. Heavier oils, on the other hand, generally contain less of these more toxic compounds and their relative toxicity is due mostly to direct dermal contact rather than inhalation.

For most people, brief contact with a small amount of petroleum will do no harm; however, if an individual is exposed for a long period of time, permanent health impacts may result (ATSDR, 1999). Additionally, some individuals are more sensitive to chemicals, including those found in crude oils, and these individuals may have a more severe reaction from exposure than the general population (Magill and Suruda, 1998). According to the CDC (2010a), individuals may experience the following after short-term exposure to petroleum oils (oil type dependent):

- **Inhalation:** Irritation to eyes, nose, throat, breathing difficulties, increased dizziness, disorientation, or headache.
- **Dermal Contact:** Skin reddening, swelling, rash, and burning which may get worse if the skin is also exposed to the sun. May make one more likely to develop a skin infection.
- **Ingestion:** Upset stomach, vomiting, and diarrhea, but is unlikely to have long-lasting health effects. Consumption of seafood contaminated by oil may be a secondary exposure route; however, contamination via seafood is unlikely due to government controls on consumption of potentially contaminated seafood and the natural ability of seafood to remove hydrocarbons from their system.

As recent evidence shows, seafood tainting from an offshore oil spill is unlikely (FDA online, 2011; Wright, 2010; BP, 2012).

Long-term exposure studies to document the effects to responder personnel and the public are ongoing. As in all cases of possible exposure to chemicals, it is prudent for individuals to limit their direct exposure to oil and to adhere to health and safety requirements, including using appropriate personal protective equipment (PPE).

Dispersants

Modern dispersants are formulated to be safer for use in the environment than early formulations. Dispersants are less toxic than crude oil and adding dispersant at the appropriate application ratios does not increase the toxicity of the oil (EPA online, 2011). Most dispersants are also biodegradable and contain ingredients which are similar to those found in many common household soaps, cosmetics, detergents, and shampoos and even food (Fabisiak and Goldstein, 2012).

The most widely used dispersant in the United States (Corexit® 9500) was found to be significantly less toxic than common dish soaps to freshwater trout (Environment Canada, 2013). Although dispersants are formulated to be low in toxicity, response workers should use proper PPE and follow sound operational procedures, as in all cases when chemicals are handled (Department of Health and Human Services (DHHS) et al., 2010; NIOSH, 2010a). In addition, the general public is not likely to ever be exposed to dispersants, since dispersant application operations are generally required to be carried out in waters more than three miles from shore and only when people are out of the spray zone. This is especially true since vessel-based and airborne delivery of dispersants is carried out in a well-defined manner with the goal of delivering them accurately to targeted slicks offshore. For more information on application requirements and protocols, refer to **Fact Sheet #5 — Dispersant Use Approvals in the United States** and **Fact Sheet #7 — Aerial and Vessel Dispersant Operations**.

Five things that were considered by the CDC to control a person's health risk from contact with dispersants are (CDC online, 2010b):

- The number of times they are in direct contact
- How long they are in contact
- The volume with which they come in contact
- How much dispersants have been diluted with water
- The primary way they came in contact (eyes or skin contact, inhalation or ingestion)

As with any chemical compound it is a good practice to minimize exposure. Upon consideration of this:

- The most likely exposure will be to any staff handling and transporting the material, although the risk is mitigated with proper PPE.
- Most people in coastal areas will not come in direct contact with oil spill dispersants.
- Brief contact with a small amount of dispersants should not harm a person.
- Long term, repeated exposure to dispersants is unlikely.

As with exposure to oil, potential health threats from dispersant exposure are similar and include (OSHA online, 2010):

- Eye irritation.
- Dermatitis or irritation after prolonged or repeated contact
- Respiratory irritation as a result of repeated or prolonged inhalation exposure.

Ingestion is considered an unlikely route of exposure.

Dispersed Oil

In 2010, EPA tested eight of the 14 dispersants listed on the US Environmental Protection Agency's (EPA) National Contingency Plan (NCP) Product Schedule, including the ones used during the 2010 Deepwater Horizon incident in the Gulf of Mexico. Their tests found that a mixture of dispersants and oil were no more toxic than the oil alone (EPA ORD, 2010).

In general, the public is unlikely to be exposed to dispersed oil since the dispersed oil will be mixed into the water column and be diluted far from shore and away from the public. In the unlikely event that it was to occur, short-term exposures to dispersed oils would be expected to have effects similar to those of being exposed to the oil itself.

Long-term studies to document potential short term exposure effects of dispersed oil to responder personnel and the public are ongoing.

Human Safety Considerations

When addressing the safety of the public and of response workers, one must consider the most likely sources of oil and dispersant contact.

Public Safety

For the public, there are no likely sources of exposure to dispersants or dispersed oil.

As previously mentioned, because dispersant operations are typically carried out more than three miles from shore, contact with dispersant spray itself or significant inhalation of fumes by those on shore is unlikely. The safety of the public is maximized if people avoid contact with oiled areas and avoid handling items that have oil or oil-like sprays on them. Since dispersants serve to remove oil slicks from the water surface, their use will keep oil away from shorelines, therefore limiting the possibility of public exposure.

Seafood Safety and Consumption

An extensive federal and state response was initiated immediately following the Deepwater Horizon incident to monitor for the potential for contamination by crude oil and response methods that would compromise the safety of the Gulf seafood resources. Public concerns about the consumption of seafood tainted from the oil, dispersants, and dispersed oil were addressed by the FDA, NOAA, and state agencies. Through an extensive national effort to evaluate seafood safety protocols and by using multiple methodologies, these evaluations began in early May 2010 (Gohlke et al., 2011). The results have shown that oil and dispersed oil levels are well below Levels of Concern (LOC)[1] for human health risk (Ylitalo et al., 2011; FDA online, 2011).

Response Worker Safety

NIOSH recommends that worker exposures to petroleum distillates, a solvent component present in dispersants, be reduced to prevent harmful respiratory and dermal health effects (NIOSH, 2010b). Since response workers may be in close proximity to oil, dispersants, and dispersant application operations, their protection involves the use of PPE and proper operating procedures. This may include the use of coveralls, boots, gloves, respirators, etc. The decision of what PPE should be used for each response task is based on OSHA guidelines and directives. Other safety-related operational procedure oversight includes such things as how long personnel may work in areas close to oil covered waters and dispersant operations. Due to strict application requirements, most response workers are unlikely to experience any exposure to the dispersed oil.

References

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. **Toxicological Profile for Total Petroleum Hydrocarbons**. Available on line from http://www.atsdr.cdc.gov/.

Capuzzo, J.M. 1987. **Chapter 8: Biological Effects of Petroleum Hydrocarbons: Assessments from Experimental Results**. In: Boesch and Rabalais (eds.). Long-term Environmental Effects of Offshore Oil and Gas Development. Elsevier Applied Science, New York, NY. pp. 343-410.

Centers for Disease Control and Prevention (CDC). 2010a. **Table of Chemical Constituents Commonly found in Crude Oil**. Available online from: http://www.bt.cdc.gov/gulfoilspill2010/pdf/chemical_constituents_table.pdf.

Centers for Disease Control and Prevention (CDC) online. 2010b. **2010 Gulf Oil Spill website – Dispersant Quick Facts for Coastal Residents**. Two page Fact Sheet. Available online from: http://emergency.cdc.gov/gulfoilspill2010/.

Department of Health and Human Services (DHHS), National Institute of Environmental Health Sciences (NIEHS), and Occupational Safety and Health Administration (OSHA). 2010. **NIEHS Oil Spill Cleanup Training Tool: Oil Spill Cleanup Initiative – Safety and Health Awareness for Oil Spill Cleanup Workers**. OSHA 3388-052010. Worker Education & Training Program. June 2010, v7. 116 slides.

Environment Canada online. 2013. Spilltox database. Available online at http://www.etc-cte.ec.gc.ca/databases/SpillTox/Default.aspx.

EPA. 2011. Freedom of Information Act (FOIA) request to EPA on the release by EPA of an aggregate list of 57 ingredients found in the chemical dispersants listed on the NCP Product Schedule as of April 2010.

EPA ORD. 2010. **Toxicity of Louisiana Sweet Crude Oil (LSC) and Chemically Dispersed LSC to Two Gulf of Mexico Aquatic Test Species** – August 2010 and the updated report of September, 2010; as posted on the EPA website: http://www.epa.gov/bpspill/dispersants-testing.html.

Fabisiak, J.P. and B. Goldstein. 2012. **Appendix 1f: Oil Dispersants & Human Health Effects**. Unabridged White Paper published in *The Future of Dispersant Use in Oil Spill Response Initiative* (CRRC, RPI, and NOAA eds.), March 22, 2012. 23 p. Available online from: http://www.crrc.unh.edu/.

US Food and Drug Administration (FDA) online. 2011. **Gulf of Mexico Oil Spill Update FDA's Role in Seafood Safety** webpage. Available online from: http://www.fda.gov/Food/RecallsOutbreaksEmergencies/Emergencies/ucm210970.htm.

Gilfillan, E.S., D.S. Page, S.A. Hanson, J.C. Foster, J.R. Hotham, D. Vallas, and R.P. Gerber. 1983. **Effect of Spills of Dispersed and Non-dispersed Oil on Intertidal Infaunal Community Structure**. In: Proc. 1983 International Oil Spill Conference, San Antonio, TX. American Petroleum Institute, Washington, DC. API Publ. No. 4356. pp. 457-463.

Gohlke, J.M., D. Doke, M. Tipre, M. Leader, and T. Fitzgerald. 2011. **A Review of Seafood Safety after the Deepwater Horizon blowout**. *Environmental Health Perspectives*. Volume 119(8):1062-1069.

Magill, M.K. and A. Suruda. 1998. **Multiple Chemical Sensitivity Syndrome**. *Am Fam Physician*, 1998 Sept. 1; 58(3):721-728.

[1] The Level of Concern (LOC) is the calculated concentration of chemical that, if found in seafood samples, would be con¬sidered unsafe for human consumption.

National Institute for Occupational Safety and Health (NIOSH). 2010a. **Interim Guidance for Protecting Deepwater Horizon Response Workers and Volunteers**. CDC Workplace Safety & Health Topics – Deepwater Horizon Response webpage online. Last updated 07/26/2010. Available online from: http://www.cdc.gov/niosh/topics/oilspillresponse/protecting/#effects.

National Institute for Occupational Safety and Health (NIOSH). 2010b. **NIOSH Health Hazard Evaluations Summary Report**. Available online from: http://www.cdc.gov/niosh/hhe.

Occupational Safety and Health Administration (OSHA) online. 2010. **Human Health Hazards as summarized from the Materials Safety Data Sheets (MSDSs) for Dispersants Corexit 9500A and 9527A**. Available online from: http://www.osha.gov/oilspills/msds.html.

Rand, G.M. (Ed.). 1995. **Fundamentals of Aquatic Toxicology: Effects, Environmental Fate, and Risk Assessment**. Second Edition. Taylor & Francis Publishers, Washington, DC. 1124 pgs.

Wright, J. 2010. FDA: "**Gulf Seafood Free of Dispersants.**" Reported online on 01 November, 2010, Seafood News Food Safety & Health Webpage. Available online from: http://www.seafoodsource.com.

Ylitalo, G.M., M.M. Krahn, W.W. Dickhoff, J.E. Stein, C.C. Walker, C.L. Lassiter, E.S. Garrett, L.L. Desfosse, K.M. Mitchell, B.T. Noble, S. Wilson, N.B. Beck, R.A. Benner, P.N. Koufopolos, and R. W. Dickey. 2012. **Federal Seafood Safety Response to the Deepwater Horizon Oil Spill**. *PNAS Early Edition*. Available online from: http://www.pnas.org/lookup/suppl/doi:10.1073/pnas.1108886109.

FATE OF **OIL AND WEATHERING**

Things You **Should Know**

After oil is spilled in the environment, it immediately begins to undergo a wide variety of physical, chemical, and biological processes that begin to transform the oil.

Oil weathering can have a significant impact on the properties of a slick and affect dispersant performance.

Oil in the water column will appear anywhere from milky-white to red-brown to orange after being treated with dispersant.

If some dispersant lands near a slick in open water, it rapidly dilutes below acute toxic thresholds and begins to biodegrade.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these very small oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume (See **Fact Sheet #1 — Introduction to Dispersants**).

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools — mechanical recovery and burning in place (also known as in-situ burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas et al., 1991; 1995).

This fact sheet summarizes the primary weathering processes that affect and change the oil as it remains in the environment. A good working knowledge of the likely behavior of the oil as it weathers is required to accurately predict and address the changing spill response needs over time. Monitoring weathered oil properties during a spill response is key to ensure that dispersants are used most effectively, especially as their usefulness may decrease after the first few days following a spill.

Fact Sheet Series

Introduction

What Happens to Sprayed Dispersants?

When dispersants are applied to a slick they mix with the oil, where they will remain and biodegrade along with the resulting dispersed oil droplets. During aerial application, aircraft typically fly at an altitude of approximately 75 feet (25 meters) above the sea surface. At this altitude the sprayed dispersant droplet sizes ensure that most will encounter the targeted oil slick. In the case where some of the dispersant may miss the slick and land in open water, the dispersant ingredients rapidly dilute and are biodegraded by microscopic organisms already present in the water column (Davies et al., 2001). This colonization process begins as soon as the dispersant enters the marine environment, but it may take a few days for rapid biodegradation to commence. Using vessels for dispersant application can result in even more effective slick targeting, but vessel application is unable to match the size of the treated area made possible by the use of aircraft (See **Fact Sheet #1 — Introduction to Dispersants** for more information).

Oil and Dispersant Appearance

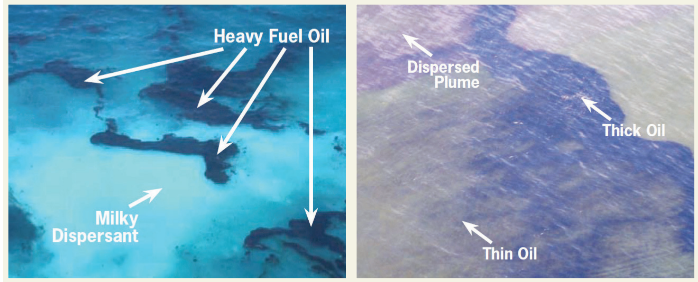
Before dispersants are applied, an oil slick may display different colors depending on oil type, thickness, weather conditions, and other factors. It may display a rainbow-like appearance, have a metallic look, or appear as a dark brown or black slick on the water surface depending on its thickness (**Table 1**) (NOAA, 2007a).

TABLE 1. Oil color, appearance and approximate thickness. Developed from NOAA, 2007a.

Description of Appearance	Approx. Thickness (μm)
Sheen	0.04 to 0.30
Rainbow	0.30 to 5.0
Metallic	5.0 to 50.0
Discontinuous true oil color (heavy oil)	50 to 200
Continuous true oil color (heavy oil)	>200

When dispersants are initially sprayed, they may exhibit a white, milky color. If they miss the oil during application or do not mix with the oil, they may form a milky cloud beneath the surface (**Figure 1 [*Left*]**). When applied appropriately to surface oil, the dispersed oil will generally form a cloud that is typically brown to a milky brown color. It is often described as having the appearance of café au lait (**Figure 1 [*Right*]**).

FIGURE 1. *Left:* example of initial dispersant application with the milky-white color that indicates that the dispersant did not mix with the oil; *Right:* example of an effective dispersant application with a café au lait dispersion. From: NOAA, 2007b.



Different Oil Types and Dispersants

Petroleum oils come in many different compositions and the type of oil being treated can influence the effectiveness of the dispersant.

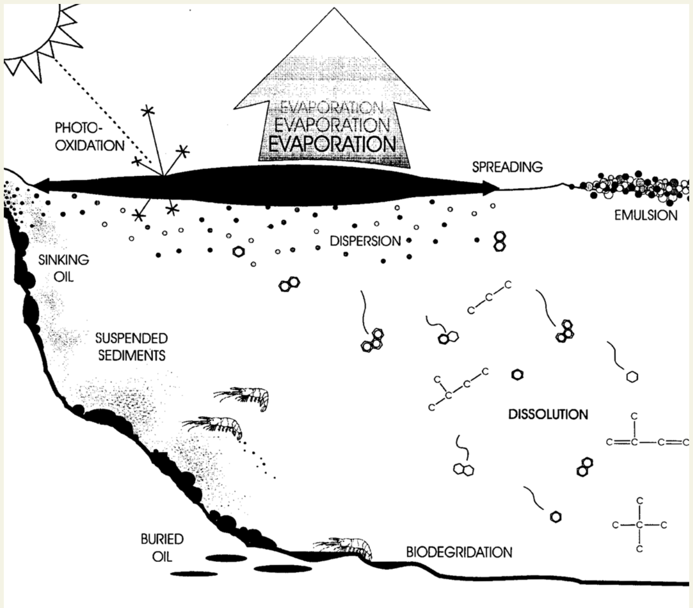
Oils are not made up of just one type of molecule, but are made up of a wide range of components. This results in a variety oil classes — from light refined products like gasoline to heavier materials that are more like asphalt (Etkin, 2003). The very light oils tend to evaporate on their own, leaving little residue, while the very heavy oils do not evaporate nearly as much and may be less likely to disperse completely. For those products in between very light and very heavy oils, the use of dispersants may be the best response option.

Oil Weathering and Dispersants

The "weathering" process refers to the changes that occur to oil as it spends time in the environment. After oil is released, it undergoes a wide variety of physical, chemical, and biological processes that begin to transform the oil almost immediately. This process is affected by the spill location, surrounding air and water temperatures, wave activity, wind, and other factors, such as the presence of particulates or sediment in the water. Each weathering process has the potential to influence the effectiveness of a dispersant application (ITOPF online, 2012). **Figure 2** summarizes the major weathering processes and a brief summary of the five dominant processes and how they affect dispersant applications is provided below.

Spreading: The movement of oil on the water's surface. For example, if a small amount of oil is poured into a pool of water, a circle of oil, that gets thinner and thinner, will grow over time due to spreading. When oil spreads it creates a larger surface area presented to both the air and the water underneath. This serves to increase the effectiveness when dispersants are

FIGURE 2. Summary of the major oil weathering processes for oil spilled into the environment (API, 1999).



applied, since the thinner, larger area is more rapidly diluted into the water. However, because this process enlarges the surface slick, more area needs to be covered during dispersant operations and more equipment may be needed for an effective response.

Evaporation: The preferential loss of the lighter weight, volatile organic components of the oil into the atmosphere. This process may increase the density and viscosity of the oil, and in some cases, make it more difficult to disperse.

Emulsification: The incorporation of water in the oil, ultimately leading to thickening and an increase in the total volume remaining. At the same time, emulsification can reduce the other natural weathering processes. Different emulsions react differently with dispersants and some recent experiments have shown that it is possible to disperse a wide range of emulsified oil (SINTEF, 2010-2011).

Natural Dispersion: Occurs when wave action causes a surface slick to break into oil drops which mix and spread within the water column. These naturally dispersed droplets are larger than those observed when dispersants are used and they may float back to the surface where they recombine to form another slick. Some natural dispersion occurs with all oils, especially light oils. In rough seas, light oils may even be completely dispersed by this process.

When a dispersant is applied to surface oil, it facilitates the formation of much smaller droplets that do not rise back to the surface very quickly. Instead, they have the time to dilute in the water column rather than recombining to form a new slick.

Sedimentation: The association of oil with heavier solids suspended in the water column, generally close to shore. Over time, these suspended solids may settle on the sea floor to form sediments. If dispersants are applied before sedimentation has the potential to occur, they can serve to prevent this process by dispersing the oil offshore, thereby preventing it from coming into shallow shoreline areas, where it may encounter abundant sediment. The dispersed oil droplets remain buoyant and do not sink.

Biodegradation: The process where naturally occurring bacteria and fungi consume hydrocarbons to use as an energy source. These bacteria are common and are present in waters around the world (Arctic/Antarctic to the equator). The process of dispersing the oil into the water column to enhance natural biodegradation is the ultimate goal of dispersant use. Research has shown that the petroleum-degrading microbes in the water column more rapidly colonize dispersed oil droplets than oil droplets without dispersant (Venosa and Holder, 2007; Davies et al., 2001; Varadaraj et al., 1995).

Why It Matters

When an oil spill occurs, the decision-makers involved with response efforts conduct a rapid Net Environmental Benefit Analysis (NEBA) when considering the various options available to them. A prompt decision-making process is important since oil changes properties as it weathers and the efficiency of dispersants may decrease with time. This leads to a distinct window of opportunity and prompt decision-making is key. The NEBA approach analyzes the potential trade-offs of the various response options to determine ways to minimize any impact to resources or the environment. The decision to use dispersants involves evaluating the risk from oil on the water's surface to that of its presence in the water column. The goal is to choose the approach that offers the best outcome, taking all the environmental factors into consideration. For more information on the NEBA process refer to **Fact Sheet #6 — Assessing Dispersant Use Trade-offs**.

References

Davies, L, F. Daniel, R. Swannel, and J. Braddock. 2001. **Biodegradability of Chemically-dispersed oil**. Developed for MMS, ADEC, and the USCG. 33 pp. + appendices. Available on line from: http://www.bsee.gov/Research-and-Training/Technology-Assessment-and-Research/Project-338.aspx.

EPA ORD. 2010. ***Toxicity of Louisiana Sweet Crude Oil (LSC) and Chemically Dispersed LSC to Two Gulf of Mexico Aquatic Test Species***; as posted on the EPA website: http://www.epa.gov/bpspill/dispersants-testing.html. NOAA. 2007. **Dispersant Application Observer Job Aid**. Available online from: http://response.restoration.noaa.gov/dispersants_jobaid.

Etkin, D.S. 2003. **Determination of Persistence In Petroleum-based Oils**. Prepared for the USEPA Oil Program. 24 pp. + appendices. Available online from: http://www.environmental-research.com/erc_reports/ERC_report_17.pdf.

Fingas, M. F., R. G. Stoodley, N. Stone, R. Hollins, and I. Bier. 1991. **Testing the Effectiveness of Spill-Treating Agents: Laboratory Test Development and Initial Results**. In: *Proc. 1991 International Oil Spill Conference*. API. Washington, DC.

Fingas, M. F., D. A. Kyle, N. D. Laroche, B. G. Fieldhouse, G. Sergy, and R. G. Stoodley. 1995. "The Effectiveness of Spill Treating Agents." **The Use of Chemicals in Oil Spill Response**, ASTM STP1252, P. Lane, ed. ASTM, Philadelphia, Pennsylvania.

International Tanker Owner's Pollution Federation Limited (ITOPF) web page – Weathering Process: http://www.itopf.com/marine-spills/fate/weathering-process/.

Leirvik,F., A. Kjersti, and P.S. Daling, 2010. **Laboratory Study of the Dispersibility of DWH Surface Emulsions.** Report: SINTEF A16134. Trondheim, Norway. 17 pgs.

Nedwed, T. 2011. Presentation at the 2011 Clean Gulf Conference. **Recent Dispersant Developments.**

National Oceanic and Atmospheric Administration (NOAA). 2007a. **Open Water Oil Identification Job Aid for Aerial Observation. New Standardized Oil Slick Appearance and Structure Nomenclature and Code**. Updated November 2007. NOAA Office of Response and Restoration, Emergency Response Division, Seattle, WA. 50 pages. Available from: http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/open-water-oil-identification-job-aid.html.

National Oceanic and Atmospheric Administration (NOAA). 2007b. **Dispersant Application Observer Job Aid**. NOAA Office of Response and Restoration, Emergency Response Division, Seattle, WA. 34 pages. Available from: http://response.restoration.noaa.gov/oil-and-chemical-spills/oil-spills/resources/dispersant-application-observer-job-aid.html.

Venosa, A. and E.L. Holder. 2007. **Biodegradability of Dispersed Crude Oil at Two Different Temperatures**. Marine Pollution Bulletin, Vol. 54:5, pp. 545-553.

Varadaraj et al., 1995. **Dispersion and Biodegradation of Oil Spills on Water**. In: *Proc. 1995 International Oil Spill Conference*. Available online from: http://www.ioscproceedings.org/doi/pdf/10.7901/2169-3358-1995-1-101.

SpillPrevention.org

TOXICITY AND **DISPERSANTS**

Things You **Should Know**

- Dispersants included in EPA's list of approved products have low toxicity (EPA Office of Research and Development (ORD), 2010).
- Many household products are more toxic than approved dispersants.
- Most substances are toxic at some level.
- Oil is more toxic than dispersants.
- Dispersed oil and dispersants rapidly dilute in the water to concentrations below most acute toxicity thresholds.
- Because of enhanced dilution and biodegradation, dispersed oil is less likely to persist and cause chronic effects than untreated oil.
- Laboratory tests are used to determine the relative toxicity of different dispersants and to help predict potential effects in the environment.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these tiny oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume.

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools — mechanical recovery and burning in place (also known as in-situ burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas et al., 1991; 1995).

This fact sheet provides an overview of aquatic toxicity testing and the potential effects that may occur when dispersants are used to respond to oil spilled on water. **Toxicity** is defined as the "inherent potential or capacity of a material to cause adverse effects in a living organism" and **Aquatic Toxicity** is the effect of chemicals, materials, and activities on aquatic organisms. The range of these effects is considered from the subcellular level, to whole organisms and even to individual communities and whole ecosystems (Rand, 1995).

Fact Sheet Series

- Introduction to Dispersants
- Dispersants — Human Health and Safety
- Fate of Oil and Weathering
- **Toxicity and Dispersants**
- Dispersant Use Approvals in the United States
- Assessing Dispersant Use Trade-offs
- Aerial and Vessel Dispersant Operations
- Subsea and Point Source Dispersant Operations
- Dispersants Use and Regulation Timeline
- Dispersant Use in the Arctic Environment

Introduction

Large volumes of dispersants were used during the response to the Macondo Well release in the Gulf of Mexico in 2010. Approximately 1.84 million gallons (7 million liters) of dispersants were used at the surface and subsurface (Lehr et al., 2010). Prior to this, the largest use of dispersant was during the 1979 IXTOC-1 spill in the Bay of Campeche, Mexico where 1 to 2.5 million gallons (~4 to 10 million liters) of dispersants were applied over a five-month period (EPA online, 2011). With the quantities of dispersant applied during the Macondo response and for responses in the past, the government and public continue to question the impact that oil and dispersed oil may have on the environment. Scientists have studied the effects of oil, dispersants and dispersed oil on organisms in the marine environment for more than 30 years.

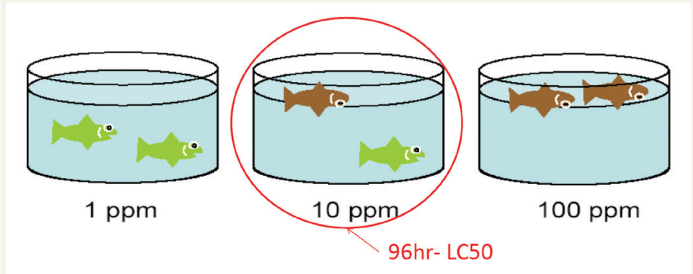
Research efforts often focus on measuring the aquatic toxicity of dispersants on standard test organisms, such as fish and shrimp (EPA ORD, 2010). Adverse effects can include changes to behavior, physiology (such as slowed movements), reproduction (such as reduced fertility), or possibly death when in the presence of certain concentrations of the test materials. Observed effects are a function of both the **duration of exposure** to the chemical and the **concentration** of the chemical during the length of the test. In the actual aquatic environment, the length of exposure varies with tides and currents and the mobility of the potentially affected organism, while the concentration of a chemical is heavily influenced by the following:

- Physical, chemical, and biological properties of the ecosystem, such as salinity, temperature, water depth, waves, and currents, which will influence vertical and horizontal mixing in the water column.
- Sources and rate of input of the chemical into the environment.
- Physical (e.g., boiling point, viscosity) and chemical (e.g., elemental composition) properties of the chemical.

Observed effects can be produced by short-term (acute) or long-term (chronic) exposure. In the case of oil spills, the potential for negative effects from short-term exposure would be expected to occur early in the spill. This is because some of the smaller, more volatile molecules in the oil are quickly lost by evaporation but also can readily dissolve into the underlying water creating short term aquatic toxicity before being diluted and degraded naturally. Alternatively, long-term exposures generally involve exposure to decreased amounts of the larger compounds found in oil that are less toxic.

The toxicity of a substance is also relative, and often, species dependent. Testing can be used to produce some basic relative categorizations about the toxicity of substances. For example, the lethal concentration to 50% of the test organisms (LC_{50}) is often used as a measure of aquatic toxicity (**Figure 1**).

FIGURE 1. Example of an LC_{50} test showing the concentration of a chemical that will kill 50 percent of the animals tested.
Source: A. Bejarano, 2012.



Measuring Toxicity

Essentially, all substances have some ability to lead to toxic or adverse effects which are directly related to concentration and length of exposure. The "adverse effects" are responses exhibited outside the normal range for healthy organisms. In an effort to understand the adverse effects of oil, dispersed oil, and the dispersant itself, the EPA and other agencies evaluate the aquatic toxicity of an exposure over a specified period of time.

NOTE:

The reader is cautioned that laboratory aquatic toxicity tests are NOT representative of the likely exposures experienced by organisms in an environment that is affected by spilled oil. Natural weathering processes like spreading, evaporation, and dilution occur which serve to reduce the potential exposure duration and concentration to well below those used in toxicity tests; refer to **Fact Sheet 3 — Fate of Oil and Weathering** for more information on how oil behaves and changes over time.

A laboratory test only allows a relative comparison between the aquatic toxicity of various chemicals and is not an evaluation of potential impacts to organisms in the environment.

Toxicity tests are used to help predict the potential adverse effects of chemicals on aquatic organisms or humans. When measuring toxicity under laboratory conditions, the goal is to estimate what concentrations of a chemical cause a specific effect over a specific period of time. These may be either short-term or long-term tests. All quantitative aquatic toxicity assessments are based on the dose-response concept (typically measured in parts per million [ppm] or mg/L; and parts per billion [ppb] or µg/L). As the dose (exposure) to a chemical increases, so does the potential for a negative response. When comparing chemicals side-by-side, the *more* chemical it takes to cause an acute effect, the *less* toxic the chemical is.

The US EPA (EPA online, 2012) has established the following scale (**Figure 2**) for interpreting laboratory-generated aquatic toxicity information using LC_{50} values (mg/L = ppm).

FIGURE 2. US EPA's LC_{50} aquatic toxicity scale for laboratory-generated aquatic toxicity data. Source: EPA online, 2012.

- Very Highly Toxic (<0.1 mg/L or ppm)
- Highly Toxic (0.1-1 mg/L or ppm)
- Moderately Toxic (1-10 mg/L or ppm)
- Slightly Toxic (10-100 mg/L or ppm)
- Practically Non-toxic (>100 mg/L or ppm)

The aquatic toxicity results for two key test species (mysid shrimp and silverside, a small fish also known as *Menidia*) as determined by EPA for the Macondo response are shown for the Macondo Well crude oil, the dispersant Corexit® EC9500A, and the oil-dispersant mix (**Table 1**).

Furthermore, the US EPA evaluated the eight commercially available dispersants and found that the dispersants tested had different levels of toxicity, but the major product used, Corexit® EC9500A, was among the least toxic. Ultimately, the crude oil by itself was found to be more toxic to the test species than the dispersants alone; the dispersants alone were less toxic than the dispersant-oil mixture; and the oil alone displayed toxicity results similar to the dispersant-oil mixtures (EPA ORD, 2010).

Influences on Toxicity of Oil-Dispersant Mixtures

Although tests can be used to produce a numerical measure of a substance's aquatic toxicity and provide important information about the effects of oil and dispersants, many of these tests do not accurately reproduce the different types of exposures organisms may experience during an actual oil spill. For example, when dispersants act to break up the oil into droplets, moving the now dispersed oil from the water surface downward into the water column, oil exposure will typically decrease for surface-dwelling and intertidal organisms, but increase for water column and possibly, bottom-dwelling organisms, for a period of time. In general, concentrations in the water column are expected to decrease fairly rapidly, i.e., within a matter of hours. This is different from test protocols which typically use a constant concentration over a fixed amount of time (typically 48 to 96 hours).

Any detectable or measurable response of an organism in a laboratory toxicity test should not be interpreted as resulting

TABLE 1. EPA's aquatic toxicity testing summary results for the spilled oil, dispersant, and dispersed oil from the Deepwater Horizon Response (EPA ORD, 2010).

	Louisiana Sweet Crude (LSC) Oil		Dispersant (Corexit 9500)		Dispersed Oil (LSC + Corexit 9500)	
Species Tested	**Mysid Shrimp**	***Menidia beryllina* (Fish)**	**Mysid Shrimp**	***Menidia beryllina* (Fish)**	**Mysid Shrimp**	***Menidia beryllina* (Fish)**
Very Highly Toxic						
Highly Toxic						
Moderately Toxic	**2.7** ppm	**3.5** ppm			**5.4** ppm	**7.6** ppm
Slightly Toxic			**42.0** ppm			
Practically Non-toxic				**130.0** ppm		

in a similar effect in the environment (Rand, 1995). During an actual incident, there are many factors that can change the effects that oil-dispersant mixtures may have. These factors can include:

- **Differences in length of exposure**. Length of exposure can vary greatly over time, as tides change or currents shift. Exposure may increase, decrease, or even stop. Exposure also varies between intertidal, surface and water column organisms.
- **Volume of dispersants or oil-dispersant mixtures**. Higher volumes may result in increased exposure to dispersed oil.
- **Weather**. Depending on sea state, oil-dispersant mixtures may spread out faster, deeper, further, and become more diluted quite quickly.
- **Weathering**. Changes the oil undergoes as a result of natural processes.

Laboratory tests give very conservative estimates of potential exposure effects to resources in the water column. The use of a spiked/declining dose "flow-through" toxicity test provides a more realistic means of evaluating the likely exposure of resources in the environment but it is not the normal procedure for most studies (ASTM, 2007a & 2007b; Rand, 1995).

Toxicity of Dispersants and Oil-Dispersant Mixtures

There are many complicating factors in the measurement and prediction of toxicity related to specific spill conditions. Many studies have evaluated the aquatic toxicity of crude oils, dispersants, and oil-dispersant mixtures. These studies indicate that dispersants are less toxic than oil itself (EPA ORD, 2010; NRC, 2005).

However, dispersants do increase the local concentration of oil in the water column for a period of time. This does not alter the toxicity of the oil, however, the potential exposure is increased for resources in the water column, at least until mixing and natural dilution occur and reduce the concentration. Potential toxicity of dispersants to humans is just as difficult to determine, especially when it is known that each dispersant formulation is composed of a different group of chemicals. However, public exposure along shorelines is unlikely, since dispersants are generally only applied more than three miles from shore by boats and planes using specialized equipment. For more information on the potential toxicity to humans (responders and the public) refer to **Fact Sheet #2 — Dispersants — Human Health and Safety**.

In summary, there is public and regulatory concern about the toxicity of the dispersant in conjunction with the oil itself in the environment. This fact sheet indicates that concern is often unwarranted as research has shown that it is the oil that is the toxic component in the exposure. Although dispersants may locally increase the oil concentration in the water column for a period of time, the large dilution potential where dispersants would be applied serves to lower the overall oil exposure duration experienced by water column organisms.

Lastly, using a Net Environmental Benefit Analysis (NEBA) approach, it is important to compare such impacts to water column organisms with those impacts to surface animals and shoreline habitats that would occur if the oil were not dispersed but remained on the water's surface. For more information on this approach, refer to **Fact Sheet #6 — Assessing Dispersant Use Trade-offs**.

References

American Society for Testing Materials (ASTM). 2007a. **ASTM E729 - 96(2007) Standard guide for conducting acute toxicity tests on test materials with fishes, macroinvertebrates, and amphibians**. Available online from: http://www.astm.org/Standards/E729.htm.

American Society for Testing Materials (ASTM). 2007b. **ASTM E1023 - 84(2007) Standard guide for assessing the hazard of a material to aquatic organisms and their uses**. Available online from: http://www.astm.org/Standards/E1023.htm.

Bejarano, A. 2012. **LC_{50} Graphic**. Used with permission. Personal communication on March 9, 2012.

EPA Online. 2011. **Questions and answers on dispersants website: Some history of dispersant use**. Last updated on 14 October 2011. Accessed online on March 9, 2012. Available from: http://www.epa.gov/bpspill/dispersants-qanda.html.

EPA Online. 2012. **Ecotoxicity categories for terrestrial and aquatic organisms**. Last updated on 9 May 2012. Available from: http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm#Ecotox.

EPA ORD. 2010. ***Toxicity of Louisiana Sweet Crude Oil (LSC) and chemically dispersed LSC to two Gulf of Mexico aquatic test species*** – August 2010 and the updated report of September, 2010; as posted on the EPA website: http://www.epa.gov/bpspill/dispersants-testing.html.

Fingas, M. F., R. G. Stoodley, N. Stone, R. Hollins, and I. Bier. 1991. **Testing the effectiveness of spill-treating agents: Laboratory test development and initial results**. In: *Proc. 1991 International Oil Spill Conference*. API. Washington, DC.

Fingas, M. F., D. A. Kyle, N. D. Laroche, B. G. Fieldhouse, G. Sergy, and R. G. Stoodley. 1995. "The Effectiveness of Spill Treating Agents." **The Use of Chemicals in Oil Spill Response**. ASTM STP1252, P. Lane, ed. ASTM, Philadelphia, Pennsylvania.

Lehr, B., S. Bristol, and A. Posollo. 2010. **Oil budget calculator Deepwater Horizon technical documentation: A report to the National Incident Command**. November 2010. Developed by the Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team. 217 pages. Available online from: http://www.crrc.unh.edu/publications/OilBudgetCalcReport_Nov2010.pdf.

National Research Council (NRC). 2005. **Chapter 5: Toxicological effects of dispersants and dispersed oil**. In: *Oil Spill Dispersants: Efficacy and Effects*. National Academy Press, Washington, D.C. pp. 193-276.

Rand, G.M. (Ed.). 1995. ***Fundamentals of aquatic toxicology: Effects, environmental fate, and risk assessment***. Second Edition. Taylor & Francis Publishers, Washington, DC. 1124 pgs.

SpillPrevention.org

DISPERSANT USE **APPROVALS IN THE UNITED STATES**

Things You Should **Know**

All dispersant products used in the US must be listed on the US EPA National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Schedule.

Approved dispersants must meet minimum effectiveness requirements and the manufacturer must report toxicity test results.

The US Regional Response Teams (RRT) may preauthorize the use of dispersants in the waters of their region. Most of the RRTs have established pre-authorized zones for dispersant use.

During an incident, the Federal On-Scene Coordinator (FOSC) has the authority to approve dispersant use. This will often be considered in consultation with an Incident-specific RRT, made up of federal, state and local trustees.

Effectiveness monitoring is required during dispersant operations.

Dispersants are approved as a response option in many countries around the world.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these tiny oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume.

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools — mechanical recovery and burning in place (also known as in-situ burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas, et al., 1991; 1995).

This fact sheet summarizes the process and decision-making required for dispersant use approval in United States waters. It is intended to provide a clearer understanding of dispersants, how their use is authorized, and their consideration in a decision-making process based on a Net Environmental Benefit Analysis (NEBA). For more information on NEBA, see **Fact Sheet #6 — Assessing Dispersant Use Trade Offs**.

Fact Sheet Series

Introduction

When an oil spill occurs, some adverse impacts are inevitable because the environment has been exposed to the spilled oil, even if it is only at the microscopic level. One primary goal of a spill response is to lessen any anticipated impacts using knowledge gathered from years of experience and research. For each spill, the available response options must be rapidly evaluated using a Net Environmental Benefit Analysis approach to determine which option or set of options, given incident-specific conditions, will result in the best outcome for the environment and which countermeasures will help minimize any adverse effects. In general, the pre-designated lead federal official, known as the Federal On-scene Coordinator (FOSC), relies on the results of the incident specific NEBA that will be performed by the responsible party in conjunction with scientific advisors, in order to determine whether dispersant use is appropriate.

The main categories of response options available for use in a spill include: 1) on-water mechanical containment, recovery and removal using booms, skimmers, etc.; 2) application of dispersants; 3) controlled (in situ) burning of floating slicks; 4) monitoring a slick for possible future action.

The objective of NEBA is to determine which option or combination of options should be used to remove/recover the spilled oil in order to mitigate the spilled oil's overall, or net, impact on resources and the environment. Because oil spreads quickly, on-scene conditions (wind and water currents) will determine the movement of the oil for large on-water spills. The response options used must be considered in relation to area-specific resources at risk, e.g., biological resources, environmentally-sensitive habitats, and human-use areas such as tourist beaches and marinas. Time-critical choices must be made about which option or options can be implemented immediately and effectively to manage potential impacts.

The collective worldwide spill response experience over the last 40 years has demonstrated that mechanical recovery alone is generally not able to recover a majority of spilled oil especially in large offshore spills. According to the US Office of Technology Assessment and by actual experience during a spill, mechanical methods typically recover no more than 10-15 percent of the oil after a major spill in open water (OTA, 1990). In more contained areas, e.g., a marina, a higher level of recovery may be achieved especially in calm conditions.

Because the majority of the spilled oil offshore likely cannot be recovered before spreading over a much larger area, decisions need to be made about how to best manage floating oil using a combination of response options for the incident-specific conditions. A key goal of a spill response is to prevent an oil slick from coming ashore. A decision to use dispersants involves evaluating the potential trade-offs: decreasing the expected risks to wildlife on the water surface and shoreline habitats while increasing the potential risk to organisms in the water column. Sometimes the use of dispersants is the only viable response option.

Regulatory Facts

The National Oil and Hazardous Substance Pollution Contingency Plan (NCP)

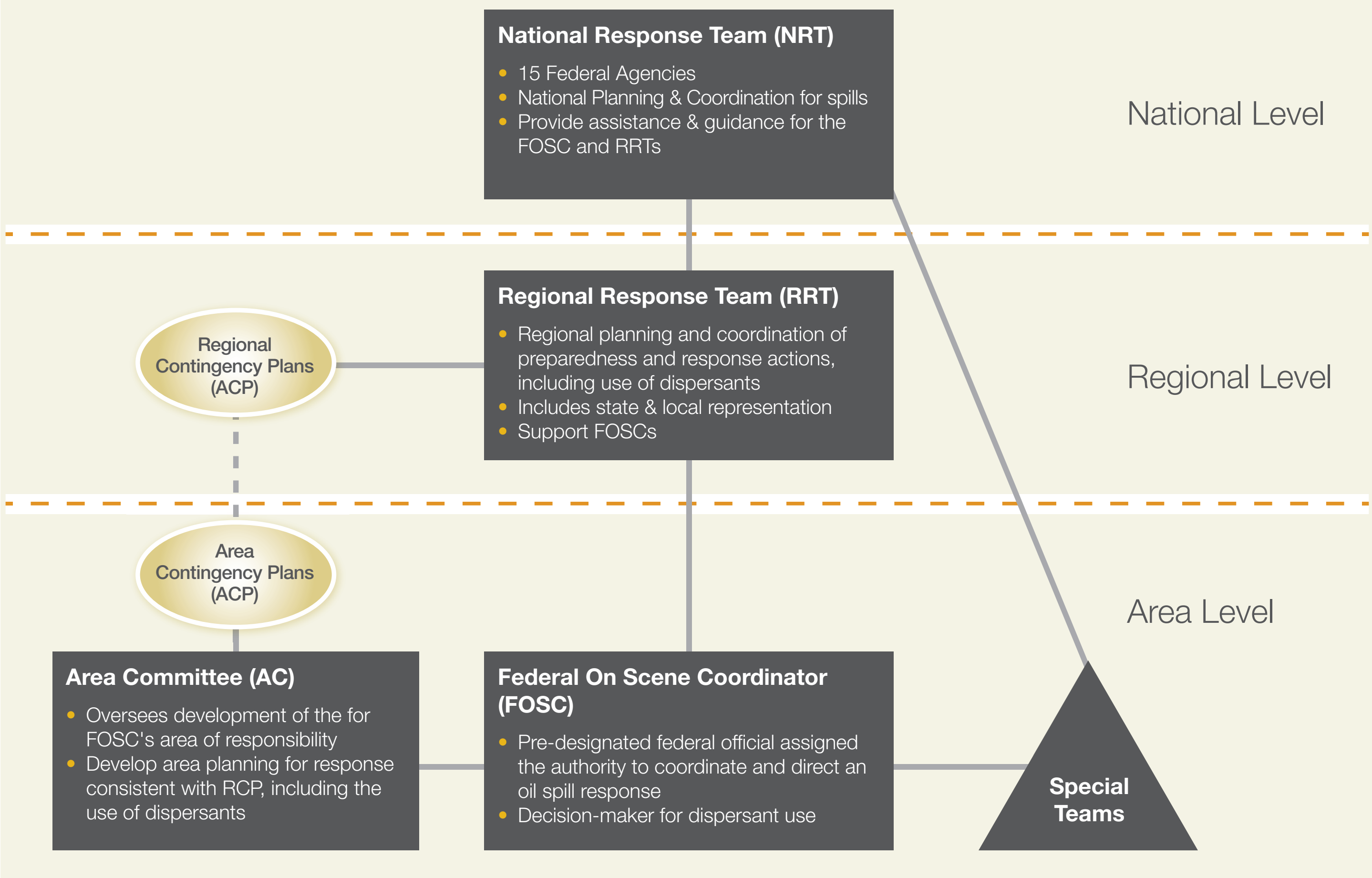
The National Oil and Hazardous Substance Pollution Contingency Plan (NCP) provides the "playbook" for oil spill response in the U.S. The organizational framework of the U.S. National Response System (NRS), as defined in the NCP is shown in **Figure 1** *(see next page)*.

The National Response System (NRS) is the mechanism for coordinating response actions by all levels of government in support of the Federal On-Scene Coordinator (FOSC) and is divided into national, regional, and area levels. The NRS is composed of the National Response Team (NRT), Regional Response Teams (RRTs), FOSC, Area Committees (AC), Special Teams, and related support entities. The basic framework for the response management structure is a unified command system that brings together the functions of the federal government, the state government, and the responsible party (i.e., the spiller) to achieve an effective and efficient response, where the FOSC retains authority (40 C.F.R. § 300).

Furthermore, the NCP specifies the response actions and responsibilities among the federal, state, and local governments and as well as the requirements for federal, regional, and area contingency plans. One component of these responsibilities is the development, selection, and implementation of response actions for each region including the procedures for the use of dispersants in spill response.

To address the needs for specific regional and area dispersant use policy, each RRT and AC defines their minimum requirements for the use of dispersants for an oil spill response. It should be noted, however, that the FOSC can approve the use of dispersants for safety reasons or in pre-approval areas without the need for concurrence of the RRT. If appropriate, the FOSC may include the use of products, including dispersants, to help limit the spread of the oil and to lessen its impact on the environment and potential resources at risk.

FIGURE 1. The National Response System (NRS) organization as dictated by the NCP.



The NCP Product Schedule

The Clean Water Act (CWA) Section 311(d)(2) and Section 4201(a)(G) of the Oil Pollution Act of 1990 requires that the President maintain a schedule of chemical and biological spill response countermeasures, including dispersants, that may be used to respond to oil spills to ensure that the products are used effectively and appropriately; the President has delegated this authority to the U.S. EPA.

Approval to use dispersants on an incident begins with the authorities laid out by the NCP. Subpart J (Use of Dispersants and Other Chemicals; 40 C.F.R. § 300.910) of the NCP is the U.S. EPA's Product Schedule for these regulated chemical and biological countermeasures (EPA online, 2011a). The Product Schedule is EPA's listing of the chemical and biological agents that have submitted the required information and, once listed, may be considered for approval by the FOSC for use during an incident.

Dispersants and other response countermeasures are required to be on this schedule if they are to be considered for use during a response. For a dispersant or other chemical to be listed on the Product Schedule, the manufacturer must submit specific test results and supporting technical data on their product to the U.S. EPA as defined in 40 C.F.R. C.F.R. § 300.915. For chemical dispersants, the listing requirements include tests for effectiveness and toxicity.

To be listed as a dispersant, the product must demonstrate a minimum effectiveness value as measured by a standard dispersant effectiveness test using defined test oils. Specific toxicity testing data, physical properties and other information about the product must also be submitted. In the wake of the response to the Macondo Well release the EPA now publishes the Toxicity and Effectiveness Data Summaries for all product categories on the Product Schedule, which facilitates comparisons and evaluations of products and categories.

NOTE: Inclusion on the Product Schedule does NOT indicate a recommendation or endorsement of any listed product by the EPA or other federal agencies; it only means that the manufacturer has submitted the required information for inclusion on the schedule and it may be used during a response.

Authorizations for Dispersant Use in the U.S.

The following sections outline the various responsibilities imposed on various agencies and organizations by the regulatory changes in U.S. policy.

The Oil Pollution Act (OPA 90)

The Oil Pollution Act (OPA 90) was signed into law in August 1990 and improved the nation's ability to prevent and respond to oil spills by establishing provisions that expanded the federal government's ability, and provided the money and resources necessary to respond to oil spills. In addition, OPA 90 provided new requirements for contingency planning both by government and industry.

The NCP was expanded in a three-tiered approach: 1) the federal government is required to direct all public and private response efforts for certain types of spill events; 2) Area Committees, composed of federal, state, and local government officials, must develop detailed, location-specific Area Contingency Plans (ACP); and 3) owners or operators of vessels, pipelines, and facilities that transport, handle, or store oil in certain quantities must prepare their own Response Plans.

As a means to address the requirements of OPA 90, a three-fold strategy was used nationally (with some location-specific modifications) to determine the regional and area planning and preparedness requirements for the use of dispersants in U.S. waters. This included:

Pre-spill Planning

Pre-spill planning, including evaluating the potential use of products listed on the NCP Product Schedule, was delegated to the RRT and AC decision-making bodies under the direction of OPA 90. The RRTs were charged with developing pre-authorization plans (also called pre-approval agreements) in advance of an incident to identify the following areas:

- **Pre-authorized zones** — areas where dispersants can be authorized by the FOSC without RRT concurrence.
- **Case-by-case basis zones** — areas where the FOSC must consult with appropriate agencies on the RRT, e.g., EPA, Department of Commerce (DOC)/NOAA, Department of the Interior (DOI), and states, to determine whether dispersant use is appropriate.
- **Exclusion zones** — areas where dispersants are not to be used.

Many RRTs have limited dispersant applications in marine waters to water depths greater than 30 feet (10 m) and in most coastal areas there is an additional requirement that the dispersants be used in areas more than 3 nautical miles (5.6 km) from shore which means use in near shore areas and estuaries is generally excluded.

Because these products are used to treat oil spills in open ocean waters, the FOSC is provided by the US Coast Guard (USCG). At this time, there is no dispersant available that is approved for use in United States freshwater environments.

Pre-authorization

Pre-authorization means that if agencies have signed a pre-authorization agreement, and if a spill meets the conditions outlined in the applicable Regional Contingency Plan (RCP), then the FOSC can approve dispersant use within specified zones as soon as he/she believes it will result in greater benefit than if they are not used.

To develop the pre-authorizations for dispersants, the RRT representatives from U.S. EPA and the states with jurisdiction over the state waters for each region, along with U.S. DOC and DOI natural resource trustees, conduct a NEBA review of the risks and benefits associated with chemical dispersant applications. This evaluation also requires an assessment of the likely impacts to threatened and endangered species residing or passing through the areas being considered by the RRT member agencies.

Each RRT will approve or disapprove the pre-authorization agreements which will be incorporated into the RCP and the associated USCG ACPs. Most pre-authorization plans outline zones where, or conditions under which, dispersants may be used. These are generally based on geographic area, distance from the shoreline, water depth, and/or season and may be limited by the presence of specific environmentally sensitive resources (e.g., a marine sanctuary).

The designation of pre-authorization areas, and the discussions that led to their establishment, can be very important steps towards a timely and effective spill response.

> **NOTE:** The pre-authorization status for each region is available from http://www.rrt.nrt.org/ on the RRT regional links. Additional information on regional decision-making relative to dispersant use can be obtained from the USCG Vessel Response Plan Program under "Maps and Photos – Dispersant Usage Map."

Approvals During an Incident — Case-by-Case

If human health or safety is at immediate risk, the FOSC needs no approval for the use of dispersants as a protective measure. Otherwise, when the FOSC determines that the use of dispersants is required and there is no pre-authorization for their use, he/she may only use them with the concurrence of the EPA representative to the RRT and state RRT representatives in consultation with the DOC and DOI natural resource trustees. This group of state and federal agency decision-makers is also known as the Incident-specific RRT.

In most instances where a spill occurs in areas where pre-authorization is not in place, the USCG FOSC requests a decision by the incident-specific RRT within four hours of his/her initial request so that a dispersant decision is rendered in time to execute a dispersant operation and effective application, also known as the "window of opportunity". For more information on this topic refer to **Fact Sheet #3 — Fate of Oil and Weathering**.

After the initial consultation, the incident-specific RRT can agree to endorse the use of dispersants, possibly with specifically-defined use conditions, or they can veto their use.

Exclusion Zones

As stated, many RRTs have established areas within their region where dispersants may not be used. Many of these exclusion zones are located within state waters, typically in areas less than 3 nautical miles (5.6 km) from shore or with water depths shallower than 30 feet (10 m). The primary reason dispersants could be used in these areas is if human health or public safety is at immediate risk from the incident. As mentioned earlier, the FOSC needs no approval for the use of dispersants as a protective safety measure.

International Approvals

Dispersants are considered a primary response option in a number of countries and are approved for use in many countries, including the U.K., South Korea, Australia, Egypt, France, Greece, Indonesia, Italy, Japan, Malaysia, Norway, Singapore, Spain, Thailand, and a number of coastal African, South American, and Middle Eastern countries (ITOPF). The requirements for application are country-specific and must be verified prior to application.

Monitoring Requirements

In the U.S., dispersant approvals include operational monitoring requirements to assist the Unified Command in determining the effectiveness of dispersant application. This can include a definition of when dispersant use should be discontinued, e.g., definition of a threshold which if reached would result in stopping the dispersant operation. Ideally, the decisions to use and discontinue the use of dispersants are made based on objective scientifically-based research and effectiveness testing and involve the components associated with a relevant NEBA. Periodic operational monitoring allows the individuals managing the incident, i.e., the Unified Command (UC) to assess the effectiveness of dispersant use and determine whether their use should be continued.

In the U.S., monitoring of dispersant effectiveness and gathering potential exposure data is performed according to the *Special Monitoring of Applied Response Technologies* (SMART) protocols, a methodology that involves the use of three tiers of monitoring. In order of increased requirements:

- **Tier I** — Visual observations by trained observers,
- **Tier II** — On-water visual observations and fluorescence spectrometry at a single depth to measure oil concentrations under treated slicks; and
- **Tier III** — On-water visual observations, fluorescence spectrometry at multiple depths, and water chemistry sample collection to monitor horizontal and vertical spreading of the dispersed oil.

Updated Regulatory Status

In 2010, during the response to the Macondo Well release in the Gulf of Mexico, large volumes of dispersants were applied to offshore surface oil by aircraft and vessel (National Commission, 2011). Following this use, the RRTs were instructed to review their existing dispersant use policies and update their Regional

Contingency Plans (RCPs) to reflect the knowledge and experienced gained.

This was also the first instance where dispersants were injected into the oil release site where it exited the seafloor. Although this use of dispersants, known as subsea injection, had been previously studied and considered for possible use, this was the first documented successful application of the approach. As a result, subsea injection of dispersants is now considered by the coastal RRTs to be a potential option to mitigate the adverse effects from subsea oil discharges offshore. The National Response Team (NRT) has issued monitoring guidance for subsea use of dispersants. For more information on the subsea application, refer to **Fact Sheet #8 — Subsea and Point Source Dispersant Operations**.

References

Fingas, M. F., R. G. Stoodley, N. Stone, R. Hollins, and I. Bier. 1991. **Testing the Effectiveness of Spill-Treating Agents: Laboratory Test Development and Initial Results**. In: *Proc. 1991 International Oil Spill Conference*. API. Washington, DC.

Fingas, M. F., D. A. Kyle, N. D. Laroche, B. G. Fieldhouse, G. Sergy, and R. G. Stoodley. 1995. "The Effectiveness of Spill Treating Agents." **The Use of Chemicals in Oil Spill Response**, ASTM STP1252, P. Lane, ed. ASTM, Philadelphia, Pennsylvania.

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (National Commission). 2011. Deepwater: **The Gulf Oil Disaster and the Future of Offshore Drilling – Report to the President**. 398 pages. Available from: http://www.oilspillcommission.gov/final-report.

National Response Team Response Committee. 2002. **NRT-RRT Fact Sheet: Who Decides What Products Can be Used during an Oil Spill Response?** 4 pp. http://nrt.org/production/NRT/NRTWeb.nsf/PagesByLevelCat/Level3ResponseCommitteePublications?Opendocument.

Office of Technology Assessment (OTA), U.S. Congress. 1990. Coping with an Oiled Sea: An Analysis of Oil Spill Response Technologies. OTA-BP-O-63. 70 pp.

U.S. EPA. 2007. **Subpart J: The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) Product Schedule**. 2 pages. Available online from: http://www.epa.gov/emergencies/content/ncp/index.htm#testing.

U.S. EPA online. 2011a. "**EPA Emergency Management – NCP Product Schedule – Subpart J**." Last modified on September 01, 2011. Available from: http://www.epa.gov/emergencies/content/ncp/index.htm#testing.

U.S. EPA online. 2011b. "**Oil Pollution Act Overview**." Last modified on January 28, 2011. Available from: http://www.epa.gov/oem/content/lawsregs/opaover.htm.

U.S. Coast Guard (USCG) online. 2011. **USCG Homeport Vessel Response Plan Program - Maps and Photos – Dispersant Usage Map**. 2011. Available from: https://homeport.uscg.mil/vrp.

International Tankers Owners Pollution Federation Limited (ITOPF), **Country Profiles**. Available online at: http://www.itopf.com/information-services/country-profiles.

U.S. Department of the Interior (DOI). 1963. **Federal Water Pollution Control Administration Policy on the Use of Chemicals to Treat Floating Oils**. July 5, 1963. 1 page.

The current version of the NCP Product Schedule can be viewed at: http://www.epa.gov/oem/content/ncp/index.htm.

ASSESSING DISPERSANT USE TRADE-OFFS

SpillPrevention.org

Things You Should Know

When oil is spilled some level of negative effects is likely.

Decision-makers use a Net Environmental Benefit Analysis (NEBA) process to identify the response action(s) that will result in the least long-term environmental impacts.

NEBA is a consensus-based tool that allows decision-makers to use input from stakeholders, subject matter experts, regulators, and responsible parties.

A NEBA assesses trade-offs of the various response options to determine which options will minimize both the short-term and long-term impacts of a spill.

NEBA trade-offs associated with dispersant use focus on impacts to sensitive shorelines and surface dwelling resources (wetlands, birds, marine mammals, turtles) versus resources that exist in the water (fish, corals, etc.).

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these very small oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume.

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools — mechanical recovery and burning in place (also known as in-situ burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas et al., 1991; 1995).

This fact sheet summarizes the trade-offs and evaluation factors used by decision-makers to determine whether the use of dispersants is warranted for an oil spill. It is intended to provide a clearer understanding of dispersants, how their use is authorized, and their consideration in the NEBA decision-making process.

Fact Sheet Series

- Introduction to Dispersants
- Dispersants — Human Health and Safety
- Fate of Oil and Weathering
- Toxicity and Dispersants
- Dispersant Use Approvals in the United States
- **Assessing Dispersant Use Trade-offs**
- Aerial and Vessel Dispersant Operations
- Subsea and Point Source Dispersant Operations
- Dispersants Use and Regulation Timeline
- Dispersant Use in the Arctic Environment

Introduction

When an oil spill occurs, decision-makers must be prepared to quickly determine the best response countermeasures for the incident-specific conditions. In most instances, government decision-makers conduct a rapid Net Environmental Benefit Analysis (NEBA) to compare and rank the pros and cons (or "trade-offs") of different response options relative to the spilled oil's potential impact on resources and the environment. In some cases NEBA is performed in advance of a potential spill during the planning stage and is then validated during a spill in an expedited manner. For each spill, the response options are evaluated to determine which option or set of options, given the incident-specific conditions, will result in the best outcome for the environment. They must determine if it is better to allow surface oil to remain, potentially impacting shorelines and wildlife that utilize the water surface, or use response options like dispersants, which would minimize the risk to surface resources but increase the potential risk to water-column organisms.

Net Environmental Benefit Analysis (NEBA)

The Net Environmental Benefit Analysis (NEBA) is a consensus-based planning tool that is used to bring natural resource trustees together to address resource-management decision-making needs for an oil spill response. NEBA provides a means to evaluate the likely environmental actions and make an assessment of the required trade-offs associated with them, considering possible impacts to sensitive resources and the environment. The NEBA analyzes the "trade-offs" of the response options, including natural recovery (no human intervention) to determine which option or combination of options can best reduce the spilled oil's overall impact, both the short-term and long-term, in the spill area.

Throughout the world, the advantage of implementing NEBA during the decision-use process has been demonstrated. The first example of a US-based NEBA oil spill evaluation occurred in 1990 when decision-makers assessed whether a mechanized "rock-washing" technique would provide benefit to the environment during the *EXXON VALDEZ* response (Tebeau, 1995). During the M/V *AMORGOS* grounding and subsequent break-up in January 2001 in Taiwan, dispersants were initially not permitted as the area of dispersant use was over unknown sea floor communities including possible coral reefs. After dive surveys revealed that there was less than 5% coral and the area was more of a "hardground community," the decision was made that there was a net environmental benefit to disperse the oil in order to prevent it from coming on-shore (Purnell, 2002).

In the United States, the formal NEBA process is conducted before a spill during the planning phase at the Area and Regional Response Team levels with input from state and federal participants to determine the benefits and limitations (or trade-offs) from using each response technology within their individual areas of responsibility. This evaluation is generally conducted in the contingency planning process. Following an incident, it may be reviewed again as additional knowledge and lessons learned are gained. For more information on the US-based dispersant approval process, refer to **Fact Sheet #5 – Dispersant Use Approvals in the United States**.

Trade-off Decision-making for Dispersants

Careful consideration is given before applying dispersants and many factors are analyzed prior to approval.

Toxicity of the oil, dispersed oil, and the dispersant itself are evaluated. Although dispersants are less toxic than the oil itself and do not increase the toxicity of oil/dispersant mixtures, their use during an incident is intended to transfer the oil from the surface into the water column. The trade-offs between surface and water-column effects must be carefully weighed.

Those in charge of a spill response must evaluate the likely effectiveness of dispersant use on the oil spilled. In most cases, dispersant use has a window of opportunity before processes such as weathering render it less effective. For this reason, it is important that responders not delay the decision making process for dispersant use (refer to **Fact Sheet #3 – Fate of Oil and Weathering** for more information on this topic).

If it is determined that dispersants will provide value to the response and the associated tradeoffs are acceptable, the individual in charge may authorize the use of dispersants. In the US, the Federal On-Scene Coordinator (FOSC) is the only official that can give this final authorization.

Exposure Routes

The primary pathways for exposure to spilled oil, dispersant, and dispersed oil may be defined as (see, for example: US National Oceanic and Atmospheric Administration or NOAA Fisheries, 2012 and US Fish and Wildlife Service or USFWS, 2010):

- **Inhalation** – For volatile organic compounds (VOCs), such as benzene, toluene, and others, inhalation is the primary route of exposure.
- **Ingestion** – This includes polycyclic aromatic hydrocarbons (PAHs) that are taken up by seafood and have the potential to ultimately be consumed people.
- **Dermal or surface contact/coating** – This is also considered a significant route of exposure for wildlife and the environment.

Resources of Concern

In general, there are four broad categories of resources/habitats that are most likely to be exposed to crude oil spilled on or in water: 1. Surface dwelling animals; 2. Water column resources; 3. Benthic/bottom dwelling resources; and 4. Intertidal and shoreline resources. In addition, socio-economic factors should be considered since amenities such as tourist beaches and marinas may contribute significantly to a region and may be affected by an oil spill or the resulting response (Baker, 1995). Examples of typical species and possible environmental effects of oil on these resources are discussed below.

1. Surface Dwelling Animals

This group consists primarily of marine birds, marine mammals, and sea turtles.

Highly vulnerable bird species are those that are closely associated or fully dependent on the marine environment – diving for food, roosting on the water surface, etc. When birds come in contact with surface oil, the exposure can result in fouling of plumage, ingestion of oil, negative effects on reproduction, and death (USFWS, 2010).

Most marine mammals, such as whales, dolphins, pinnipeds (e.g., seals), and sea otters, are dependent on the marine environment for their existence. As they must breathe air, the most likely routes of exposure to spilled oil for marine mammals include oiling of hair/skin, ingestion, and inhalation of toxic vapors when surfacing. Impacts from long term exposure to oil continue to be studied; however, recent studies indicate that marine mammals have an increased susceptibility to infection, loss of unborn young, and death (NOAA Fisheries, 2010). Behavioral alterations may also be observed such as stranding and obsessive grooming.

Sea turtles, like marine mammals, can be subjected to oiling from direct surface fouling, ingestion and inhalation of toxic vapors (NOAA Fisheries, 2010).

2. Water Column Resources

The routes of exposure for fish and plankton include direct exposure to dispersed oil. Some studies of adult fish have documented reduced growth, internal organ impacts, fin erosion and reproductive impairment when exposed to oil. Oil has the potential to impact spawning, since eggs and larvae are very sensitive to oil (USFWS, 2010).

Most fish in the open ocean are able to leave an affected area and do not generally experience short term mortalities due to exposure to oil on the surface. Plankton and planktonic life stages of many marine species, however, appear to have a wide range of sensitivities when exposed to crude oil as they are not actively able to remove themselves from the contaminated environment and drift with the surrounding wind and currents. However, dispersed oil concentrations in the water column will rarely exceed toxic threshold levels and will decrease rapidly under real world conditions (George-Ares and Clark, 2000).

3. Benthic / Bottom Dwelling Resource

Benthic and bottom dwelling plants and animals such as seagrass, oysters, and other shellfish are typically only lightly affected from oil in the water column. Primary exposure is usually the result of direct contact/coating/smothering. In general, most marine plants are quite resilient (USFWS, 2010).

4. Intertidal and Shoreline Resources

The species and resources in intertidal and shoreline zones spend most of their time under water, but may be exposed to surface oil during low tide. They are often the most visible and severely impacted organisms.

The extent of impacts to these resources will be based on the sensitivity of the species being oiled and the duration and extent of oil exposure. Intertidal organisms can include crabs, clams, grasses, etc. Primary exposure pathways are typically from direct contact/coating/smothering. As most intertidal shellfish are filter feeders, they may ingest oil present in the water column (USFWS, 2010).

Exposure & Effects with Dispersants

When used appropriately, dispersants act to decrease the amount of oil on the water's surface, thereby reducing potential impacts to coastal areas by helping it mix into the water column as very small droplets. By keeping oil off of sensitive shorelines, the use of dispersants can significantly improve the rate of overall environmental recovery (Sell, et al., 1995). The formation of small droplets that remain dispersed in the water column promotes the oil's dilution and subsequent removal by microbial biodegradation. The following topics summarize possible changes in environmental exposure and effects due to dispersant application. While not discussed explicitly here, as mentioned above, socio-economic considerations are an important topic when considering the potential effects of an oil spill and subsequent response activities.

1. Surface Dwelling Animals

Removing the oil from the surface of the water with the use of dispersants will benefit surface-dwelling birds, mammals, and sea turtles by reducing the chance for exposure and oiling of skin, fur, and feathers or ingestion of free floating surface oil. In the very unlikely case of inadvertently spraying a bird with dispersant, there may be some short-term impact due to loss of waterproofing of feathers. However, for most birds, as well as for fur-bearing mammals, and sea turtles, the benefit of removing the oil from the surface and transferring it into the water column is likely to outweigh the minimal chance of dispersant exposure (Kucklick et al., 1997; NRC, 1989).

There may be some possibility of ingesting dispersed oil which could cause injury to the gastrointestinal tract and affect the animals' ability to absorb or digest food, damage internal organs or lead to reproductive failure or death (USFWS, 2010). However, when dispersants are applied appropriately, the concentration of dispersed oil in the water column will rapidly decrease to the point where ingestion concerns are not significant.

2. Water Column Resources

Water column (mid-water) resources are often the primary concern when dispersants are being considered. In general, plankton, invertebrates, and fish are thought to be at no more risk from dispersed oil compared to undispersed oil (Boyd, 2001). In one study, test results on the effects of untreated and dispersed oil on the homing mechanism of adult salmon showed no significant difference in the percentage of return or in the time it took fish to return (NRC, 1989).

Current studies support other evidence that effects are life-stage dependent. Eggs and larval forms of marine resources are more susceptible to impacts than adults (Hatlen et al., 2010; Tjeerdema et al., 2011). Exposure to dispersed oil is expected to be of short duration as dilution occurs rapidly. Additionally, population dynamics of large numbers of eggs and larval life stages support a short-lived effect with relatively rapid recovery.

3. Benthic/Bottom Dwelling Resource

In shallow-water environments, bottom dwelling organisms would be more likely to be exposed to and affected by dispersed oil than floating oil. Shallow environments are defined as being less than 33 feet (10 m) deep and fewer than three nautical miles offshore (5.6 km) (Kucklick et al., 1997). These are generally not the primary areas where dispersant use would be recommended since, in the short-term, the concentration of dispersed oil may be high enough to cause both lethal and sub-lethal effects in some benthic resources. However, studies with seagrass beds have shown them to experience no increase in effect with exposure to dispersed versus undispersed oil (NRC, 1989; Gilfillan, 1992).

4. Intertidal and Shoreline Resources

Dispersing oil offshore *before* it impacts intertidal habitats and their resident organisms is the preferred solution in most instances (NRC, 1989; IT Corp., 1993; Kucklick et al., 1997). Aquatic toxicity studies of dispersed oil on invertebrates in shallow, intertidal environments have shown that chemically dispersing the oil results in the same or less toxicity than undispersed oil alone (NRC, 1989). Dispersed oil should also pose the same or less of a risk than undispersed oil for intertidal plants, like marsh grasses, especially in the long-term. This is because exposure to the oil is reduced with the application of dispersants, which work to decrease or eliminate the layers of oil that are normally deposited by the slick each time the tide recedes.

Dispersants should typically be applied to a slick well before it reaches the shore; in many coastal regions around the world where dispersant use may be considered, dispersant applications are restricted to areas outside of a minimum distance from shore in waters of sufficient depth. In cases where oil is appropriately dispersed prior to impacting these habitats, the net ecological effect may be much less than when oil is allowed to strand (NRC, 1989; IT Corp., 1993; Kucklick et al., 1997). For more information on the Dispersant approval process in the US, refer to **Fact Sheet #7 – Dispersant Use Approvals**.

NEBA Case Study: Tropical Investigations in Coastal Systems

The TROPICS (Tropical Investigations in Coastal Systems) field study began in 1983/84 near Bocas del Toro, Panama. The study was designed to examine the relative short and long-term effects of dispersed crude oil versus non-dispersed crude oil on tropical marine ecosystems. After baseline studies (1983), two 900 m^2 sites composed of intertidal mangrove and sub-tidal seagrass-coral zones were dosed (1984) with untreated Prudhoe Bay crude oil and Prudhoe Bay crude oil dispersed with Corexit® 9527. At periodic intervals over 25 years, the sites were monitored and effects were compared to a nearby reference site.

The TROPICS field test conditions are viewed as an extreme or worst case scenario because the average water depth was less than 1 meter and concentrations of dispersed oil in the shallow water reached over 200 ppm, significantly higher than that normally observed following dispersant use in the offshore environment. The TROPICS site has been intensely monitored during the past 29 years, with 20 separate studies conducted and reported over that period. The results serve as excellent guidance for responders to spills in comparable environments, providing clear evidence of the net environmental benefit of nearshore use of dispersants in tropical ecosystems (Baca, et al., 2005).

As in the near-shore field studies discussed in the preceding section, the dispersed oil site experienced less stranding of dispersed oil on sediment and nearshore surfaces and rapid removal of dispersed oil by tidal flushing. However, oil was not removed as promptly from the untreated oil site and still remains today. The results were:

- The untreated oil had significant effects on the mangroves. Even after 10 years (Dodge, et al., 1995 reported by Lewis and Aurand, 1997), the area still contained only half the original concentration of mangrove trees.
- There was no observed direct mortality on mangroves in the areas impacted by the dispersed oil. This is probably because dispersant kept oil from attaching to the sediments and mangrove prop roots and the dispersed oil flushed out rapidly.
- Corals were visibly affected by dispersed oil but not by untreated oil. But at the 10 year mark, those that had been impacted had recovered and no significant difference existed between experimental and control sites (Dodge, et al, 1995; Lewis and Aurand, 1997).
- Sea grasses were not affected by either treatment but invertebrates around the grasses were measurably affected by dispersed oil.

FIGURE 1. Exposure of Mangroves to Oil in TROPICS Experiment

Scientists who continue to monitor the TROPICS site indicate that some of the original untreated North Slope oil is still present and occasionally seeps out, causing a low level of ongoing chronic impact (Baca, et al., 2005; DeMicco et al., 2011). One conclusion from the Panama field test is that adding dispersant to the oil going into a sensitive habitat and seeing it promptly flushed from the area is preferable to having untreated oil remain in a low-energy area with the potential for ongoing impact. As one of the recent principal investigators, Dr. Bart Baca of CSA South, Inc., has said on many occasions, protection of the habitat is more important for the ecosystem in the long term than any resulting shorter-term effects on organisms themselves. Organisms can re-populate quickly as long as the habitat is preserved.

References

Baca, B., G. Ward, C. Lane, and P. Schuler. 2005. "**Net Environmental Benefit Analysis (NEBA) of Dispersed Oil on Nearshore Tropical Ecosystems Derived from the 20 Year 'TROPICS' Field Study.**" Proc. of 2005 International Oil Spill Conference. American Petroleum Institute. Washington, DC.

Baker, J.M. 1995. **The Net Environmental Benefit Approach for Oil Spill Response.** International Oil Spill Conference Proceedings, 1995: 611-614. Available on line from: http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-1995-1-611.

Boyd, J.N., J.H. Kucklick, D.K. Scholz, A.H. Walker, R.G. Pond, and A. Bostrom. 2001. **Effects of Oil and Chemically Dispersed Oil in the Environment.** Prepared for the American Petroleum Institute, Regulatory and Scientific Affairs. Washington, D.C. API Publication No. 4693, 60 pages.

DeMicco, E.D., P.A. Schuler, T. Omer, B. Baca.2011. **Net Environmental Benefit Analysis (NEBA) of Dispersed Oil on Nearshore Ecossystems: TROPICS – the 25th Year Research Visit.** In: *Proc. 2011 International Oil Spill Conference.* API. Washington, DC.

Dodge, R.E., B.J. Baca, A.H. Knap, S.C. Snedaker, and T.D. Sleeter. 1995. "**The Effects of Oil and Chemically Dispersed Oil in Tropical Ecosystems: 10 Years of Monitoring Experimental Sites.**" MSRC Technical Report 95-014. Marine Spill Response Corporation. Herndon, VA.

Fingas, M.F., R.G. Stoodley, N. Stone, R. Hollins, and I. Bier. 1991. **Testing the Effectiveness of Spill-Treating Agents: Laboratory Test Development and Initial Results.** In: *Proc. 1991 International Oil Spill Conference.* API. Washington, DC.

Fingas, M.F., D.A. Kyle, N.D. Laroche, B.G. Fieldhouse, G. Sergy, and R.G. Stoodley. 1995. "**The Effectiveness of Spill Treating Agents.**" The Use of Chemicals in Oil Spill Response, ASTM STP1252, P. Lane, Ed. ASTM, Philadelphia, Pennsylvania.

George-Ares, A. and J.R. Clark. 2000. **Aquatic Toxicity of two Corexit dispersants.** In: *Chemosphere* 40:897-906.

Gilfillan, E.S. 1992. **Toxic Effects of Oil and Chemically Dispersed Oil on Marine Animals and Plants.** Prepared for the State of Maine, Department of Environmental Protection. 20 May, 1992. 23 pages.

Hatlen K., C.A. Sloan, D.G. Burrows, T.K. Collier, N.L. Scholz, and J.P. Incardona. 2010. **Natural sunlight and residual fuel oils are an acutely lethal combination for fish embryos.** *AquatToxicol* 2010: 99: 56–64.

IT Corporation. 1993. **Use of Chemical Dispersants for Marine Oil Spills.** Prepared for the USEPA Office of Research & Development, Washington, DC. EPA/600/R-93/195. 132 pages.

Kucklick, J.H., A.H. Walker, R. Pond, and D. Aurand. 1997. **Dispersant Use: Considerations of Biological Concerns in the Upper 10 Meters of Marine Waters and in Shallow Coastal Waters.** Proceedings from a Workshop, August 27-28, 1996, Baltimore, MD. Alexandria, Va.: Scientific and Environmental Associates, Inc. 104 pages.

Lewis, A. and D. Aurand. 1997. "**Putting Dispersants to Work: Overcoming Obstacles.**" API Publication No. 4652A. Washington, D. C.

National Oceanic and Atmospheric Administration (NOAA). 2010 – **Fact Sheet: NOAA's Oil spill Response – Sea Turtle Strandings and the Deepwater Horizon Oil Spill.** 2 pages. Available online from: www.noaa.gov/factsheets/new%20version/sea_turtles.pdf.

National Oceanic and Atmospheric Administration (NOAA) Fisheries Office of Protected Resources (OPR) website. 2012 — **How are marine mammals and sea turtles affected by oil? webpage**. 2 pages. Available online from: http://www.nmfs.noaa.gov/pr/health/oilspill/faq.htm.

National Oceanic and Atmospheric Administration (NOAA) Fisheries. 2010 – **Fact Sheet: Impacts of Oil on Marine Mammals and Sea Turtles.** 2 pages. Available online from: www.nmfs.noaa.gov/pr/pdfs/health/oil_impacts.pdf.

National Research Council (NRC). 1989. **Using Oil Spill Dispersants on the Sea.** Prepared by the Committee on Effectiveness of Oil Spill Dispersants. Washington, D.C.: National Academy Press. 335 pages.

Purnell, K. 2002. **Recent Activities of ITOPF: The 'AMORGOS' Incident and Consideration of NEBA.** Presented at the *PAJ Oil Spill International Symposium, 2002*. 10 pages. Available online from: www.itopf.com/_assets/documents/paj2002.pdf.

Sell, D., L. Conway, T. Clark, G.B. Picken, J.M. Baker, G.M. Dunnet, A.D. McIntyre and R.B. Clark. 1995. **Scientific Criteria to Optimize Oil Spill Cleanup.** International Oil Spill Conference Proceedings, 1995: 595-610. Available on line at: http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-1995-1-595.

Tebeau, P.A. 1995. **Effectively Managing Level of Effort in Oil Spill Cleanup: Resolving the 'How Clean is Clean' Issue.** In: *Proceedings International Oil Spill Conference*, American Petroleum Institute, Publication Number 4620, Washington, DC, pages 663- 666.

Tjeerdema, R., A.C. Bejarano, and S. Edge. 2012. **Biological Effects of Dispersants and Dispersed Oil on Surface Deep Ocean species.** White Paper Report for *Future of Dispersant Use in Oil Spill Response Initiative* (March 22, 2012), 19 pages. CRRC, RPI, and NOAA conference sponsors. Available online from: http://www.crrc.unh.edu/.

Toxipedia Consulting Services (Toxipedia) and Earthjustice. 2011. **The Chaos of Clean-up: Analysis of Potential Health and Environmental Impacts of Chemical Dispersant Products.** Prepared for The Gulf Restoration Network and the Florida Wildlife Federation. 18 pages. Available online from: http://www.earthjustice.org/sites/default/files/Oil_Dispersants_Report.pdf.

U.S. Fish & Wildlife Service (USFWS). 2010. **Fact Sheet: Effects of Oil on Wildlife and Habitat.** 2 pages. Available online at: http://www.fws.gov/home/dhoilspill/pdfs/DH%20JIC%20Cleared%20FWS%20Oil%20Impacts%20Wildlife%20Fact%20Sheet%2005072010.pdf.

AERIAL AND VESSEL DISPERSANT OPERATIONS

SpillPrevention.org

Things You Should Know

Aircraft and vessel-based dispersant application platforms have the potential to treat larger and more distant spills more quickly than other response options.

Aerial application of dispersants can be the first response for an offshore spill, often arriving on scene within 4 – 8 hours.

The variety of dispersant application platforms (planes to vessels) allows all types of slicks to be treated efficiently; small to large,near and far from shore.

Spotters are used during dispersant use to ensure accuracy of applicaton and to maximize dispersion efficiency.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these very small oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume.

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools - mechanical recovery and burning in place (also known as in-situ burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas et al., 1991; 1995).

This fact sheet summarizes the operational capabilities and potential benefits of dispersant use at the water surface. This includes the application process, equipment, and planning requirements when applying dispersants to the water surface by aircraft or boat.

Fact Sheet Series

- Introduction to Dispersants
- Dispersants — Human Health and Safety
- Fate of Oil and Weathering
- Toxicity and Dispersants
- Dispersant Use Approvals in the United States
- Assessing Dispersant Use Trade-offs
- **Aerial and Vessel Dispersant Operations**
- Subsea and Point Source Dispersant Operations
- Dispersants Use and Regulation Timeline
- Dispersant Use in the Arctic Environment

Introduction

Dispersants are used for the rapid removal of oil slicks from the water surface. In general, the primary goal of a response is to remove spilled oil from the environment. When other removal methods (e.g., mechanical tools like boom and skimmers) are deemed to be inadequate for the response or have limited effectiveness due to such factors as weather conditions, distance from useable ports, or water depth, dispersants provide another method to protect vulnerable surface resources and shorelines.

Oil spilled on water poses an ever expanding problem as the slick continues to spread and affect other areas and resources as it moves on the water surface.[1] Responders must determine what response options offer the greatest potential to protect surface resources and shorelines. They must determine whether to attack the surface oil with recovery and removal techniques which may be limited in their recovery capability, potentially allowing for additional impacts to shorelines and wildlife that utilize the water surface, or to remove the spilled oil from the water surface through other means such as the use of dispersants or burning in place (in-situ burning). Both of these methods shift the potential effects from the water's surface to either the water column in the case of dispersant use or the air when in-situ burn is conducted. **Fact Sheet #5 – Dispersant Use Approvals in the United States** summarizes the current requirements for dispersant use for on water spill events.

If dispersants are being considered as a response option, the decision-makers must also consider the toxicity of the oil, dispersed oil, and the dispersant itself since mixing the oil into the water column potentially exposes an array of resources and habitats that normally would not be exposed if the oil were left on the surface. Although scientific research has shown that dispersants are not as toxic as the oil itself and do not increase the toxicity of oil/dispersant mixtures (EPA Office of Research and Development (ORD), 2010), some components of dispersants may be toxic (ASTM, 2006) and their use during an incident must be carefully considered. For more information, refer to **Fact Sheet #4 – Toxicity and Dispersants**.

In different parts of the world, government regulations may require the pre-contracting of aerial and vessel dispersant response resources for dispersant application, including personnel who are trained in and capable of applying dispersants. This may include a requirement for having trained personnel for aerial tracking of oil available.[2]

1 For more information on the forces and weathering effects on oil spilled in water, refer to **Fact Sheet #3 – Fate of Oil and Weathering**.

FIGURE 1. **Dispersant Applications:** *Top Left* – Aerial (plane) application; *Top Right* – Aerial (helicopter) application; *Bottom Left* – Boat spray bar dispersant application; *Bottom Right* – Point source injection (at the wellhead)

Dispersant Applications

After receiving authorization, there are several ways in which dispersants can be operationally applied to spilled oil. These are: 1. aerial dispersant applications (plane and helicopter); 2. boat dispersant applications; and 3. subsea or point source applications.

Dispersants have also been used for the protection of response workers working at a well blowout. As soon as oil comes in contact with the air, it begins to evaporate and the air above a surface slick may contain fairly high levels of Volatile Organic Compounds (VOCs). A number of the smaller molecules contained in the VOCs are known to be harmful to human health. The use of dispersants to keep the oil off of the water's surface was found to be an effective means to keep VOC levels low during the Macondo Well spill response. This was especially important since it improved conditions and allowed responders to work safely in the location of the former platform, an area that had fresh oil present for more than 90 days (Curd, 2011).

Aerial Application Equipment

When applying dispersant from the air, aircraft are equipped with dispersant tanks and spray systems designed for specific aircraft. Current aircraft capabilities vary in size from a helicopter to a Lockheed C-130 Hercules cargo plane (NOAA, 2009). Jet aircraft platforms are soon to be available as well. These platforms will have considerably greater range and can get to a spill site, ready to apply dispersants, quite quickly (OSRL, 2013).

2 In the US, these are described in 33 CFR §154.1045(i) and (j), see references.

FIGURE 2.

Use of dispersants to "knock down" VOCs for responder safety

FIGURE 3.

Aerial Dispersant Deployment System (ADDS) being loaded onto a C-130.

One of multiple examples of aerial spray equipment, such as the NIMBUS and MASS spray systems, is the Aerial Dispersant Deployment System (ADDS). This is a removable tank and spray system that can be fitted to a large C-130 aircraft. It is rolled into the airplane's cargo bay and quickly set up to carry and spray up to 5,000 gallons (19,000 L) of dispersant. Helicopters can be equipped with underslung spray buckets to spray dispersant but are limited to carrying up to 240 gallons (~ 900 L).

FIGURE 4.

Spray nozzle system for dispersant

Nozzles on the spray systems of all aircraft are designed to produce a spray at a particular droplet size to cover the surface of an oil slick with an amount of dispersant to meet agreed upon application ratios (ASTM 2011; 2007a; 2007b), generally five gallons per acre (~47 L/hectare).

Operations

Prior to application, spotter personnel in aircraft identify the location of dispersible surface oil and direct the spray aircraft to these areas. The spotter aircraft directs the pilot when to turn on and off the dispersant spray to ensure exact targeting and avoid overspray. Spray aircraft apply dispersant at altitudes from 50 to 100 feet (15 to 30 m) and at application speeds of 125 to 145 knots (230 to 270 kph). Figure 5 shows a "Race Track" model, which diagrams one of several dispersant application strategies using aircraft (NOAA, 2009).

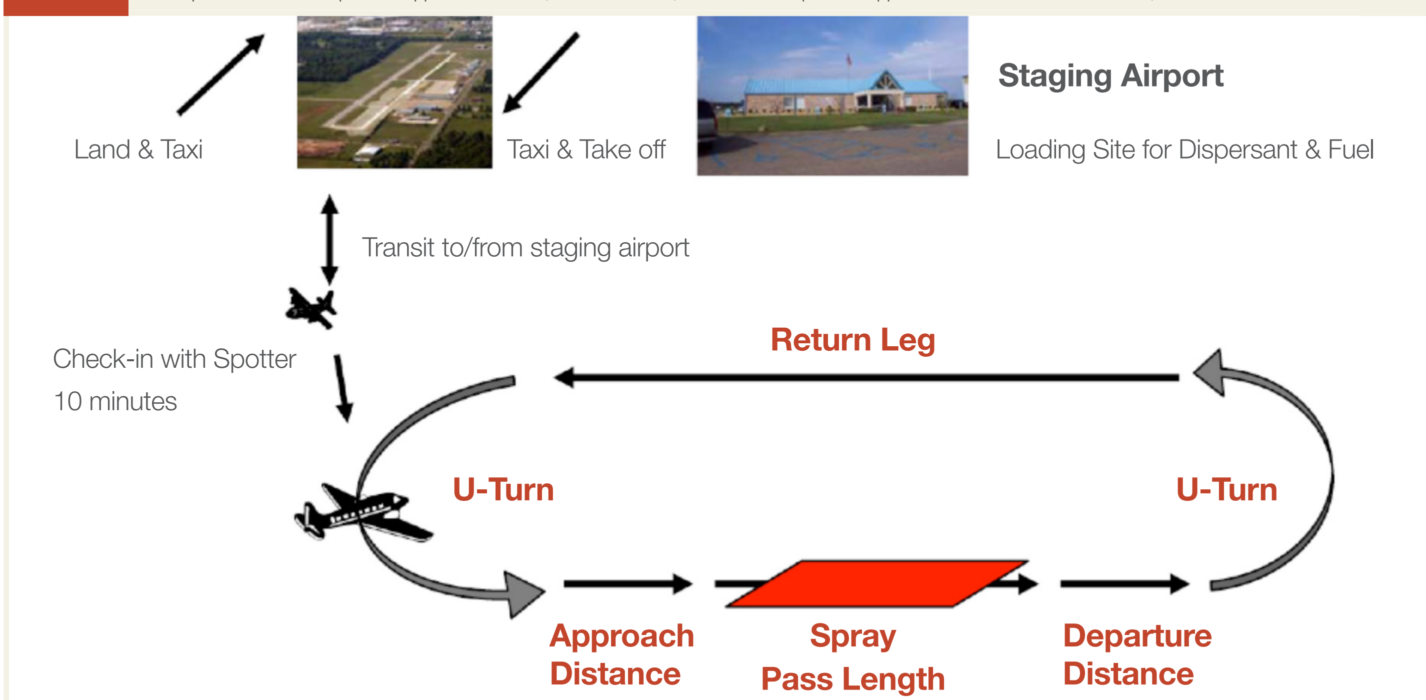
Boat Application

Boat applications are conducted for two reasons: 1) targeted small scale dispersion operations, and for 2) VOC suppression to protect response worker health and for areas where aircraft cannot fly.

For dispersant applications, boats of various sizes can be equipped with portable totes or ISO tanks and a spray arm system. Like aerial applications, the boat spray arm nozzles are adjusted to spray at a specified rate and droplet size to cover the surface of an oil slick with dispersant. As with spray planes, dispersant boats are directed by spotter planes.

Boats provide a valuable platform to help response operations (including capping and containment activities) progress safely and expeditiously. In order to assure the safety of response personnel working at a source location, dispersants may be applied from a boat to reduce the concentration of VOCs in the work area.

FIGURE 5. Example of an aerial dispersant application model, the Race Track, for efficient dispersant application on water. Source: NOAA, 2009.



Benefits and Limitations of Dispersant Applications

Each method of dispersant application has its own benefits and limitations that must be carefully weighed before beginning operations (Allen, 1988).

Benefits:

- Aerial (plane and helicopter) application of dispersants:
  - Can be conducted over very large areas.
  - Greatly increase the volume of oil capable of being treated in a single day.
  - Can arrive at oil slicks far out to sea and begin treatment on day 1 quickly.
  - Provide rapid response (using dedicated aircraft with 2-4 hour response times), especially when additional releases occur, reducing time for oil spreading.
  - Typically have a fast turnaround time for refueling, refilling, etc., often less than 60 minutes.
  - Can operate during heavy sea states, when skimmers and in-situ burning cannot.
- Boat application provides greater safety for response workers by reducing VOC exposures from oil and fumes while working on water.

Limitations:

- Aerial and boat applications are limited during fog when it may be difficult to spot the surface slicks. Aerial assets cannot conduct spray operations in bad weather (e.g., excessive winds) or low visibility.
- Unlike ship-based systems, aerial applications may not be able to observe an oil slick closely to determine thickness, consistency and presence of tarballs.
- Unlike ship-based operations, aircraft observers cannot always distinguish biogenic materials such as jellyfish blooms, fish spawn or sea grass beds from floating oil.

Operational Requirements

During dispersant application, the use of clearly defined logistics, coordination, communication, and trained personnel are required for safe and effective operations. Additionally, there may be specific requirements and components needed for dispersant application, such as the definition of exclusion zones or the use of monitoring equipment

References

33 CFR §154.1045(i) – **Dispersant Operation Requirements**. Available online at http://ecfr.gpoaccess.gov/.

33 CFR §154.1045(j) – **Aerial Oil Tracking Resources**. Available online at http://ecfr.gpoaccess.gov/.

Agency for Toxic Substances and Disease Registry (ATSDR). 1999. ***Toxicological Profile for Total Petroleum Hydrocarbons***. Available on line from http://www.atsdr.cdc.gov/.

Allen, A. 1988. ***Comparison of response options for offshore oil spills***. Proceedings, Artic and Marine Oil Spill Pollution, Vancouver, June 7-9, 1988, pp. 289-306.

ASTM International. 2011. ***ASTM F2465/F2465M*: Standard Guide for Oil Spill Dispersant Application Equipment: Single-point Spray Systems.** Available for purchase online at: www.astm.org/Standards/F2465.htm.

ASTM International. 2008. ***ASTM F1779-08*: Standard Practice for Reporting Visual Observations of Oil on Water.** Available for purchase online at: www.astm.org/Standards/F1779.htm.

ASTM International. 2007a. ***ASTM F1460 – 07*: Standard Practice for Calibrating Oil Spill Dispersant Application Equipment Boom and Nozzle System.** Available for purchase online at: www.astm.org/Standards/F1460.htm.

ASTM International. 2007b. ***ASTM F1413 – 07*: Standard Guide for Oil Spill Dispersant Application Equipment: Boom and Nozzle Systems**. Available for purchase online at: www.astm.org/Standards/F1413.htm.

ASTM International. 2006. ***F2532 – 06*: Standard Guide for Determining Net Environmental Benefit of Dispersant Use**. Available from: http://www.astm.org/Standards/F2532.htm.

Centers for Disease Control and Prevention (CDC). 2010. ***2010 Gulf Oil Spill website***. Specific topic information provided on the Public Health Issues, Hazardous Substances, and General Information weblinks maintained on this webpage: http://emergency.cdc.gov/gulfoilspill2010/.

Curd, H. 2011. **The Use of Dispersant for the Control of Volatile Organic Compounds**. In: Proceedings of the 2011 International Oil Spill Conference, Portland, OR. 7 pages. Available from: http://www.ioscproceedings.org/doi/abs/10.7901/2169-3358-2011-1-359.

National Oceanic and Atmospheric Administration (NOAA). 2009. ***NOAA Dispersant Mission Planner 2*** (DMP2). Available from: http://response.restoration.noaa.gov/dmp2.

Oil Spill Response Limited (OSRL). 2013. **Aviation Capability – Hercules Aircraft Replacement Project.** Available from: http://www.OilSpillResponse.com.

SpillPrevention.org

SUBSEA AND POINT SOURCE DISPERSANT OPERATIONS

Things You Should Know

- Dispersants may only be applied with the appropriate government approvals.
- Subsea injection reduces the amount of oil coming to the surface and the potential for exposure by personnel to the volatile organic components of the oil.
- Subsea injection may require significantly less dispersant compared to dispersing at the surface. In a subsea release or a puncture of a pipeline or tanker that cannot be rapidly controlled, decision-makers should consider the application of dispersants as close to the leak source as possible.
- An efficient subsea dispersant delivery system could potentially treat the vast majority of oil escaping from a single release point before it reaches the surface and forms a widely spread slick.
- Subsea injection may proceed day and night and is generally not limited by weather. Other response options are usually limited to daylight hours and could have significant weather limitations.
- Dispersants remove oil from the water surface thereby protecting birds, mammals and sensitive shorelines.
- Oil discharged in deep waters will be removed from the environment by petroleum degrading bacteria found throughout the water column world-wide. The addition of dispersant will enhance the rate of biodegradation due to the increased surface area accessible to bacteria.
- Treated oil is rapidly diluted to the point that biodegradation occurs at low concentrations without depleting oxygen or nutrients.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these very small oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume.

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools - mechanical recovery and burning in place (also known as *in-situ* burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas, et al., 2001; 2005)

This fact sheet summarizes the benefits and limitations of dispersants use for subsea and point source injection.

Fact Sheet Series

- Introduction to Dispersants
- Dispersants — Human Health and Safety
- Fate of Oil and Weathering
- Toxicity and Dispersants
- Dispersant Use Approvals in the United States
- Assessing Dispersant Use Trade-offs
- Aerial and Vessel Dispersant Operations
- **Subsea and Point Source Dispersant Operations**
- Dispersants Use and Regulation Timeline
- Dispersant Use in the Arctic Environment

Introduction

If an oil spill occurs, some level of impact is inevitable. The use of dispersants is one response method used to reduce those impacts. In general, the use of dispersants is only authorized with appropriate government approvals. **Fact Sheet 5 – Dispersant Use Approvals in the United States** provides an example of the necessary regulatory authorities and requirements for the use of dispersants.

Dispersants have typically been used for the rapid removal of oil from the water surface when other removal methods (e.g., mechanical recovery) are deemed to be inadequate for the response or have limited effectiveness due to weather conditions, response time, etc. Subsea and point source dispersant operations allow dispersant to be applied at the point of release to more efficiently protect vulnerable surface resources and shorelines rather than waiting for the oil to surface and spread out in large surface slicks that would present a challenge for recovery. While there will likely be some level of impact to water column-dwelling organisms, impacts are expected to be limited and relatively short lived in comparison to effects that would be experienced by sensitive shoreline communities.

Subsea and Point Source Dispersant Application

Subsurface Injection by ROV at the well head. Photo provided by BP.

During subsea dispersant applications (also referred to as subsurface injection), dispersants are transferred from a surface ship or a dispersant storage tank on the sea floor and are applied directly at the point of release by a remotely operated vehicle (ROV) or hard piped into the blow-out preventer (BOP) or some other subsea assembly. A hose and nozzle are manipulated by ROVs to deliver dispersant directly into oil being discharged, such as from a broken pipe or well head, as was done for the Macondo Well response in 2010. This allows:

- The dispersant to mix with oil more effectively. The encounter rate with oil (dispersant interacting with the oil during application) can be as high as 100%, whereas encounter rates with surface dispersant application methods, albeit high, can vary with sea state, wind, etc.
- Dispersion to occur in deeper waters in order to rapidly reduce the size and concentration of oil droplets and prevent them from reaching the water's surface.

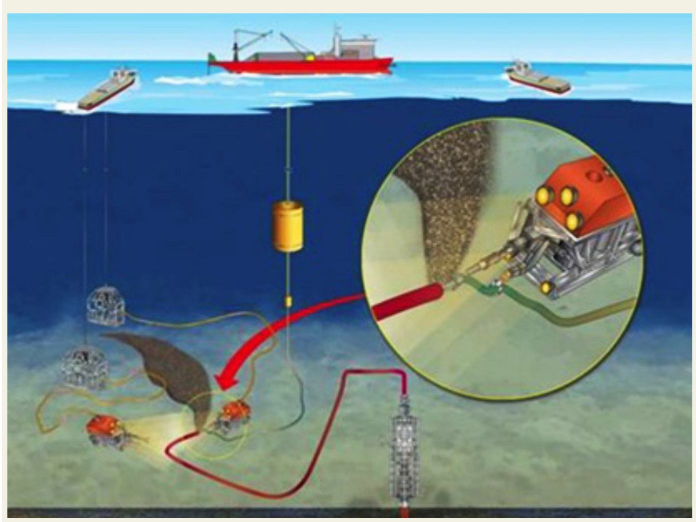
Dispersants can also be directly applied to the source of oil leaking from a foundering ship in heavy weather or to a holed vessel at sea when other response methods may have limited effectiveness, i.e., as a point source application.

Advantages of Subsea and Point Source Application

Subsea and point source applications have several advantages over surface dispersant applications:

- **Safety** — subsea injection reduces the amount of oil coming to the surface and this in turn (a) reduces the potential for exposure of surface vessels and personnel to volatile components of the oil and (b) reduces the need for surface recovery, *in-situ* burn, and surface dispersant operations, thereby reducing the potential for exposure of response personnel to accidents during these operations.
- Point source applications can reduce the potential for worker and public exposures by treating the oil where it is being discharged and preventing it from spreading or coming closer to shore.
- **Oil Removal** — Natural biodegradation processes will remove the oil from the environment as petroleum-degrading bacteria found throughout the water column world-wide consume the oil as a food source. The addition of dispersant will enhance the rate of biodegradation due to the increased surface area of the very small individual droplets that are formed.
- **Efficiency** — Subsea injection may require significantly less dispersant compared to dispersing at the surface.

Example of subsurface dispersant injection using a ROV. Graphic provided by ExxonMobil.



- **Precision** — Subsea application ensures that all dispersant is mixed with the oil at one manageable location before it spreads, instead of trying to treat widely spread oil slicks at the surface.
- **Application** — Surface and point source dispersant applications require favorable weather conditions, while subsea dispersant injection from a vessel can proceed in a much broader range of conditions.
- **Timing** — Application can occur around the clock, whereas surface (aerial and vessel) applications are usually restricted to daylight hours.
- **Effectiveness** — The operational effectiveness of dispersant applications on subsurface and point source oil discharges is likely to be more effective as the oil being treated has not undergone extensive weathering. Weathering of the oil can make it less dispersible. For more information refer to **Fact Sheet 3 – Fate of Oil and Weathering**.
- **Biodegradation Enhancement** — Dispersant treated oil is rapidly diluted to the point that biodegradation can occur at very low concentrations without depleting oxygen or nutrient levels in the water column.

Regulatory Requirements

As of 2013, there are no regulations that apply specifically to subsea and point source dispersant use. The approval process is generally the same as for surface use, however, this may change.

To date, none of the Regional Response Teams (RRTs) have specifically addressed subsea injection and point source dispersant applications in their regional and area planning documents, although its use is a topic of current discussion. The RRTs have the responsibility to evaluate and provide decision-making guidance/policy on the use of response technologies within each region. As this technology has not been widely applied, the National Response Team (NRT) has developed guidance to assist the RRTs as they may be asked to evaluate the potential use of subsea dispersant injection as well as associated monitoring requirements. For more information refer to **Fact Sheet 5 – Dispersant Use Approvals in the United States**.

Areas Under Further Investigation

Numerous research projects are currently investigating various aspects of subsea injuection of dispersants, including:

- Effects of dispersed oil at depth on living organisms and the food chain
- Whether or not sedimentation of oil on the sea floor is affected by the use of dispersants
- Long term effects of oil at extreme depths
- Rate of biodegradation at depth

It is expected that the application protocols associated with subsea dispersant use will be further refined as more data are available.

References

Etkin, D.S. 2009. **Analysis of U.S. Oil Spillage**. The American Petroleum Institute, Regulatory and Scientific Affairs Department. Washington, D.C.: American Petroleum Institute. 86 pages.

Fingas, M.F., R.G. Stoodley, N. Stone, R. Hollins, and I. Bier. 1991. **Testing the Effectiveness of Spill-Treating Agents: Laboratory Test Development and Initial Results**. In: *Proc. 1991 International Oil Spill Conference.* API. Washington, DC.

Fingas, M.F., D.A. Kyle, N.D. Laroche, B.G. Fieldhouse, G. Sergy, and R.G. Stoodley. 1995. "The Effectiveness of Spill Treating Agents." **The Use of Chemicals in Oil Spill Response**, ASTM STP1252, P. Lane, Ed. ASTM, Philadelphia, Pennsylvania.

International Association of Oil & Gas Producers (OGP). 2010. **OGP Risk Assessment Data Directory – Blowout Frequencies**. Report No. 434-2. 20 pages. Available online from: www.ogp.org.uk/pubs/434-02.pdf.

SINTEF. 2012. SINTEF Offshore Blowout Database – Definitions. Available on line from: http://www.sintef.no/home/Technology-and-Society/Safety-Research/Projects/SINTEF-Offshore-Blowout-Database/.

SpillPrevention.org

DISPERSANT USE & REGULATION TIMELINE

Things You Should Know

Scientists have been studying the effects of dispersants and dispersed oil on the marine environment for over 30 years so much is already known and research is still ongoing.

In addition to laboratory studies, real world spills have provided responders with lessons about how to use these products more efficiently and with the fewest impacts to the ecosystem.

The lessons have resulted in modern commercial dispersants that are more effective and safer to use in the environment than materials used in early response efforts.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these very small oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume.

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools — mechanical recovery and burning in place (also known as in-situ burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas, et al., 2001; 2005)

This fact sheet summarizes significant spill events and subsequent regulatory changes that have advanced spill response and the use of dispersants as an operational response tool.

Fact Sheet Series

- Introduction to Dispersants
- Dispersants — Human Health and Safety
- Fate of Oil and Weathering
- Toxicity and Dispersants
- Dispersant Use Approvals in the United States
- Assessing Dispersant Use Trade-offs
- Aerial and Vessel Dispersant Operations
- Subsea and Point Source Dispersant Operations
- **Dispersants Use and Regulation Timeline**
- Dispersant Use in the Arctic Environment

Introduction

On 18 March 1967, the tanker vessel (T/V) *Torrey Canyon* ran aground on Pollard's Rock near Cornwall, England carrying nearly 860,000 barrels (36,120,000 gallons; 137,000 m^3) of crude oil. Much of the oil was consumed in a fire or lost into the Atlantic Ocean. The spill response in 1967 was the first time responders realized that mechanical recovery methods were not going to be effective for the incident because of the weather and wave conditions in the spill area. As a result, they attempted to chemically remove the oil from the water surface and shoreline and mix the oil into the water column using chemical degreasers that were not designed for oil spill response to "disperse" the oil. This was an unfortunate initial attempt to "disperse" oil as these degreasers are generally cited as doing more harm than good.

From these beginnings, the world response community has learned many lessons and now utilizes very different low toxicity dispersant formulations. Dispersants are a key component of the spill response tool kit, and in many cases and countries they represent a primary or secondary response option. In all cases, dispersant products and their use are regulated by government agencies to ensure that they are used appropriately and effectively.

Figure 1(a-e) displays a timeline from 1967 to 2010 that summarizes the history of significant spill response events with dispersant use and the subsequent regulatory actions. It should be noted that the list is a sampling of events and does not include the evaluation of dispersant performance during numerous large scale test tank and field trial evaluations. As lessons have been learned and regulatory requirements have been developed, modern dispersants have been prepared that are effective under a range of conditions and when used appropriately, have low environmental and human health risk. The decision to use or not use dispersants in response to a spill should be based on a well informed Net Envrionmental Benefit Analysis (NEBA) (see **Fact Sheet 6: Assessing Dispersant Use Trade-offs**).

1967 — *T/V Torrey Canyon*, Cornwall, England, UK

At the time, the *T/V Torrey Canyon* was the biggest on-water oil spill in world history — losing nearly 470,000 barrels (19.7 million gallons; 75,000 m^3) of crude oil over a 12 day period. Little was known about how to deal with a spill of this size. Ultimately, more than 120 miles (190 km) of coastline were affected by the oil with extensive damage to marine and intertidal communities. The spill created an oil slick measuring 270 square miles (700 km^2), and oiled 180 miles (300 km) of coastland. More than 15,000 sea birds and large numbers of aquatic animals were estimated to be killed before the spill was brought under control. Unfortunately, efforts to clean up the oil only compounded the situation when the Royal Navy attempted to disperse it using industrial degreasers.

These products were toxic, resulting in a great deal of damage to the marine environment, birds, sea lions, and other marine life. The use of these degreasers is generally considered to have been a great mistake.

1968 — Initial US National Contingency Plan

The US responded to the *Torrey Canyon* spill by developing its first National Contingency Plan (NCP). It was the nation's initial attempt to develop a coordinated approach to cope with potential spills in U.S. waters and provided the first comprehensive system of accident reporting, spill containment, and cleanup.

1969 — Well A-21 Blowout — Santa Barbara, CA, USA

On 28 January 1969 the Santa Barbara, CA well (A-21), located six miles off the coast, experienced a blowout and oil began to leak. Several unsuccessful attempts were made to cap the leak. An estimated 77,000 barrels (3.2 million gallons; 12, 000 m^3) of oil were released, causing significant damage to shorelines and injuring thousands of birds and marine mammals. As part of the response, 900 barrels (37,500 gallons; 143 m^3) of the product, ARA Gold Crew Bilge Cleaner, were applied to the slick in an attempt to mix the oil into the water column to prevent shoreline impacts. As with the *Torrey Canyon* response, this product was not created for dispersing oil. No official estimates of effectiveness or toxicity were made for the cleaning product (Fingas 2011; NOAA, 1992).

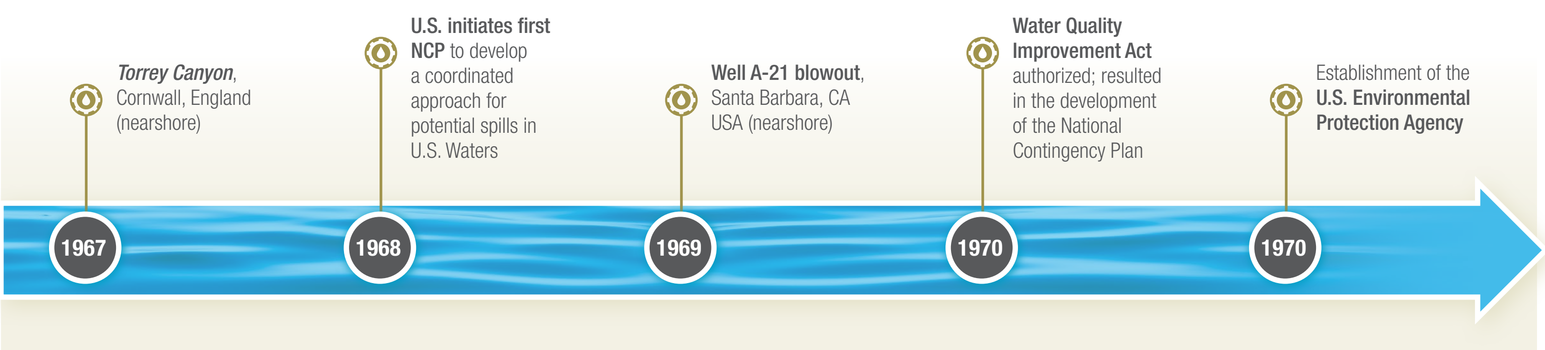
1969 Santa Barbara well blowout. Photo: from the LA Times *online*

The 1969 Santa Barbara Well A-21 response was the first use of dispersants during an ocean blowout.

1970 — Water Quality Improvement Act and NCP Authorized

Recognizing the importance of clean water to the public health and welfare, the US Congress legislated the basic legal authority for federal regulation to improve the quality

FIGURE 1(A). Timeline of dispersant use and subsequent regulatory changes: **1967 – 1970**



of water resources and to establish a national policy for the prevention, control, and abatement of water pollution. Additional legislation was passed that expanded its authority over water quality standards and water polluters through the Water Quality Improvement Act of 1970. This Act placed additional limits on the discharge of oil into water where it could damage human health, marine life, wildlife, or property. The act also included a number of other provisions intended to reduce water pollution.

Congress also broadened the scope of the NCP to include a framework for responding to hazardous substance spills as well as oil discharges. Over the years, additional revisions have been made to the NCP to address further legislation related to oil spills.

1970 — US Environmental Protection Agency Established

On 2 December 1970, President Nixon established the US Environmental Protection Agency (EPA) to consolidate federal research, monitoring, standard-setting, and enforcement activities into one agency to ensure environmental protection of US waters.

Due to the haphazard nature of water quality regulation, Congress restructured the authority for water pollution control and consolidated authority in the EPA Administrator.

1970 — Chevron Main Pass Block 41, Platform C, Gulf of Mexico (GOM), USA

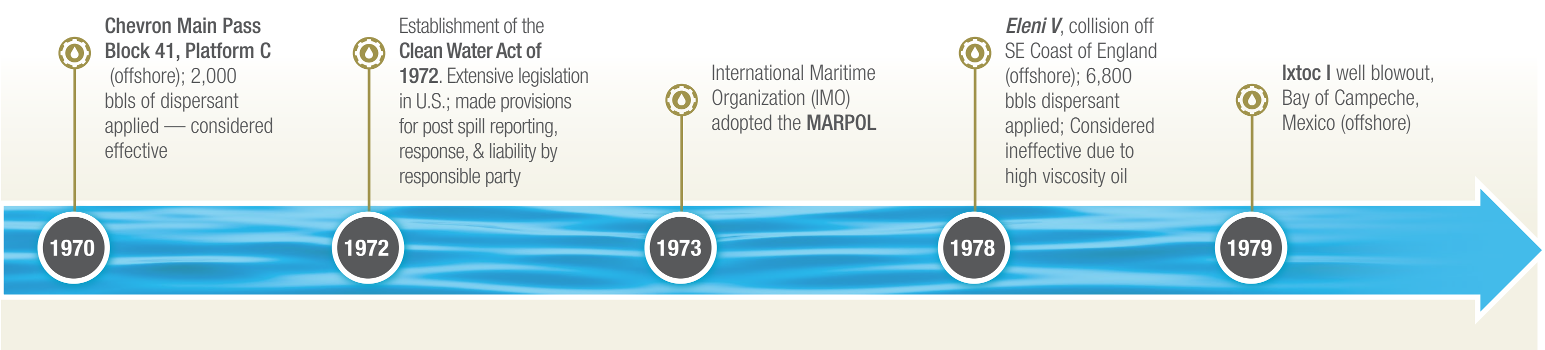
On 10 February — 10 March 1970, the Chevron Main Pass Block 41C platform burned as oil and gas were lost from the wellhead. An estimated 65,000 bbls (2.7 million gallons; 10,300 m^3) of crude oil were released into the environment. Once the fire was out, approximately 2,000 bbls (84,000 gallons; 320 m^3) of dispersants were applied to the platform to prevent the rig from re-igniting; no attempt was made to treat the entire slick with dispersants. Little damage was recorded for beaches, wildlife, or marine life from the spill and dispersed oil. The application of dispersants in this manner was from a health and safety standpoint, rather than as an operational response tool (NOAA, 1992).

1972 — US Clean Water Act Authorization

The Federal Water Pollution Control Act of 1948 was the first major US law to address water pollution. As amended in 1972, the law became commonly known as the Clean Water Act (CWA). The amendment (*from EPA online*, 2012):

- "Established the basic structure for regulating pollutants discharges into the waters of the US.
- Gave EPA the authority to implement pollution control programs such as setting wastewater standards for industry.
- Maintained existing requirements to set water quality standards for all contaminants in surface waters.
- Made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions.
- Funded the construction of sewage treatment plants under the construction grants program.
- Recognized the need for planning to address the critical problems posed by nonpoint source pollution."

FIGURE 1(B). Timeline of dispersant use and subsequent regulatory changes: **1970 – 1979**



1973 — International Maritime Organization Adopts International Convention for the Prevention of Pollution from Ships (MARPOL)

The IMO adopted the International Convention for the Prevention of Pollution from Ships (MARPOL) on 2 November 1973, which covered pollution by ships from operational or accidental causes. This included pollution from oil, chemicals, harmful substances in packaged form, sewage, and garbage. Subsequent modification of the 1973 Convention has incorporated tanker design and operations into the Protocol (IMO online, 2013).

1978 — *T/V Eleni V*, Southeast coast of Norfolk, England, UK

On 6 May 1978, the *T/V Eleni V* collided with another vessel and was broken in two off the southeast coast of England. Approximately 52,500 bbls (2.2 million gallons; 8,400 m^3) of heavy fuel oil was released. The oil was very thick and produced a large "viscous slick that was brown to black in color" (NOAA, 1992) and impacted both the UK and Dutch coastlines with thick emulsions washing ashore. Responders applied some 6,800 bbls (285,000 gallons; 1,100 m^3) of dispersants over a three week period to the spreading slicks. However, due to the oil type, weathering, and emulsification, the products available at the time were not effective and did little to prevent shoreline oiling. This response confirmed that the dispersant formulations that existed at the time were not effective on heavy viscous oils (NRC, 1989).

1979 — Ixtoc-1 Well Blowout, GOM, Mexico

On 3 June 1979 the Ixtoc I platform, located in Mexico's Bay of Campeche located in the southern Gulf of Mexico, experienced a blowout due to a loss of drilling mud circulation. The oil and gas being released at the surface caught fire and the platform collapsed into the wellhead area, preventing initial attempts to control the release.

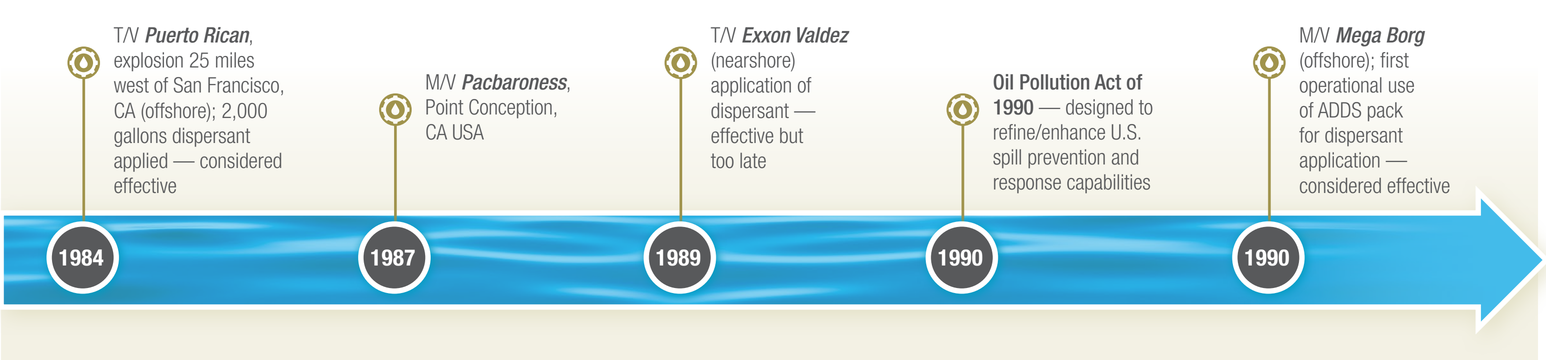
IXTOC-1 well blowout. Photo: NOAA.

The well was estimated to produce 20,000 barrels per day [bpd] (840,000 gallons per day; 3,200 m^3 per day). When it was capped on 23 March 1980, the total discharge was estimated to be 3,520,000 bbls (148 million gallons; 562,000 m^3) (Fingas, 2011; NOAA, 1992). As part of the response, approximately 1,100 square miles (2900 km^2) of surface slicks in Mexico's waters were treated with the dispersant Corexit© 9527 which was designed specifically for use with on-water oil spills. While quantitative measurements of dispersant effectiveness do not exist for the multiple applications to a range of different slicks, there were indications that the use of dispersants did reduce the amount of surface oil (Fingas, 2011; NOAA, 1992; NRC, 1989).

1984 — *T/V The Puerto Rican*, San Francisco, CA, USA

The *T/V Puerto Rican* response was the first time that dispersants were authorized on a major oil spill in the US. The ship broke into two parts following explosions and fires approximately 32 miles (51 km) offshore from the Golden Gate Bridge, San Francisco, CA. Approximately 100,000 barrels (4,200,000 gallons; 16,000 m^3) of lube oil, bunker fuel, and additives were discharged into the Pacific Ocean. The spill was treated with 50 barrels (2,000 gallons; 7.6 m^3) of Corexit 9527 and was considered initially effective (NOAA, 1992; NRC, 1989).

FIGURE 1(C). Timeline of dispersant use and subsequent regulatory changes: **1984 – 1990**



1987 — *M/V Pacbaroness*, Point Conception, CA, USA

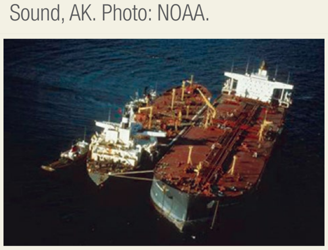
Pacbaroness. Photo: NOAA.

After a collision with another vessel, the bulk carrier *Pacbaroness* sank in almost 1,400 feet (425 m) of water almost twelve miles (19 km) off the coast of Point Conception, CA, discharging over 30 bpd (1,200 gallons per day; 4.6 m^3 per day) of fuel oil. It is thought that up to 475 bbl (20,000 gallons; 760 m^3) of fuel oil may have been released from the wreckage.

This spill provided an opportunity to study the effectiveness of oil dispersants. Three separate dispersant trials were conducted by applying more than 8 barrels (350 gallons; 1.3 m^3) of Corexit 9527 using fixed wing aircraft and helicopter applications. Even with careful measurements, the results of the study were somewhat inconclusive because of complicating factors, such as slick breakup due to heavy winds, the thin nature of the slick and the limited area of treatment (NOAA, 1992).

1989 — *T/V Exxon Valdez*, Prince William Sound, AK, USA

Exxon Valdez incident in Prince William Sound, AK. Photo: NOAA.



The 24 March 1989 grounding of the tanker *Exxon Valdez* on Bligh reef created the US's second largest on water spill response, with more than 262,000 bbls (10,900,000 gallons; 41,000 m^3) of crude oil released into a remote, scenic, and biologically productive body of water. The type of oil that was released, Alaska North Slope or ANS, has been studied on numerous occasions since and has been found to be amenable to dispersion. An initial aerial dispersant application trial was thought to be successful, but severe weather during the early stages of the spill response halted any further dispersant applications and dispersants were not a tool that was used during the response (Wiens, 2013)

This incident prompted the US to revise its oil spill prevention, response, and cleanup preparedness regulations.

1990 — The Oil Pollution Act of 1990

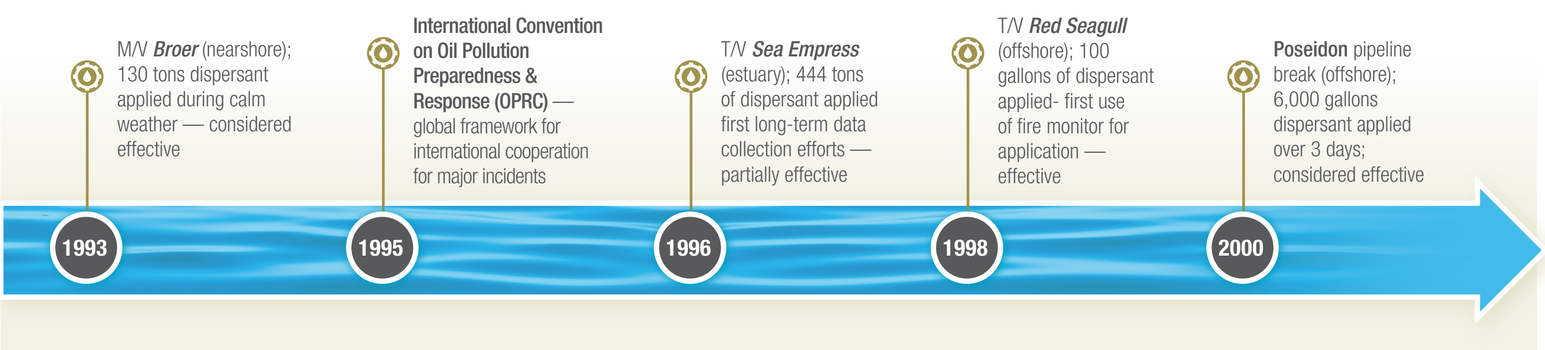
The US Congress passed the Oil Pollution Act (OPA) in August 1990, following the Exxon Valdez incident.

"The OPA improved the nation's ability to prevent and respond to oil spills by establishing provisions that expand the federal government's ability, and provide the money and resources necessary, to respond to oil spills. The OPA also created the national Oil Spill Liability Trust Fund, which is available to provide up to one billion dollars per spill incident.

In addition, the OPA provided new requirements for contingency planning both by government and industry. The National Oil and Hazardous Substances Pollution Contingency Plan (NCP) has been expanded in a three-tiered approach: the Federal government is required to direct all public and private response efforts for certain types of spill events; Area Committees — composed of federal, state, and local government officials — must develop detailed, location-specific Area Contingency Plans; and owners or operators of vessels and certain facilities that pose a serious threat to the environment must prepare their own Facility Response Plans.

Finally, the OPA increased penalties for regulatory noncompliance, broadened the response and enforcement

FIGURE 1(D). Timeline of dispersant use and subsequent regulatory changes: **1993 – 2000**



authorities of the Federal government, and preserved State authority to establish law governing oil spill prevention and response." (excerpted from USEPA online, 2011)

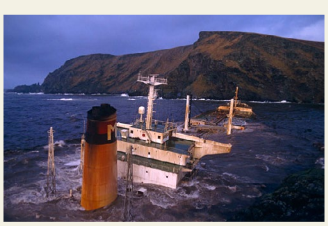
1990 — *T/V Mega Borg*, GOM, USA

T/V Mega Borg incident in the US GOM. Photo: NOAA.

On 8 June 1990, the *Mega Borg* was disabled by a fire and explosion in the Gulf of Mexico, 57 miles (92 km) southeast of Galveston, TX in international waters. The ship then drifted while leaking burning oil for several days before the fire was extinguished. Estimates indicate that between 300-1,000 barrels (12,000-40,000 gallons; 45–150 m^3) of light crude oil were released into the water and did not burn. The use of Corexit© 9527 was authorized within five nautical miles (9 km) of the stricken vessel to treat the rapidly spreading surface oil. Six dispersant applications over a five-day period totaling ~300 barrels (11,300 gallons; 43 m^3) were determined to be effective on the crude oil surface slicks (NOAA, 1992).

1993 — *M/V Braer*, Shetland, Scotland, UK

The *Braer* foundering off Shetland, Scotland. Photo: www.thetimes.co.uk.



On 5 January 1993 the *M/V Braer* ran aground very close to shore at Garth's Ness, Shetland, Scotland during heavy weather. Over a 12 day peroid nearly all of its 600,000 barrel (25 million gallons; 95,000 m^3) cargo of Norwegian Gullfaks crude oil and its heavy bunker oil were released as the ship broke apart. Conditions prevented mechanical recovery, but during calmer periods 1,000 bbl (42,000 gallons; 130 m^3) of dispersant (Dasic) was applied.

The *M/V Braer* was unusual because no large surface slick was produced and cleanup was minimal for the volume spilled, primarily because of the very energetic conditions of the wind and waves. The oil was effectively dispersed both naturally and by the addition of dispersants. This incident demonstrated that dispersion can prevent effects associated with a floating slick (Kingston, 1999).

1995 — International Convention on Oil Pollution Preparedness, Response, and Co-Operation (OPRC)

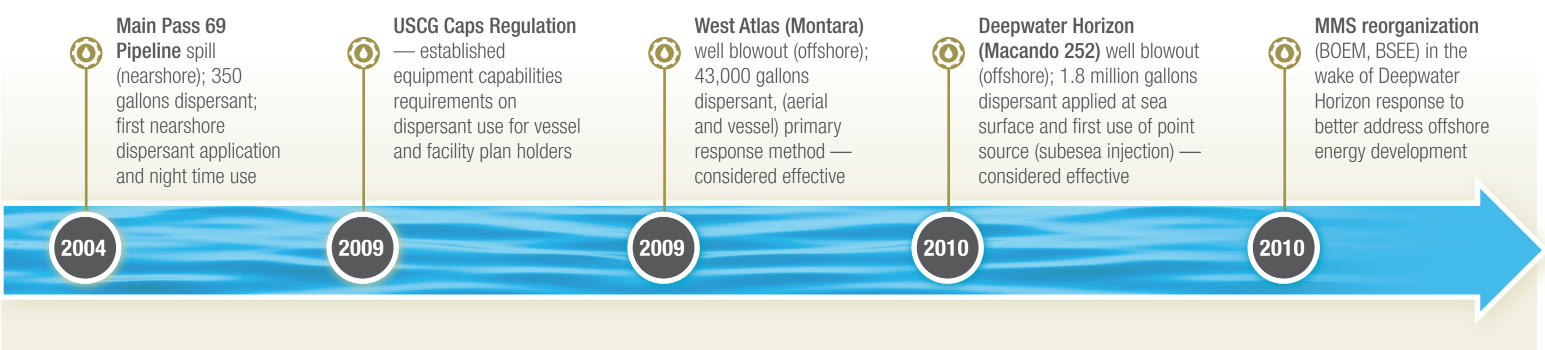
OPRC is the first overarching international agreement dealing with **response** to marine pollution. It was adopted by IMO in November 1990 and became international law in May 1995. The Convention is designed to:

- Help governments prepare for and respond to major oil pollution incidents
- Facilitate international co-operation and mutual assistance relative to a major oil pollution incident
- Encourage States to develop and maintain an adequate capability to deal with oil pollution emergencies.

1996 — *M/V Sea Empress*, Milford Haven, Wales, UK

On 15 February 1996, the *M/V Sea Empress*, carrying roughly 460,000 bbl (19.5 million gallons; 74,000 m^3) of forties crude oil and 2,300 bbl (100,000 gallons; 370 m^3) of heavy fuel oil ran aground and released its cargo. This incident was the first to be monitored promptly and in detail. Methods used included two aircraft equipped with Side Looking Airborne Radar (SLAR), downward looking video, as well as Infrared (IR)

FIGURE 1(E). Timeline of dispersant use and subsequent regulatory changes: **2004 – 2010**



M/V Sea Empress vessel casualty. Photo: www.walesonline.co.uk.

and UV cameras. Modeling was also used to assist in planning. Approximatley 2,800 bbl (120,000 gallons; 444 m^3) of Corexit© and Dasic© dispersants were applied and research indicated that a significant amount of emulsified oil formation was prevented. This likely served to prevent oiling of wildlife and commercially important beaches and served to demonstrate the potential that dispersant use offers (White and Baker, 1998).

1998 — *M/T Red Seagull* tanker, Galveston, TX, USA

The *M/T Red Seagull* began leaking light crude oil while anchored in the Galveston Lightering Area and released a total of 400 bbl (17,000 gallons; 64 m^3) of oil. After the leak was repaired it was estimated that 100 bbl (4,200 gallons; 16 m^3) of oil were trapped under the ship. As a response measure and also a demonstration of the ability of fire monitors to be used for application of dispersants, an estimated 20-30 bbl (840-1,260 gallons; 3-5 m^3) of oil were effectively treated with 80 gallons Corexit© 9500. This application demonstrated the proof of concept for using a modified fire monitor to apply dispersant. Additionally, effective dispersion of the surface oil was reported. (Henry, 2005).

2000 — Poseidon Pipeline Discharge, GOM, USA

On 21 January 2000, a 24” (0.61 m) crude oil pipeline that transports oil from offshore to onshore facilities experienced a pipeline failure and leak approximately 65 miles (105 km) south of Houma, Louisiana. The spilled oil was within a pre-approval zone for dispersant use and met all US EPA Regional Response Team requirements for authorization.

Over a two-day period, approximately 140 bbl (6,000 gallons; 23 m^3) of Corexit 9527 dispersant was applied to the surface slicks. An estimated 75% effectiveness rate was observed for the first day of applications. Using the required analytical protocols, on-water dispersant monitoring efforts verified that the dispersant application had been effective. Once the dispersant appeared to lose its effectiveness as the oil weathered (for more information, see **Fact Sheet 3: Fate of Oil and Weathering**), dispersant operations were halted. This dispersant application was considered to be highly successful and documented by both visual observation and analytical methods based on fluorometry measurements (Henry, 2005).

2004 — Main Pass 69 Pipeline, Louisiana, USA

On 15 September 2004, Hurricane Ivan damaged the Main Pass 69 pipeline where an 18 inch (0.46 m) and a 20 inch (0.51 m) pipeline crossed; both lines were damaged and leaked crude oil. The leak continued for 20 days until the source was controlled. An estimated 7,000 bbl (300,000 gallons; 1,140 m^3) of oil may have been released.

Due to the location of the release site, the US Fish & Wildlife Service noted that approximately 2,000 birds on an exposed sandbar were at immediate risk from the oil and thousands of other birds were potentially at risk in the general area. Given that the spill location was outside the existing pre-authorization zone, specific approval was required to proceed with dispersant use. This was granted and dispersants were applied in areas where oil escaped the recovery operations and presented a direct risk to wildlife and sensitive habitat. A total 8 bbl (350 gallons; 1.3 m^3) of Corexit 9527 and 120 bbl (5,000 gallons; 19 m^3) of Corexit 9500 were applied on two different days. While dispersant effectiveness received mixed reports, this represented the first time dispersants were applied in nearshore waters since OPA 90 was enacted (Henry, 2005).

2009 — US Coast Guard CAPS Regulation

The USCG initiated the "CAPS" rule (Vessel and Facility Response Plans for Oil: 2003 Removal Equipment Requirements and Alternative Technology Revisions) in 2009, making dispersant capability a regulatory requirement for vessels and facilities planning in the US by 2011. The CAPS rule enhances the existing response requirements by requiring advance contracts for dispersants and related delivery equipment; and, aerial tracking and trained observation personnel.

2009 — Montara Well Blowout, East Timor Sea, Australia

The Montara Wellhead Platform casualty. Photo: AMSA.

On 1 August 2009 the Montara wellhead platform off of the northwestern Australia in the East Timor Sea had a blowout, releasing oil and gaseous hydrocarbons into the environment. The discharge continued for 10 weeks until the well was killed on 3 November and capped by 3 December, 105 days after the initial blowout. The incident response was challenged since the platform was located 140 nautical miles (260 km) from shore.

Initial estimates were that the well was releasing approximately 400 bbl (17,000 gallons of oil; 65 m^3) per day, but later estimates ranged from 400 to 3,000 bbl (17,000 to 126,000 gallons; 65 to 4,800 m^3) per day. Over the duration of the incident, the majority of the oil remained within 19 nautical miles (35 km) of the platform (AMSA, 2010).

Aerial dispersant operations began on August 23rd and continued through November 1st. Seven types of dispersants were applied during this period — approximately 1,160 bbl (48,600 gallons; 184 m^3) — using aerial and vessel spraying operations. It was eventually concluded that in this response, the use of dispersants "*was highly effective in assisting the natural process of biodegradation and minimising the risk of oil impacts on reefs or shorelines*" (AMSA, 2010).

2010 — Deepwater Horizon Blowout, GOM, USA

On 20 April 2010 the Deepwater Horizon drilling platform, located approximately 47 miles (87 km) offshore of Louisiana in the Gulf of Mexico, suffered a blowout that resulted in an explosion and fire killing eleven people. The platform eventually sank.

The resulting spill was the largest marine oil spill in US history, and while estimates vary, the US Government's estimates that the volume released was 4.9 million barrels (205 million gallons; 780,000 m^3) (Lehr et al., 2010) and the operator's estimate is 2.45 million barrels (102.9 million gallons; 389,500 m^3) (Post-Trial Memorandum, 2013).

The Deepwater Horizon Platform on fire. Photo: USCG.

Numerous response techniques were used, including the application of 43,000 barrels (1.8 million gallons; 6800 m^3) of dispersant. Approximately 18,000 barrels (770,000 gallons; 2,900 m^3) of which were applied through subsurface injection at the source of the leak at the seafloor (National Commission, 2011; Lehr et al., 2010). For additional information on the use of dispersants in a subsea application, see **Fact Sheet 8 — Subsea and Point Source Dispersant Operations**.

This spill response continues to be the most studied in US history. The use of dispersants is considered to have been effective in the water column for enhanced biodegradation (Camilli et al., 2010; Hazen et al., 2010); however the full environmental effects continue to be studied. Numerous research projects are studying long-term and short-term effects of the oil, dispersant, and the dispersant-oil mixture. Studies range from overall environmental effects, to individual species DNA level effects.

2010 — Minerals Management Service (MMS) Reorganization

The Minerals Management Service was created on 19 January 1982, consolidating components from the U.S. Geological Survey, the Bureau of Land Management and the Bureau of Indian Affairs. In the wake of the Deepwater Horizon response, the President of the US tasked the Secretary of the Department of the Interior to conduct a fundamental restructuring of MMS to divide its three conflicting missions into separate entities with independent missions. The new divisions include:

- **Bureau of Ocean Energy Management** (BOEM): responsible for managing environmentally and economically responsible development of the nation's offshore resources.
- **Bureau of Safety and Environmental Enforcement** (BSEE): responsible for ensuring safety and environmental oversight of offshore oil and gas operations, including permitting and inspections, of offshore oil and gas operations.
- **Office of Natural Resources Revenue** (ONRR): responsible for the royalty and revenue management of all revenues associated with both federal offshore and onshore mineral leases.

References

33 CFR §154.1045(i) — **Dispersant Operation Requirements**. Available online at http://ecfr.gpoaccess.gov/.

33 CFR §154.1045(j) — **Aerial Oil Tracking Resources**. Available online at http://ecfr.gpoaccess.gov/.

Australian Maritime Safety Authority (AMSA). 2010. **Response to the Montara Wellhead Platform Incident**. Report of the Incident Analysis Team. March 2010. 48 pages. Available online from: http://www.amsa.gov.au/Marine_Environment_Protection/Montara_Well_Head_Platform/.

Australian Maritime Safety Authority (AMSA). 2009. **Shoreline Assessment Ground Survey: An operational component of the Monitoring Plan for the Montara Well Release Timor Sea October 2009.**

Camilli, R.,C.M. Reddy, D.R. Yoerger, B.A.S. Van Mooy, M.V. Jakuba, J.C. Kinsey, C.P. McIntyre, S.P. Sylva, and J.V. Maloney. 2010. **Tracking Hydrocarbon Plume Transport and Biodegradation at Deepwater Horizon.** *Science*, 8 October 2010: Vol. 330 No. 6001. pp. 201-204 Available online from: http://www.sciencemag.org/content/330/6001/201.short

Fingas, M.F., D.A. Kyle, N.D. Laroche, B.G. Fieldhouse, G. Sergy, and R.G. Stoodley. 1995. **The Effectiveness of Spill Treating Agents**. *The Use of Chemicals in Oil Spill Response*, ASTM STP1252, P. Lane, ed. ASTM, Philadelphia, Pennsylvania.

Fingas, M.F., R.G. Stoodley, N. Stone, R. Hollins, and I. Bier. 1991. **Testing the Effectiveness of Spill-Treating Agents: Laboratory Test Development and Initial Results**. In: *Proc. 1991 International Oil Spill Conference*. API. Washington, DC.

Hazen, T.C., et al. 2010. **Deep-Sea Oil Plume Enriches Indigenous Oil-Degrading Bacteria**. *Science*. 8 October 2010: Vol. 330; no. 6001. pp. 204-208. Available online from: http://ieg.ou.edu/publication/PDF/Deep-sea oil plume enriches Indigenous oil-degrading bacteria.pdf

Henry, C. 2005. **Review of Dispersant Use in U.S. Gulf of Mexico Waters since the Oil Pollution Act of 1990**. In: *Proceedings of the 2005 International Oil Spill Conference*, 4 pages.

International Maritime Organization (IMO) online. 2013. **History of MARPOL** webpage. Available online from: http://www.imo.org/KnowledgeCentre/ReferencesAndArchives/HistoryofMARPOL/Pages/default.aspx

Kingston, P. 1999. **Recovery of the Marine Environment Following the Braer Spill, Shetland**. In: *Proceedings of the International Oil Spill Conference*. March 1999, Vol. 1999, No. 1, pp. 103-109. Available online from: http://dx.doi.org/10.7901/2169-3358-1999-1-103.

Lehr, B., S. Bristol, and A. Possolo. 2010. **Oil Budget Calculator — Deepwater Horizon Technical Documentation. A Report to the National Incident Command**. A Report by the Federal Interagency Solutions Group, Oil Budget Calculator Science and Engineering Team. 217 pages. Available online from: http://www.crrc.unh.edu/

National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling (National Commission). 2011. **Deepwater: The Gulf Oil Disaster and the Future of Offshore Drilling — Report to the President**. 398 pages. Available online from: http://www.oilspillcommission.gov/final-report.

National Oceanic and Atmospheric Administration (NOAA) News. 2010. **Federal Science Report Details Fate of Oil From BP Spill** weblink. Available online from: http://www.noaanews.noaa.gov/stories2010/20100804_oil.html.

National Oceanic and Atmospheric Administration (NOAA). 1992. **Oil Spill Case Histories 1967-1991; Summaries of Significant U.S. and International Spills**. Report No. HMRAD 92-11. NOAA/Hazardous materials Response and Assessment Division, Seattle, WA.

National Research Council (NRC). 1989. **Using Oil Dispersants on the Sea**. Committee on the Effectiveness of Oil Spill Dispersants, Marine Board, National Academy Press, Washington, DC. 335 pages.

Office of Technology Assessment (OTA), U.S. Congress. 1990. **Coping with an Oiled Sea: An Analysis of Oil Spill Response Technologies**. OTA-BP-O-63. 70 pp.

Oil Spill Response Ltd. 2009. **Role of Dispersants in Oil Spill Response**. Available online at http://www.oilspillresponse.com.

Perry, R. 1995. **The *Braer* Oil Spill**. In: *Proceedings of the International Oil Spill Conference* Proceedings: February 1995, Vol. 1995, No. 1, pp. 874-876. Available online from: http://dx.doi.org/10.7901/2169-3358-1995-1-874.

Post-Trial Memoranda, In Re: Oil Spill by the Oil Rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010, MDL No. 2179 (No. 10-02179) (E.D. La. Dec. 20, 2013).

U.S. Coast Guard (USCG) online. 2011. **USCG Homeport Vessel Response Plan Program — Maps and Photos — Dispersant Usage Map**. 2011. Available from: https://homeport.uscg.mil/vrp.

U.S. EPA online. 2011. **Oil Pollution Act Overview** webpage. Last modified on January 28, 2011. Available from: http://www.epa.gov/oem/content/lawsregs/opaover.htm.

U.S. EPA online. 2012. **History of the Clean Water Act** webpage. Available online from: http://www.epa.gov/lawsregs/laws/cwahistory.html.

Westergaard, R. 1987. **All About Blowout**. *Norwegian Oil Review*.

White, I. and J. Baker. 1998. **The Sea Empress Oil Spill in Context**. Paper presented at the International Conference on the Sea Empress Oil Spill, 11-13 February 1998, Cardiff, Wales. 33 pages. Available online from: http://www.itopf.com/information-services/publications/papers/seeec.html.

Wiens, J.A., **Oil in the Environment: Legacies and Lessons of the Exxon Valdez Oil Spill**, J.A. Wiens, ed., Cambridge University Press, 2013.

SpillPrevention.org

DISPERSANT USE IN THE **ARCTIC ENVIRONMENT**

Things You Should Know

- Eight countries have territory in the Arctic.
- Depending on the time of year or location of a spill, responding to spills in the Arctic can present unique challenges requiring appropriate equipment, knowledge, and experience.
- The presence of ice and cold temperatures can greatly reduce the spreading and weathering of spilled oil.
- Biodegradation occurs in all marine environments, including ice-covered waters.
- Scientists have been studying the effects of dispersants on the marine environment for over 30 years, and are still actively engaged in dispersant research, development, and innovation in all temperatures, including the Arctic.
- Dispersants can be used effectively in cold temperatures, in the presence of ice, even in brackish waters.
- Dispersant formulations today are more efficient and safer to use in the environment than materials used in early response efforts.
- Dispersant use in Arctic environments and heavy ice is an appropriate response countermeasure if application requirements are met.
- In open drift ice conditions, waves may be strong enough for chemical dispersion of oil; in dense ice, propellers from a vessel can be used to generate turbulence and result in effective dispersion.

Overview

Dispersants are products used in oil spill response to enhance natural microbial degradation, a naturally occurring process where microorganisms remove oil from the environment. All environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), making them more available for microbial degradation. Wind, current, wave action, or other forms of turbulence help both this process and the rapid dilution of the dispersed oil. The increased surface area of these very small oil droplets in relation to their volume makes the oil much easier for the petroleum-degrading microorganisms to consume.

Dispersants can be used under a wide variety of conditions since they are generally not subject to the same operational and sea state limitations as the other two main response tools — mechanical recovery and burning in place (also known as in-situ burning). While mechanical recovery may be the best option for small, near-shore spills, which are by far the majority, it has only recovered a small fraction of large offshore spills in the past and requires calm sea state conditions that are not needed for dispersant application. When used appropriately, dispersants have low environmental and human health risk and contain ingredients that are used safely in a variety of consumer products, such as skin creams, cosmetics, and mouthwash (Fingas et al., 1991; 1995).

This fact sheet summarizes the oil spill response and dispersant use requirements for releases in Arctic environments, including regulatory requirements.

Fact Sheet Series

Introduction

The Arctic is thought to hold the world's largest remaining untapped gas reserves and some of its largest undeveloped oil reserves with a significant proportion of these reserves existing in offshore coastal habitats in the Arctic's shallow and biologically productive shelf seas. Oil and gas exploration efforts in the Arctic continue to undergo increased public scrutiny because the potential for oil spills, whether from blowouts, pipeline leaks, or shipping accidents, poses a risk to arctic ecosystems. One of the major public concerns is whether an effective oil spill response can be carried out in the Arctic.

The Arctic is characterized by a short productive season, low temperatures, and periods of limited sunlight. As a result, it may take an extended time for Arctic regions to recover completely from the habitat disruption of any kind. Responding to an oil spill presents challenges in general, but Arctic conditions require additional considerations to protect the people and the environment.

Geopolitical Ownership of the Arctic

In 1982, the United Nations treaty known as the "Law of the Sea" Convention, was passed and granted exclusive economic rights to any natural resource that is present on or beneath the sea floor out to a distance of 200 nautical miles (230 miles; 371 kilometers) beyond their natural shorelines. Based on the terms and conditions of the Law of the Sea Convention, significant undersea portions of the Arctic belong to Canada, the United States, Russia, Norway, and Denmark. They can also extend their claim up to 350 miles from shore for any area that is proven to be a part of their continental shelf. This additional resource inclusion adds Iceland, Sweden, and Finland claiming ownership. All of these nations have gained significant oil and natural gas resources as a result of this treaty. However, the United States has yet to sign the treaty due to concerns regarding American economic and security interests.

Arctic Considerations

The following are some of the main factors associated with potential difficulties of working in the Arctic (King, 2012):

- Remoteness and Lack of Infrastructure: there are few existing pipelines to transport oil and gas, few deep-water ports and limited transportation in and out of the area; extreme weather conditions and the presence of ice make transport difficult for much of the year.

FIGURE 1. Geopolitical boundaries within the Arctic Circle. Source: http://www.arctic.gov

- **Low Temperatures:** the extreme winter conditions of the Arctic require that equipment and personal protection be specially designed to withstand frigid temperatures.
- **Harsh Environment:** the range of extremes, e.g., from frozen ground and permafrost to marshy Arctic tundra and the presence of snow and ice, can inhibit activities.
- **Presence of Ice:** dynamic icepack conditions can hinder transport of personnel, equipment, and oil for extended periods.
- **Biological Resources:** the main Arctic resources of concern are (Johnsen et al., 2010):
  - the large number of migratory birds from around the globe that breed and live seasonally in the area, inhabiting both off shore and on shore areas.
  - a variety of mammals that inhabit the regional ocean waters and near shore and shoreline areas, including a number of protected species.
  - fish such as salmon, cod, and pollock that thrive in Arctic and sub-Arctic waters, supporting valuable commercial and subsistence fisheries.

Responding to Spills in the Arctic

Oil spill response is demanding under most circumstances and Arctic conditions can impose additional environmental and logistical challenges. The three primary options for oil spill response are mechanical recovery, in situ-burning, and the use of dispersants. Any final decision to utilize a particular response strategy depends on the spill conditions at the time, relative risks to response personnel and the environment, and a Net Environmental Benefit Analysis (NEBA) of all aspects of the strategy (see **Fact Sheet #6: Assessing Dispersant Use Trade-offs** for a discussion of NEBA).

As in all spill responses, monitoring and observation are crucial in providing real-time information on the size of a surface slick and direction that it may be moving. Such close scrutiny allows responders to modify the response to the changing situation and to use the best tools at all times.

Effects of Arctic Conditions on Spilled Oil

Perhaps the most significant challenge posed by an Arctic spill is dealing with the presence of ice since it may make it more difficult to find a spill, reach it, and safely deploy equipment and personnel. Refer to **Fact Sheet #3 — Fate of Oil and Weathering** for more information on the processes that affect oil on the water's surface.

Processes that need to be considered for oil slicks, and how Arctic conditions influence them, include:[1]

- **Oil spreading:** Cold temperatures tend to slow the rate of spreading. Any oil spilled on an ice surface may be completely contained as a thick pool if the ice has natural contours that act to contain it. As a result, slicks on ice tend to be thicker and less extensive than slicks on open water. Additionally, snow may absorb spilled oil, further reducing its spread.
- **Oil movement:** In many Arctic areas, water currents under the ice are not strong enough to carry spilled oil very far. Surface roughness under the ice will serve to slow oil movement and oil will generally remain in the area where the spill occurred. However, if the ice begins drifting, the oil will drift with it.
- **Evaporation:** Oil spilled in sub-freezing temperatures evaporates more slowly than oil in warmer temperatures. Oil under snow will evaporate even more slowly. Oil under or trapped in ice is not expected to evaporate to any significant extent. Less evaporation means that oil remains suitable for dispersion or burning for longer periods of time.
- **Emulsification and natural dispersion:** Ice environments can reduce mixing action from waves, thus reducing the rate or likelihood of emulsification or natural dispersion.
- **Biodegradation:** Studies have shown that natural biodegradation of oil under Arctic conditions and in the deep ocean continues at a significant rate (McFarlin, 2011; Hazen, 2010; Zhenmei, 2011).
- **Oil under new sea ice:** During extreme cold, oil spilled under new or growing sea ice can be encased in ice within hours to days as the ice grows downward and thickens. However, oil spilled under ice in late spring in the Arctic, or after mid-spring in the sub-Arctic, may not be encased by growing ice since ice no longer continues to grow in warming conditions.

  If oil has been frozen in growing ice, it will remain trapped until the spring thaw, when the daily air temperatures stay above freezing. This will then allow the oil to move to the surface through cracks in the melting ice. Once the oil reaches the ice surface, it may remain in patches on the melting ice.
- **Oil under old sea ice:** Oil spilled under multi-year ice will remain in place as it would under first-year ice, however, older ice appears to trap more oil than first-year ice. This can result in very thick individual pools of oil beneath the surface. Oil spilled under old ice may also rise to the surface through cracks, but this is likely to be much later in the melt season than with new first-year ice.
- **Oil during spring thaw conditions:** When an ice sheet breaks up, oil remaining in melt pools on the surface will likely drain onto the water in the form of a very thin rainbow-colored sheen trailing from the drifting and melting ice. Thick oils that have gelled in the cold could enter the water as thicker, non-spreading mats or droplets. Once exposed to mixing action from waves, fluid oil may naturally disperse or form thicker emulsions, depending on the properties of the oil.

[1] The information provided in this section was obtained from Potter et al.'s "**Spill Response in the Arctic Offshore**" (2012).

Dispersant Use in Arctic Habitats

In general, dispersants are affected by the arctic environment in the following manner:[2]

- **Cold temperatures:** Dispersants are effective when applied at freezing and near-freezing temperatures. If the spilled oil remains liquid, dispersants are likely to be effective if wave action is present or mixing energy is provided in another manner, e.g., propeller wash. If oil can be dispersed, cold temperatures may actually increase the window of opportunity for dispersant use by slowing the weathering process due to evaporation.
- **In ice:** In waters partially covered with ice, waves are greatly reduced, slowing the rate of weathering of the oil. Since weathered oil is more difficult to disperse, the presence of ice can increase the dispersant effectiveness. In areas with less than 70 – 90 % ice cover, decreases in wave energy do not limit the effectiveness of dispersants. In denser ice floe accumulations, however, a response vessel's bow thrusters or propellers may be needed to provide the mixing energy needed for dispersion to occur.
- **Salinity:** Most dispersants are effective in water with a salinity between 25 and 40 parts per thousand (PPT) (e.g., saltwater). The effectiveness of most dispersants declines when salinities are higher or lower than this range, althought dispersants for fresh water use have been developed.
- **Toxicity:** Modern dispersants are composed of low toxicity, biodegradable chemicals, and ingredients found in many household products. The toxicicity effects from dispersed oil are from the oil itself and not the dispersants (EPA, 2010). Dispersants do not increase the toxicity of the oil. Dispersants themselves are of low toxicity to marine life and are less toxic than the oil that is dispersed; concentrations start low and are rapidly diluted. However, dispersed oil can cause temporary impacts to sensitive marine species, but these are limited to the immediate spill vicinity and for a short period of time. See **Fact Sheet #4 — Toxicity and Dispersants** for more information.
- **Biodegradation:** Dispersed oil readily biodegrades in the marine environment at temperatures approaching those expected in Arctic waters (McFarlin, 2010). Naturally occurring oil-degrading microbes begin to grow on dispersed oil droplets within hours to days. Compared to biodegradation rates at room temperature, i.e., at 21°C (70°F), those experienced under Arctic water conditions, ca 0° – 5°C (32-41°F), are only slightly reduced.[3]

Regulatory Requirements

Although arctic conditions pose significant challenges, dispersants are still a viable option. This is especially true when mechanical recovery using such tools as boom and skimmers cannot be used successfully in heavily iced areas. Decision-makers must evaluate the trade-offs and challenges associated with the use of dispersants and make science-based decisions on the likely effects of dispersed oil on the resources and the arctic habitats. A Net Environmental Benefit Analysis (NEBA) should be employed to address the issues associated with oil remaining on the surface or dispersed into the water column.

Regulatory Considerations in the US

Given the challenges of mechanically recovering oil in offshore and coastal environments before it spreads over a much larger area, decisions need to be made about how to best manage floating oil using a combination of response options for the incident-specific conditions. This is particularly true when oil is spilled in an ice environment. A decision to use dispersants involves evaluating the potential trade-offs: decreasing the expected risks to wildlife on the water surface and shoreline habitats while increasing the potential risk to organisms in the water column. It is possible that the use of dispersants may be the only viable response option.

There are several federal and state requirements for protecting the natural resources during an oil spill response, including the waters of the US Arctic.[4] Whenever federal agencies authorize, fund, or carry out actions that may adversely modify or destroy critical habitats, they must consult the federal natural resource trustee agencies to ensure that any effects to protected species and resources from the spill response are documented and

[2] The information provided in this section was obtained from Potter et al.'s "**Spill Response in the Arctic Offshore**" (2012).

[3] For reference, a 5°C (41°F) temperature exists at a 5,000 ft (1,500 m) depth in the Gulf of Mexico and around the world.

[4] During an oil spill event which may affect listed species and/or critical habitat, emergency consultations under the ESA are implemented for oil spill response actions. The FOSC coordinates the consultation requirements specified in the ESA regulations, 50 CFR 402.05, with the pollution response responsibilities outlined in the NCP, 40 CFR 300.

addressed. The regulations that must be addressed in a spill response include:

- The **National Historic Preservation Act** (NHPA) — impacts to cultural and archaeological resources.
- The **Alaska Historic Preservation Act** — including subsistence activities or the resources upon which they depend.
- The **Endangered Species Act** (ESA)/**Essential Fish Habitat** (EFH) and the critical habitat components of each.

Each is summarized below.

National Historic Preservation Act (NHPA)

During an oil spill, there is the potential for the oil as well as the necessary cleanup measures to potentially affect historic properties and archaeological sites. The National Historic Preservation Act (NHPA) requires federal agencies to consider potential impacts of projects they carry out, assist, or permit on historic properties. Historic properties or historic resources are defined as "*any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register [of Historic Places], including artifacts, records, and material remains related to such a property or resource.*" Historic properties need not be formally listed in the National Register to receive consideration under Section 106. It only needs to meet the criteria for listing in the National Register.

Section 106 of the NHPA seeks to accommodate historic preservation concerns with the needs of an emergency spill response through consultation; however, immediate rescue and salvage operations conducted to preserve life or property are exempt from the provisions of Section 106. For spill responses in US waters of the Arctic, the Federal On Scene Coordinator (FOSC) is responsible for ensuring that historic properties are appropriately considered in the planning for and during emergency response actions. This includes the operational use of all response tools.

Alaska Historic Preservation Act

Under the *Alaska Statutes, 41.35.020 — Title to Historic, Prehistoric, and Archaeological Resources*, historic, prehistoric, and archeological resources situated on land owned or on state-owned or controlled land, including tideland and submerged land, require protection and documentation to any and all actions that will potentially affect them, including an oil spill response.

The Act defines "historic, prehistoric, and archeological resources" as deposits, structures, ruins, sites, buildings, graves, artifacts, fossils, or other objects of antiquity which provide information pertaining to the historic or prehistoric culture of people in the state as well as to the natural history of the state. The Act is designed to preserve and protect these resources from loss, desecration, and destruction so that the scientific, historic, and cultural heritage embodied in these resources may pass undiminished to future generations.

The Endangered Species Act (ESA)

The ESA requires all federal agencies to carry out programs for the conservation of threatened and endangered plants and animals and the habitats in which they are found.[5] There are approximately 2,000 species listed under the ESA as endangered or threatened; 17 are residents of Alaska. The U.S. Fish & Wildlife Service (USFWS) maintains a worldwide list of endangered species (USFWS, 2013) and the National Oceanic and Atmospheric Administration (NOAA) Fisheries Office of Protected Resources (OPR) manages mostly marine and anadromous species (NOAA Fisheries, 2013), while the USFWS manages the remainder of the listed species, mostly terrestrial and freshwater species.

FOSCs are required to coordinate with natural resource trustees and efforts must be made to ensure the protection of endangered species and their critical habitats (USFWS and NFMS, 1998; USCG et al., 2001).[6] Endangered species protection should be addressed during planning stages as well as actual responses. In each of the environments covered here, there are different lists of endangered species and protection methods will vary greatly. FOSCs need to consult with the federal Resource Trustees to consider the likely effects and impacts from the various response countermeasures on the trust resources and their critical habitats.

[5] The Endangered Species Act of 1973 (ESA), as amended, 16 U.S.C. §1531 et seq., provides a means to protect threatened and endangered species and the ecosystems upon which they depend. The ESA requires that federal agencies insure that the actions they authorize, fund, or carry out do not jeopardize listed species or adversely modify their designated critical habitat. Regulations for conducting Section 7 consultation are set forth in 50 CFR Part 402.

[6] The EPA/USCG and the Department of the Interior (DOI) U.S. Fish & Wildlife Service (Service) and the NOAA National Marine Fisheries Service (NMFS) and National Ocean Service signed an Interagency Memorandum of Agreement (MOA) stipulating emergency consultation procedures for oil spill response under the Endangered Species Act (ESA). A copy of this MOA can be obtained from http://www.uscg.mil/npfc/docs/PDFs/urg/App/ESA_MOA_AppA_04.pdf.

For the use of dispersants, existing application requirements in the US are determined by the Regional Response Teams (RRTs) that limit their application and use to waters typically 3 miles from shore and in waters deeper than 10 meters (refer to **Fact Sheet #5 — Dispersant Use Approvals in the United States**). The Trustees may provide recommendations for how to minimize or avoid adverse effects to listed species during the emergency response. Such recommendations are strictly advisory and are to be implemented at the discretion of the emergency response personnel (USCG et al., 2001).

Essential Fish Habitat (EFH)

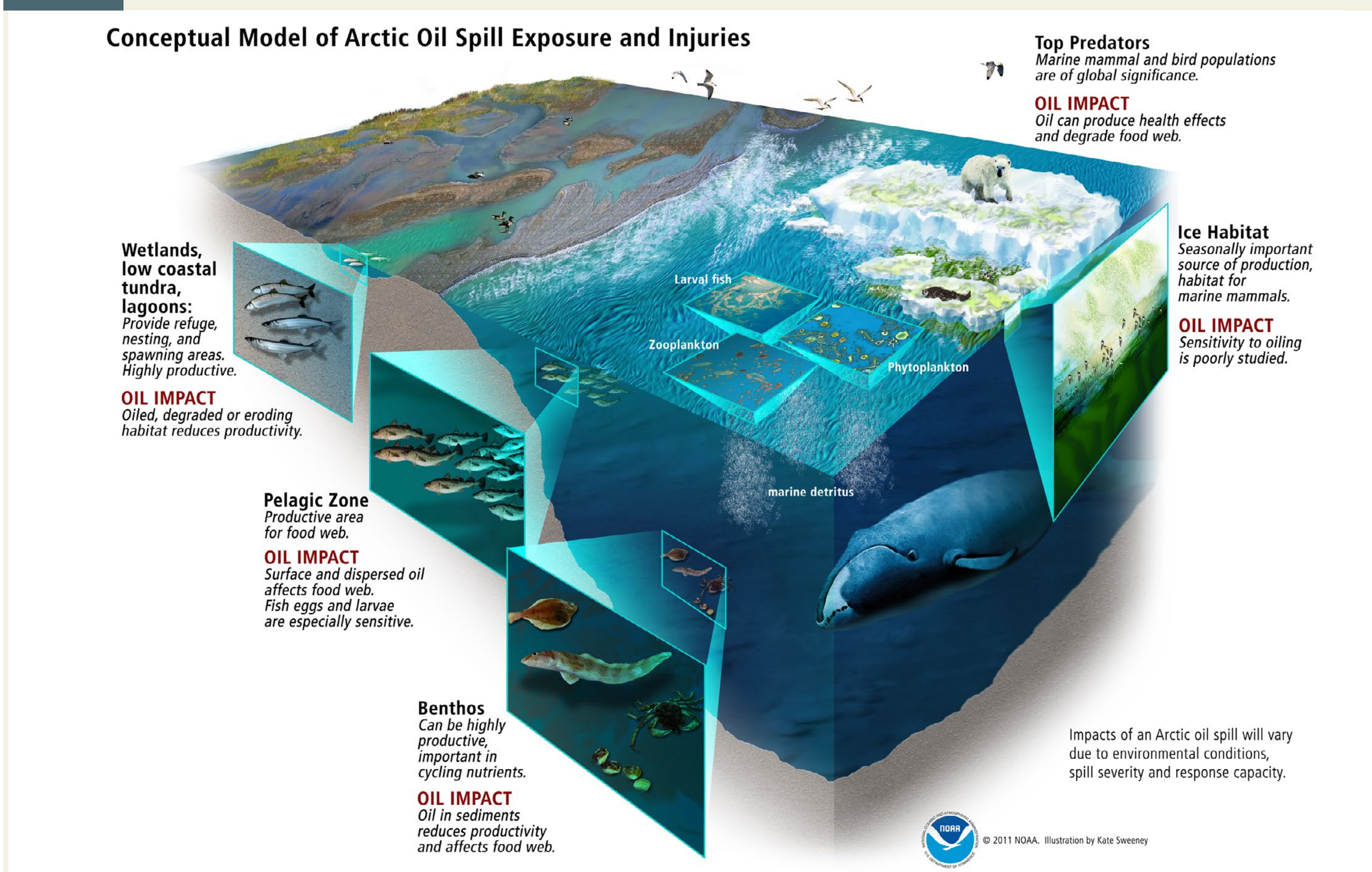
NOAA Fisheries works with the regional fishery management councils to identify the essential habitat for every life stage of the federally managed species under the Magnuson-Stevens Act (NOAA Fisheries, 2012). Using the best available scientific information, EFH and habitat areas of particular concern (HAPCs)[7] have been described for approximately 1,100 managed species to date. NOAA Fisheries has identified coastal wetlands, corals, rivers, and fish passages as being critical habitats [8] or HAPC for their protected species.

Figure 2 provides NOAA's conceptual model to summarize the potential oil spill response exposure and injury to resources in Arctic US waters. NOAA used this model to determine the likely effects an oil spill will have on the environment (including natural resources that people use). For more information on the potential impact to the resources that utilize the critical habitats refer to **Fact Sheet #6 — Assessing Dispersant Use Trade-offs**.

[7] HAPCs are considered high priority areas for conservation, management, or research because they are rare, sensitive, stressed by development, or important to ecosystem function.

[8] Critical habitat is designated for the survival and recovery of species listed as threatened or endangered under the ESA.

FIGURE 2. Conceptual model of Arctic oil spill exposure and injury. Source: NOAA/Kate Sweeney, 2011



References

36 CFR Part 800 — **Protection of Historic Properties.** Available online from: http://www.achp.gov/nhpa.html.

Budzik, P. 2009. **Arctic Oil and Natural Gas Potential.** U.S. Energy Information Administration Office of Integrated Analysis and Forecasting Oil and Gas Division. October 2009.

Fingas, M. F., D. A. Kyle, N. D. Laroche, B. G. Fieldhouse, G. Sergy, and R. G. Stoodley. 1995. "**The Effectiveness of Spill Treating Agents**." The Use of Chemicals in Oil Spill Response, ASTM STP1252, P. Lane, ed. ASTM, Philadelphia, Pennsylvania.

Fingas, M. F., R. G. Stoodley, N. Stone, R. Hollins, and I. Bier. 1991. **Testing the Effectiveness of Spill-Treating Agents: Laboratory Test Development and Initial Results.** In: Proc. 1991 International Oil Spill Conference. API. Washington, DC.

Hazen, T.C., E.A. Dubinsky, T.Z. DeSantis, G.L. Andersen, Y.M. Oiceno, N. Singh, J.K hansson, A. Probst, S.E. Borglin, J.L. Fortney, W.T. Stringfellow, M. Bill, M.S. Conrad, L.M. Tom, K.L. Chavarria, T.R. Alusi, R. Lamendella, D.C. Joyner, C. Spier, J. Baelum, M. Auer, M.L. Zemla, R. Chakroborty, E.L. Sonnenthal, R.D. Haeseleer, H-Y.N. Holman, Sl Osman, Z. Lu, J.D. Van Nostrand, Y. Deng, J. Zhou, and O.U. Mason. 2010 **Deep-sea oil plume enriches indigenous oil-degrading bacteria.** In: Science Express, August 24, 2010 DOI: 10.1126/science. 1195979.

Johnsen, K.I., B. Alfthan, L. Hislop, J.F. Skaalvik (Eds.). 2010. **Protecting Arctic Biodiversity**. United Nations Environment Programme, GRID-Arendal. 100 pages. Available online from: www.unep.org.

King, H. 2012. **Oil and Natural Gas Resources of the Arctic** — Geology.com webpage: Available from: http://geology.com/articles/arctic-oil-and-gas/.

McFarlin, K.M., R.A. Perkins, W.W. Gardiner and J.D. Word, 2011 **Evaluating the biodegradability and effects of dispersed oil using Arctic test species and conditions: Phase 2 activities**. In Proceedings of the 34th Arctic and Marine Oilspill Program (AMOP) Technical Seminar on Envrionmental Contamination and Repsone, Calgary, Alberta, Environment Canada, Ottawa, Ontario, Canada.

National Oceanic and Atmospheric Administration (NOAA) Fisheries. 2013. **Office of Protected Resources: Species Information** webpage. Last updated on January 10, 2013. Available online from: http://www.nmfs.noaa.gov/pr/species/index.htm.

Potter, S. I. Buist, K. Trudel, D. Dickins, and E. Owens. 2012. **Spill Response in the Arctic Offshore**. Prepared for the American Petroleum Institute and the Joint Industry Programme on Oil Spill Recovery in Ice. 157 pages. Available online at: http://www.api.org/environment-health-and-safety/clean-water/oil-spill-prevention-and-response/spill-response-in-arctic-offshore.aspx.

U.S. Coast Guard (USCG), U.S. Environmental Protection Agency, Department of Interior (DOI), U.S Fish & Wildlife Service (USFWS), National Oceanic and Atmospheric Administration (NOAA) National Marine Fisheries Service (NMFS) and National Ocean Service (NOS). 2001. **Inter-agency Memorandum of Agreement Regarding Oil Spill Planning and Response Activities Under the Federal Water Pollution control Act's National Oil and Hazardous Substances pollution Contingency Plan and the Endangered Species Act**. Available online from: http://www.uscg.mil/npfc/docs/PDFs/urg/App/ESA_MOA_AppA_04.pdf.

U.S. Fish & Wildlife Service (USFWS). 2013. **Endangered Species Program: Find Endangered Species** webpage. Last updated on February 21, 2013. Available from: http://www.fws.gov/endangered/.

U.S. Fish & Wildlife Service (USFWS) and National Marine Fisheries Service (NMFS). 1998. Endangered Species Consultation Handbook: Procedures for Conducting Consultation and Conference Activities under Section 7 of the Endangered Species Act. 315 pages. Available online from: http://www.fws.gov/endangered/esa.../esa_section7_handbook.pdf.

Zhenmei Lu, Ye Deng, Joy D Van Nostrand, Zhili He2, James Voordeckers, Aifen Zhou, Yong-Jin Lee, Olivia U Mason, Eric A Dubinsky, Krystle L Chavarria, Lauren M Tom, Julian L Fortney, Regina Lamendella, Janet K Jansson, Patrik D'haeseleer, Terry C Hazen and Jizhong Zhou, 2011. **Microbial gene functions enriched in the Deepwater Horizon deep-sea oil plume.** In: The ISME Journal (2012) 6, 451–460; doi:10.1038/ismej.2011.91; published online 4 August 2011.