The Chaos of Clean-Up

Analysis of Potential Health and Environmental Impacts of Chemicals in Dispersant Products

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Acknowledgements

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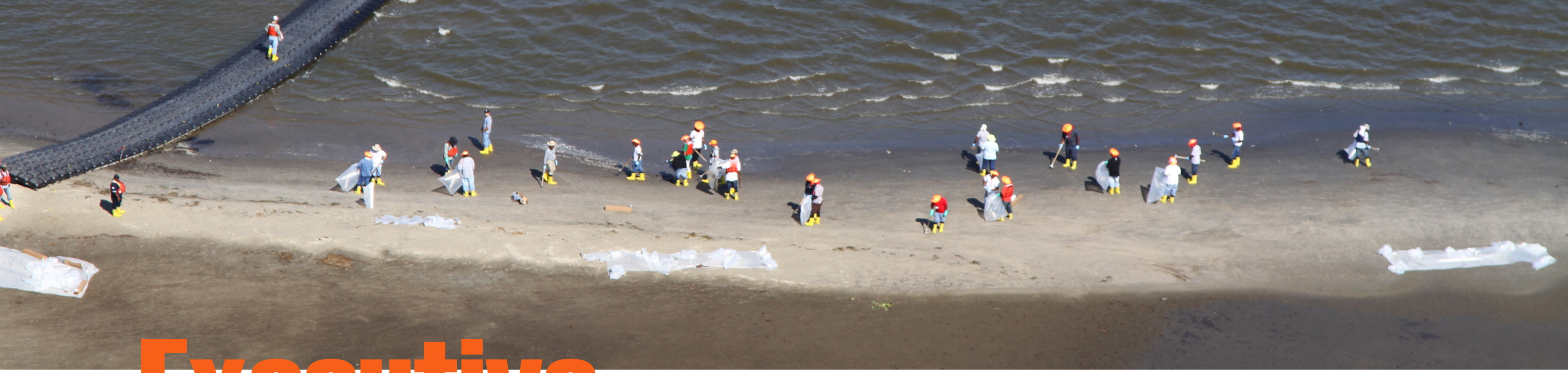


Executive
SUMMARY

This report was prepared in response to widespread public concern among Gulf Coast communities about the safety of chemicals, known as dispersants, that were poured into the Gulf of Mexico to disperse oil during the Deepwater Horizon disaster. This report presents findings from a literature review of scientific research on each of 57 chemical ingredients that are found in dispersants that were eligible for use at the time of the Deepwater Horizon disaster. The ingredients and formulas for various dispersants on the market typically are not available, and it is not fully known which chemical ingredients among the 57 are found in which dispersant.

The review demonstrates the wide range of potential impacts from exposure to the chemicals found in dispersants. From carcinogens, to endocrine disruptors, to chemicals that are toxic to aquatic organisms, some of the ingredients in oil dispersants are indeed potential hazards. For instance, of the 57 ingredients,

- 5 chemicals are associated with cancer
- 33 chemicals are associated with skin irritation, from rashes to burns
- 33 chemicals are linked to eye irritation
- 11 chemicals are suspected or potential respiratory toxins or irritants
- 10 chemicals are suspected kidney toxins.

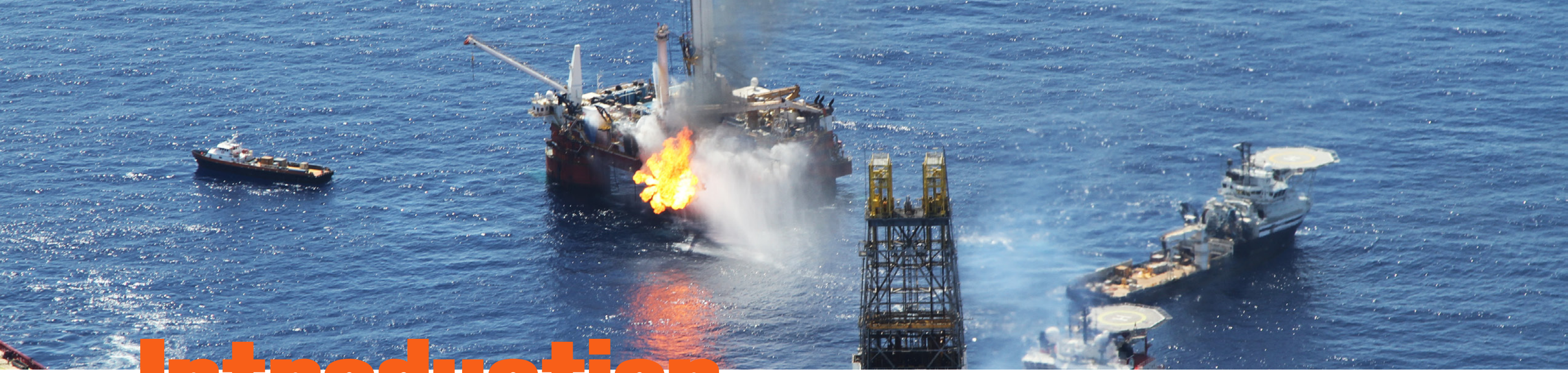
As for potential effects on the marine environment,

- 8 chemicals are suspected or known to be toxic to aquatic organisms
- 5 chemicals are suspected to have a moderate acute toxicity to fish

Clearly, some of the chemical ingredients are more toxic than others, and some dispersants are more toxic in particular environments. The widely-varying toxicity of different dispersants underscores the importance of full disclosure and proper selection of dispersants for use in oil spill response.

While revealing some of the potential hazards of dispersants, the literature review also highlights the extent of our current lack of knowledge about dispersants and their impacts. Ultimately, the absence of thorough scientific research on dispersants and the chemicals that comprise dispersants, as well as the lack of public disclosure of each dispersant's ingredients and formulation, hinders any effort to understand the full impacts of dispersant use. These findings call for more research, greater disclosure of the information that is known, comprehensive toxicity testing, the establishment of safety criteria for dispersants, and careful selection of the least toxic dispersants for application in oil spill response.

Many of the environmental impacts of the chemical dispersants used in the Gulf are still unknown.



Introduction

DISPERSANT USE DURING THE DEEPWATER HORIZON DISASTER

The Macondo well blowout in April 2010 released more than 200 million gallons of oil into the Gulf of Mexico over the course of three months. Dispersants, used in an attempt to prevent large slicks from entering fragile coastland and marshes, were applied in unprecedented amounts, totaling approximately 1.84 million gallons. They were also applied in an unprecedented manner. In addition to approximately 1.07 million gallons of dispersant applied in standard practice to the ocean's surface, for the first time ever, response teams released dispersants at the site of the gushing oil well one mile below the ocean's surface. In total, 771,000 gallons of dispersant were applied subsea.

Two dispersants—Corexit 9500 and Corexit 9527, both produced by Nalco—were used during the response. Corexit 9500 was the primary dispersant used; Corexit 9527 was only used at the beginning of the response effort. Toxicity testing shows that a mixture of Corexit 9500 and Number 2 fuel oil is more than four times as toxic as Number 2 fuel oil alone and nearly ten times more toxic than Corexit alone.[1] Additionally, comparison of toxicity testing results for dispersants listed on the Product Schedule show that Corexit 9500, when mixed with Number 2 fuel oil, is the dispersant that is most toxic to silversides (an estuary fish tested under required protocols) and the second least effective at dispersing South Louisiana crude oil.

As early as 1989, the National Research Council of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine had issued a call for more research on dispersants and the impacts of dispersant use.[2] More than a decade and a half later, the Council continued to conclude in 2005 that "the current understanding of key processes and mechanisms [in dispersant use] is inadequate to confidently support a decision to apply dispersants."[3] "Given the potential impacts that dispersed oil may have on water-column and seafloor biota and habitats," the Council stated, "thoughtful analysis is required prior to the spill event so that decisionmakers understand the potential impacts with and without dispersant application."[4] Yet, as the Council noted, "[t]he mechanisms of both acute and sublethal toxicity from exposure to dispersed oil are not sufficiently understood," and "[t]he factors controlling rates of the biological and physical processes that determine the ultimate fate of dispersed oil are poorly understood."[5]

Unfortunately, as was made appallingly evident during the response to the Deepwater Horizon disaster, the National Research Council's 2005 report did not lead to significant progress on research. On May 20, 2010, nearly one month after BP started using Corexit in response to the oil gushing from the Macondo well, the Environmental Protection Agency ("EPA") directed BP to identify within 24 hours and to begin using within 72 hours a less toxic alternative from the Product Schedule[6] on grounds that dispersant was being used "in unprecedented volumes and because much is unknown about the underwater use of dispersants."[7] In response, BP identified five dispersants on the Product Schedule that were as effective as Corexit 9500, but less toxic. As BP explained, however, one of these products, Sea Brat # 4, was ruled out as an alternative because the product contains an ingredient that may degrade to a potential endocrine disrupting chemical, but "[t]he manufacturer has not had the opportunity to evaluate this product for those potential effects, and BP has not had the opportunity to conduct independent tests to evaluate this issue either."[8]

With respect to the other potentially less-toxic alternatives, BP noted that it would "be prudent to obtain the chemical formulas [of these dispersants] . . . evaluate them for their potential to degrade to [an endocrine disruptor]," but that it was not "able to obtain this information in the 24 hour time frame provided in [EPA's] directive." BP further pointed out that "there may be only limited information on the constituents of the dispersants, since the dispersants typically contain proprietary substances whose identities are not publicly available."[9] Ultimately, BP justified its decision to continue using Corexit on the basis of the lack of availability of other less-toxic dispersants and a lack of understanding about their potential impacts:

> *COREXIT was the only dispersant that was available immediately, in sufficiently large quantities to be useful at the time of the spill. Subsequent efforts have identified Sea Brat #4 as a possible alternative that is equally effective at dispersing oil, but has fewer acute toxicity effects. In the short time provided to us, BP and the manufacturer of Sea Brat #4 have not had the opportunity to evaluate other potentially significant criteria, including the risk that a small fraction of Sea Brat #4 may degrade to [an endocrine disruptor], and/or may persist in the environment.*
>
> *None of the other dispersants that [were identified as less toxic alternatives] are available in sufficient quantities at this time. In addition, before supporting a decision to switch to those dispersants, it would be important to review the formula for each alternative, and evaluate it for additional risks, such as persistence in the environment. BP has not been able to do this in the time provided.*

Following what it deemed BP's inadequate response, EPA conducted its own testing "to determine the least toxic, most effective dispersant available."[11] EPA released the results of its first round of toxicity testing on June 30, 2011, when one million gallons of Corexit had already been applied at the surface and 565,000 gallons applied subsea.[12] It concluded that none of the eight dispersants tested, including Corexit 9500, displayed biologically significant endocrine disrupting activity, and that JD-2000 and Corexit 9500 (alone, not mixed with oil) were generally less toxic to small fish than other dispersants that were tested. Results from the second phase of testing were released in August 2010, weeks after dispersant use had halted. EPA's testing included determining potential endocrine disruption effects and assessing the dispersants' cytotoxicity.[13] EPA also repeated the standard acute toxicity tests, which dispersant manufacturers already were required to conduct before listing on the Product Schedule, but this time using Louisiana Sweet Crude rather than the No. 2 fuel oil tested previously. As EPA explained:

> *Although these industry-submitted test results provide guidance, the tests were conducted on the dispersants by different laboratories and on the dispersants mixed with No. 2 fuel oil which is not the type of oil in the Gulf. EPA wanted to conduct its own toxicity tests in one laboratory under EPA oversight for better comparative analysis and to test the dispersants mixed with the oil from the Gulf.*[14]

Meanwhile, public controversy swirled around the use of dispersant, and public alarm heightened in light of the manifest uncertainties regarding the toxicity of such use.[15] The lack of information about the toxicity of dispersants on the Product Schedule, including their chemical ingredients, made a sham of the public debate over whether less toxic alternatives existed. Representative Edward Markey (D-Mass.) waded into the controversy, questioning BP's selection of Corexit, the potential toxic effects of the dispersant use, the impact of dispersants on the safety of seafood in the region, and the Coast Guard and EPA's approval of dispersant use.[16] On June 9, 2010, after at least 1.12 million gallons of Corexit had already been applied in the Gulf, and following weeks of complaints from public health advocates and members of Congress, EPA made the full list of ingredients in Corexit 9500 and 9527 publicly available.

Brown pelicans were just one of many wildlife species greatly affected by the oil spill in the Gulf.

The story of dispersant use in the Deepwater Horizon response depicts the continuing and significant gaps in our understanding of dispersants and the flaws in the regulatory framework that permit the release of insufficiently studied chemicals into the oceans. As the President's Commission on the incident concluded:

> *Perhaps more than anything, the Deepwater Horizon experience with dispersants reveals the paucity of the kind of information that government officials need to make intelligent decisions about dispersant use in response to an oil spill. Although the absence of such information was well known before April 20, 2010, its practical effect had not been so glaringly realized.*[17]

The failures that were made most vivid included (1) the lack of consistent, independent toxicity testing across all dispersants, which led EPA to scramble to conduct such testing during the disaster; (2) the lack of toxicity testing using applicable inputs and parameters, such as testing on Louisiana Sweet Crude or on sensitive or at-risk species unique to the affected area; (3) the lack of testing for non-acute impacts, such as endocrine disruption and other non-fatal or chronic effects, which similarly led EPA to scramble to conduct additional testing during the disaster; (4) the lack of available information on ingredients, which prevented BP from assessing potential toxic impacts of other dispersants and prevented the public and emergency responders from learning about the potential impacts of the chemicals to which they were being exposed.

Now over a year after the blowout, concerns about the long-term effects of the released dispersants on human health and the environment linger. Anecdotal accounts in Gulf Coast communities, and particularly among oil spill response workers, of illnesses and health effects from dispersant exposure are widespread.[18] These questions and concerns, combined with EPA's frantic rush to find a safer alternative as oil flowed from the wellhead, demonstrate the need for research on the toxicity of dispersants, disclosure, and more careful analysis and selection of dispersants in advance of disaster response.

Background
TO THE REPORT

Dispersants are used in response to oil spills in water to remove slicks from the surface that might otherwise contaminate fragile coastal and estuarine areas. Typically applied to the ocean's surface, dispersants change the chemical and physical property of oil. By separating an oil slick into small droplets, dispersants increase mixture of the oil into the water column. Wind, waves, and other turbulence in the water break up these oil droplets and disperse them further throughout the water column. Dispersant use does not reduce the total amount of oil released into the environment. Rather, it reduces oil exposure to shoreline habitat while increasing oil exposure in the water column and on benthic habitats.

We all use small quantities of oil dispersants, or at least the ingredients of these dispersants, in our daily lives in the form of soaps and shampoos. The challenge lies both in understanding the human health and ecological hazards of applying large quantities of dispersants into the ocean, and in ensuring that only the least harmful dispersants are applied when necessary to address oil releases.

The current regulatory framework for dispersants fails at both of these challenges. Minimal testing is conducted and no safety criteria are imposed on dispersants before they are identified for potential selection and use in oil spill response. Additionally, dispersant manufacturers are permitted to claim that the formulas and specific chemical ingredients in their dispersant products are confidential business information ("CBI"), making such information unavailable to the public.

The National Contingency Plan Product Schedule—a list maintained by the EPA that identifies dispersants and other chemicals that are eligible for use in oil spill response—identified fourteen different dispersants that were available for potential selection and use at the time of the April 2010 well blowout in the Gulf of Mexico.[19] Freedom of Information Act litigation by public interest environmental groups in the wake of the disaster resulted in the release by EPA of an aggregate list of the 57 ingredients found in these dispersants.[20] This report analyzes these 57 chemicals and their potential human health and environmental effects.

The key findings—that the effects of different ingredients, and therefore different dispersants, vary widely, and that much is yet unknown about dispersants—support a call for more research on dispersants and their chemical ingredients, greater public disclosure of the information that is known about dispersants, comprehensive toxicity testing, the establishment of safety criteria for dispersants, and careful selection of dispersants for use in response to oil spills.

This report begins by identifying problems with the existing regulatory framework that have resulted in substantial gaps in knowledge about dispersants. The report then summarizes key findings from a literature review of research on the 57 chemical ingredients in dispersants, and compares the findings for four dispersants, including Corexit 9500 and 9527, for which full ingredient lists have been disclosed. The report concludes with recommendations to help ensure that decision-makers responding to future oil releases are properly armed with the information necessary to select the least toxic and most appropriate dispersant for the particular incident.

I. The Statutory and Regulatory Framework for Dispersant Listing and Selection

The National Contingency Plan is a statutory scheme for planning and authorizing responses to discharges of oil and hazardous substances. Pursuant to the Oil Pollution Act of 1990, which was enacted to address failures in responding to the Exxon Valdez spill, the President must prepare and publish a National Contingency Plan with a schedule identifying "dispersants, other chemicals, and other spill mitigating devices and substances, if any, that may be used in carrying out the Plan," as well as the waters in which such chemicals may be used and the quantities of chemicals which can be used safely in such waters. 33 U.S.C. § 1321. In turn, the President delegates this responsibility to EPA.

Under the regulatory framework adopted and implemented by EPA, dispersants are identified for selection and use with little or no information about the product's potential toxic effects and little or no public disclosure of the product's chemical ingredients. The EPA regulations, known as Subpart J of the National Contingency Plan, set forth the requirements for listing a dispersant on the Product Schedule.[21] Once listed, a dispersant may be selected for use in oil spill response without further testing. Problematically, however, the regulations require only minimal toxicity testing and do not require a dispersant to meet any safety criteria in order to be listed on the Product Schedule.

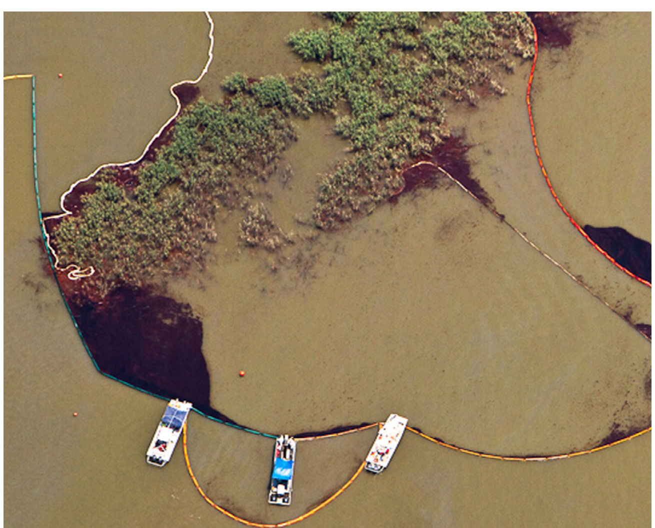
The Challenge lies both in understanding the human health and ecological hazards of applying large quantities of dispersants into the ocean, and in ensuring that only the least harmful dispersants are applied when necessary to address oil releases.

To have its product listed on the NCP Product Schedule, a dispersant manufacturer is required to demonstrate that the product meets a 45% effectiveness threshold (as determined by the Swirling Flask Dispersant Effectiveness Test described in the regulations, which involves testing two types of oil). Dispersants that meet the effectiveness threshold are then tested for toxicity using the Revised Standard Dispersant Toxicity Test described in the regulations. In contrast to the requirement for effectiveness, however, Subpart J does not establish any criteria for safety or toxicity and requires only documentation that the toxicity test was performed.

The Revised Standard Dispersant Toxicity Test, meanwhile, does not test the dispersant for anything beyond its acute mortality effects on two species. The test exposes silversides, a type of estuary fish, and mysid shrimp to varying concentrations of the test product, both by itself and mixed with Number 2 fuel oil, to determine mortality rates at the end of 96 hours for silversides and 48 hours for mysid shrimp. Such testing does not ascertain a dispersant's chronic impacts; its non-lethal impacts; its impacts on particularly sensitive and at-risk species, such as coral; or its impacts on other key ecological indicators, such as algal species. It also fails to test the dispersant's toxicity under the conditions in which the products might be used, such as in varying temperature and pressure, or with different types of oil. Insufficient as the required toxicity testing is, the results of such testing are in any event irrelevant to EPA's decision to list the dispersant on the Product Schedule, due to the absence of any safety or toxicity criteria.

In addition to meeting the 45% effectiveness standard and submitting results from the Revised Standard Dispersant Toxicity Test, manufacturers are required to provide product data, including contact information of the manufacturer, vendor, and primary distributors; handling and worker precautions; shelf life; recommended application procedures, concentrations and conditions for use; and components. The submission of a product's "components" requires the manufacturer to identify each ingredient in the dispersant formulation by chemical name and percentage by weight. Significantly, however, Subpart J allows the submitter to assert that information in data submissions, including the dispersant's components, are CBI. A majority of the dispersants currently listed on the Product Schedule fail to disclose at least some ingredients on the basis of a claim that the ingredients are CBI.[22]

Once listed on the Product Schedule, a dispersant can be selected for use without further toxicity testing or research. Under Subpart J, regional response teams and area committees, which implement the National Contingency Plan at the local level, can design preauthorization plans that address the specific contexts in which a dispersant should and should not be used. Once approved by the appropriate state and federal agencies, the preauthorization plans are incorporated into regional and area contingency plans, and use of dispersants in accordance with the plan proceeds without any need for further testing or approval when a spill occurs. Where a spill scenario is not addressed by an applicable preauthorization plan, a federal on-scene coordinator is required to consult with appropriate agencies before authorizing the use of any dispersant listed on the Product Schedule. The consultations that occur under these circumstances are rapid-fire and do not provide the luxury of additional testing or information-gathering to determine which dispersant on the Product Schedule is most effective and least toxic under the particular circumstances of the spill.



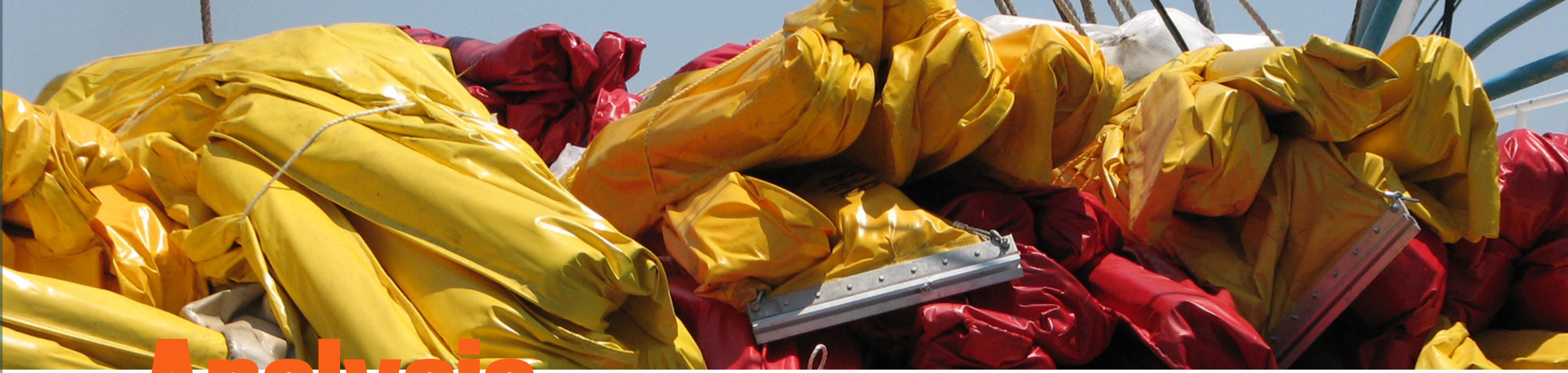
Skiimmers use booms to try to collect oil in the Gulf.

II. Freedom of Information Act Litigation

The lack of information available to the public about the safety of dispersants and the debate about the selection of Corexit products for use in the Deepwater Horizon disaster response prompted two public interest organizations—Gulf Restoration Network and Florida Wildlife Federation[23]—to file a FOIA request to EPA on May 28, 2010, before the wellhead was capped. The request sought the full ingredient list of each dispersant on the Product Schedule that was eligible for use in the Deepwater Horizon response; the application materials, including toxicity test results, submitted to EPA for listing of these dispersants; any health and safety studies submitted to EPA regarding the chemical ingredients in these dispersants; and communications between BP and EPA concerning the selection of a dispersant for use in the response.

When EPA failed to respond to the request in a timely way, the two organizations brought suit to obtain the requested information. Pursuant to this legal action, EPA released most of the requested information. Specifically, it provided the application materials and results of the required toxicity testing for the fourteen dispersants listed on the Product Schedule at the time of the Deepwater Horizon disaster; an aggregated list of the 57 ingredients in these dispersants; more than 90 health and safety studies concerning the chemical ingredients in these dispersants; and correspondence regarding EPA's selection of dispersant for use in the response. Product-specific application materials obtained through this litigation are now available to the public on Toxipedia.org.[24]

In light of EPA's longstanding permissiveness in allowing manufacturers of chemical products to claim confidentiality for information about their product and the fact that most companies have asserted CBI claims to keep the ingredients of their dispersant secret, EPA did not identify the ingredients of each dispersant on the Product Schedule as requested. EPA concluded that CBI claims prevented it from doing so (although it had disclosed the ingredients of Corexit 9500 and 9527 and also determined that the ingredients of Dispersit SPC 1000 and Mare Clean 200 were not confidential). Instead, EPA released an aggregate list of the 57 ingredients in all of the fourteen dispersants on the Product Schedule at the time of the Deepwater Horizon disaster.[25] That list of 57 chemicals is the focus of this report.



Analysis

OF CHEMICAL COMPONENTS IN DISPERSANTS

This section sets forth key findings from a literature review of scientific research on each of the 57 chemical ingredients. The goal of this analysis is to provide some sense of the potential toxicity of these chemicals and to begin to fill in the gaps in our understanding of how dispersants affect human health and the marine environment. The synthesis in this report was drawn from a review of information gathered from the health and safety studies obtained from EPA as a result of the litigation described above; information on government websites, such as the Hazardous Substance Data Bank, the National Library of Medicine, and TOXNET; as well as published articles from professional journals found in the PubMed database operated by the National Institutes of Health.

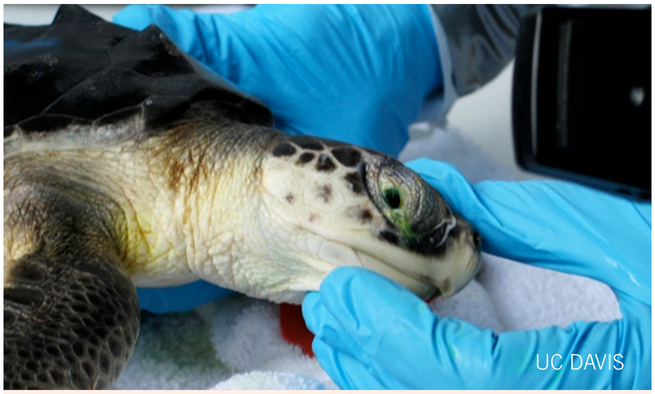
I. Potential Human Health and Environmental Impacts of the Chemical Ingredients of in Dispersants

Existing scientific research on the ingredients of dispersants indicate that some of these chemicals are indeed potential hazards. From carcinogens, to endocrine disruptors, to chemicals that are toxic to aquatic organisms, the chemicals that comprise dispersants can pose serious threats. The toxicity of different ingredients varies widely, however. Some chemicals are potentially carcinogenic; others are not. Some are suspected neurotoxins; others are not. Some are known to be toxic to aquatic organisms; others are not. The synthesized information, moreover, is only one step toward a comprehensive understanding of the impacts of dispersants given the absence of thorough scientific research and the unavailability of dispersant formulations.

The list below highlights key findings from the literature review of the 57 chemical ingredients in dispersants.[26] To view all findings, view the chart of all 57 ingredients and their corresponding impacts on www.toxipedia.org.

▶ Potential Impacts on Human Health

- Of the 57 chemical ingredients, 5 are linked to cancer: 1 is a possible human carcinogen, 1 is a likely human carcinogen, 1 caused cancer in tests on rats, 1 caused cancer in animal tests with unknown relevance to humans, and 1 causes effects that can later lead to cancer in humans.
- 33 chemicals are potential, suspected, or known skin irritants and toxins. Effects include slight skin irritation, skin sensitization, skin burns, and rash.
- 33 chemicals are potential, suspected, or known eye irritants. Effects include slight eye irritation, corrosion, permanent eye damage, and blindness.
- 11 chemicals are suspected or potential respiratory toxins or irritants.
- 10 chemicals are suspected kidney toxins.
- 8 chemicals are suspected reproductive toxins or have been shown to cause adverse effects to reproduction in test animals.
- 7 chemicals are suspected liver toxins.
- 6 chemicals are suspected neurotoxins.
- 5 chemicals are suspected to be toxic to the immune system.
- 4 chemicals are suspected blood toxins.
- 3 chemicals are associated with asthma.
- 1 chemical is a suspected to be toxic to the endocrine system.



▶ Potential Impacts on the Marine Environment

- 8 chemicals are suspected or known to be toxic to aquatic organisms.
- 5 chemicals are suspected to have a moderate acute toxicity to fish.
- 4 chemicals possibly adsorb on suspended solids or sediment and thereby pose a greater threat of entering the food chain through consumption by marine organisms.
- 1 chemical has a high potential for bioaccumulation.

Although the information summarized above and detailed in the chart available on the Toxipedia website provides some sense of the risks associated with dispersant use and exposure, the lesson learned is not that all dispersants are dangerous. Rather, the review of existing scientific research leads to two conclusions. First, the effects of different ingredients, and therefore different dispersants, vary. Second, the precise impacts of individual dispersants on human health and the environment is not fully known at this time.

The variation in toxicity of different chemical components clearly suggests that not all dispersants are created equal. Depending on their chemical composition, some dispersants are significantly safer for humans and for the environment than others. As more research is conducted in the future, some dispersants likely will also be found to be safer under certain conditions and for certain organisms than others. The implication is that careful dispersant selection is paramount. In other words, the regulatory framework should go beyond merely permitting the use of any dispersant listed on the Product Schedule, particularly when listing requires only submission of minimal toxicity testing results without any mandated safety criteria. Instead, intelligently designed regulations would require the selection and use of dispersants that have been shown to be safest and least toxic under the unique circumstances of a particular spill.

Site-specific selection of the most appropriate dispersant for a particular response requires an understanding of the impacts of individual dispersant products, however, and this information currently is unknown. No information on toxicity, safety, or potential effects could be identified for thirteen of the 57 chemical ingredients.[27] Extensive review of government databases, peer-reviewed scientific journals, and the health and safety studies obtained from EPA yielded no information indicating the safety of these chemicals.[28] All of this suggests that little or no research has been done on these chemicals and/or that research that has been done is not readily accessible to the public.

Even if sufficient research regarding individual chemical components existed, the lack of information about the chemical ingredients of individual dispersants stands in the way of fully understanding the impacts of those dispersants. Chemicals behave differently when combined with other chemicals, so the mix of ingredients and the percentages of the various components in a dispersant matter. Because the manufacturers of most dispersants claim their ingredient list is CBI, it is impossible to know which of the 57 chemical components are in each dispersant and which dispersant contains chemicals that may be more harmful, alone or in combination.

The failure to disclose dispersant formulations, which include the percentage composition of individual ingredients in a product, further limits understanding of a specific dispersant's impacts. Several chemical components are suspected toxins to a variety of organs and body functions. The term "suspected" suggests that there is evidence that the chemical may have an impact but that more study is necessary to determine the exposure and dose that causes harm. Similarly, for chemicals that cause varying degrees of eye or skin irritation, knowing the types and levels of exposure that will cause negative effects is essential to protecting those who are exposed to the dispersant containing that chemical. Not knowing a dispersant's formulation means that the percentage or ratio of chemicals in that dispersant are a mystery. Therefore, even if more research were done to identify the precise types and levels of exposure to specific chemicals that cause negative effects, it would be impossible to determine the levels of exposure to a dispersant that would cause potentially hazardous impacts in the absence of that dispersant's formula.

II. Potential Human Health and Environmental Impacts of Corexit 9500, Corexit 9527, Dispersit SPC 1000, and Mare-Clean 200

This section details the potential impacts of each of the four dispersants for which EPA has disclosed a full list of chemical ingredients: Corexit 9500, Corexit 9527, Dispersit SPC 1000, and Mare-Clean 200.[29] The section first discusses the potential impacts of the chemical ingredients found in Corexit 9500 and 9527, the two dispersants used in the Deepwater Horizon response. Findings in this section may be of particular interest to those who have been directly involved in the Deepwater Horizon disaster and its aftermath. The report then compares emerging pictures of the potential health and environmental impacts of the four dispersants. The difference in the toxicity of chemical components in these four dispersants and the state of knowledge about these chemicals demonstrates the need for more research, full disclosure, and careful selection of dispersants for use.

A. Corexit 9500 and 9527

Corexit 9500 was the primary dispersant employed by BP in response to the Deepwater Horizon disaster. Corexit 9527 was also used, particularly at the start of the response. This section highlights findings regarding the potential impacts of the chemicals found in both Corexit products.[30]

The following chemicals found in Corexit products have potential negative effects on human health, but more research is necessary to further investigate these serious potential impacts. Each of the chemicals identified below are found in both Corexit 9500 and 9527 unless otherwise indicated.

♦ **Sorbitan, mono-(9Z) 9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs (CAS# 9005-65-6)**[31]

- *Exposure may cause chemical pneumonitis (inflammation of lungs and difficulty breathing) and intestinal obstruction*[32]
- *Adverse reproductive effects have occurred in experimental animals*[33]

♦ **Butanedioic acid, sulfo-, 1,4-bis(2-ethylhexyl) ester, sodium salt (CAS# 577-11-7)**

- *Listed as a suspected neurotoxicant*[34]
- *Toxic to blood*[35]
- *Classified as moderately toxic*[36]
- *Strong irritant to eye and may irritate skin by removing natural oils*[37]
- *Ingestion causes diarrhea and intestinal bloating.*[38]

♦ **2-Propanol, 1-(2-butoxy-1-methylethoxy) (CAS# 29911-28-2)**

- *Listed as a suspected neurotoxicant*[39]
- *Prolonged exposure to skin may cause drying of the skin, leading to dermatitis*[40]

♦ **Distillates (petroleum), hydrotreated light (CAS# 64742-47-8)**

- *Confirmed animal carcinogen with unknown relevance to humans*[41]
- *Prolonged inhalation of high concentrations may damage respiratory system*[42]
- *Frequent and prolonged skin contact may cause dermatitis*[43]
- *Exposure by inhalation can cause dizziness, headache, nausea, drowsiness, and unconsciousness*[44] *(NIOSH)*

♦ **Ethanol, 2-butoxy, CAS# 111-76-2 (only found in Corexit 9527)**

- *Confirmed animal carcinogen with unknown relevance to humans*[45]
- *Although not registered as a carcinogen, the chemical "should be handled as a CARCINOGEN - WITH EXTREME CAUTION" according to the New Jersey Department of Health*[46]
- *Prolonged or repeated exposures can damage liver and kidneys*[47]
- *Exposure may damage developing fetus*[48]
- *Limited evidence that it may damage male reproductive system in animals and affect female fertility in animals*[49]
- *People exposed to high levels for several hours reported irritation of the nose and eyes, headache, a metallic taste in their mouths, and vomiting*[50]

Although it is impossible to establish causal certainty without research, reports among Gulf residents and cleanup workers of breathing problems, coughing, headaches, memory loss, fatigue, rashes, and gastrointestinal problems match the symptoms of blood toxicity, neurotoxicity, adverse effects on the nervous and respiratory system, and skin irritation associated with exposure to the chemicals found in Corexit.

Additionally, the following chemicals found in Corexit products may potentially be toxic to fish and aquatic organisms. Further research is necessary to ascertain the dose levels that would elicit negative impacts. The percentage composition of these chemicals in Corexit also must be known to determine whether harmful levels of the chemical are reached in its application.

♦ **Butanedioic acid, sulfo-, 1,4-bis(2-ethylhexyl) ester, sodium salt (CAS# 577-11-7)**

- *Possibility of adsorbing on sediment*[51]
- *Slight acute toxicity to fish*[52]

♦ **Distillates (petroleum), hydrotreated light (CAS# 64742-47-8)**

- *Listed as harmful to aquatic organisms*[53]
- *Moderate acute toxicity to fish*[54]

Research indicates that some of these chemicals have potentially serious impacts on human health and the environment. However, information on the dose levels that would elicit these impacts is not available. Additionally, many of these impacts are merely "suspected" or "potential" at this time, indicating a need for more research.

B. Dispersit SPC 1000

No relevant information on toxicity was found for two of the five chemical ingredients in Dispersit SPC 1000. The following are key findings on the impacts of the three ingredients on which at least some research has been done. For more complete information, please visit the Dispersit SPC 1000 page on Toxipedia.org. Potential human health impacts of chemical components in Dispersit include:

♦ **Amides, coco, N,N-bis(hydroxyethyl) (CAS# 68603-42-9)**

- *Listed as a likely carcinogen*[55]
- *Listed as a suspected immunotoxicant*[56]
- *Listed as a skin sensitizer*[57] *and skin irritant*[58]

♦ **Propanol, 1(or 2) - (2-methoxymethylethoxy) (CAS# 34590-94-8)**

- *Listed as a suspected reproductive toxin, kidney toxin, and potential central nervous system toxin*[59]
- *Repeated exposure to very high levels may affect the liver*[60]
- *Exposure can cause headache, dizziness, lightheadedness, & loss of consciousness*[61]

A third ingredient, Amines, tallow alkyl, ethoxylated (CAS# 61791-26-2), has been found to have moderately acute toxic effects on fish.[62]

C. Mare Clean 200

No relevant information on toxicity was found for three of the five chemicals in this product. Of the two chemical components on which at least some research has been done, very little information was identified relating to toxicity. Specifically:

♦ **Poly(oxy - 1,2 - ethanediyl), .alpha. - (9Z) - 1 - oxo - 9 - octadecen - 1 - yl - .omega. - (9Z) - 1 - oxo - 9 - octadecen - 1 - yl oxy—(CAS# 9005-07-6)**

- *Eye, skin, and digestive tract irritant*[63]
- *Prolonged or repeated skin exposure may cause rash, acne, and dermatitis*[64]

♦ **Sorbitan, tri-(9Z)-9-octadecenoate, poly(oxy-1,2-ethanediyl) derivs (CAS# 9005-70-3)**

- *Slightly hazardous in case of ingestion or inhalation*[65]

Overall, there was little relevant public information on the safety of the chemicals in Mare Clean 200. This suggests that more research is necessary and/or that research that has been conducted needs to be made accessible to the public. A lack of information does not constitute evidence that the chemicals found in this product are not toxic to human health or the environment.

D. Comparison of Potential Impacts

As has already been emphasized, scientific research on chemicals found in dispersants is tremendously lacking. Moreover, research findings on the impacts of a specific chemical in a dispersant do not necessarily offer a straightforward correlation to the impacts of the dispersant, given that the dispersant involves a mixture of chemicals and may have a high or low percentage of the particular chemical. With these caveats in mind, the results of the literature review presented in this report nevertheless begin to give an emerging sense of some of the impacts that may be associated with particular dispersants. The chart below compares the potential impacts of chemical ingredients in the four dispersants discussed above. An "X" designates that the product contains a chemical that is suspected, likely, or known to have a particular impact on human health or the marine environment. A "?" indicates the product's effects are currently unknown. Shaded boxes indicate the product is unlikely to have an impact.

While this chart provides a glimpse into the potential impacts of the chemicals found in these products, there is serious need for more research and investigation. Information on the chemicals found in Mare Clean, and on some of the chemicals in other dispersants, was not readily available. Until that information becomes available, the safety of the chemicals and the product is unknown. Additionally, since many of the "X"s represent potential or suspected impacts, research needs to clarify the likelihood of these impacts, the dose levels that elicit them, and the likelihood of those impacts from the use of the dispersant.

	COREXIT 9500	COREXIT 9527	DISPERSIT SPC 1000	MARE CLEAN 200
Carcinogen	?	X	X	?
Neurotoxicant	X	?	(shaded)	?
Immunotoxicant	(shaded)	(shaded)	X	?
Respiratory Toxin	X	?	(shaded)	?
Central Nervous System Toxin	(shaded)	(shaded)	X	?
Kidney Toxin	(shaded)	X	X	?
Blood Toxin	X	?	(shaded)	?
Reproductive/ Developmental Toxin	X	X	?	?
Liver Toxin	(shaded)	X	X	?
Toxic to Fish	X	X	X	?
Harmful to Aquatic Organisms	X	X	(shaded)	?
Attaches to Sediment	X	X	?	?

X = toxic ? = unknown (shaded) = likely no effect

Conclusions

AND RECOMMENDATIONS

The synthesis of existing research on chemicals found in dispersants identifies several areas of concern for the safety of humans and the marine environment. Almost none of the information reviewed for this analysis is required by EPA when listing a dispersant on the Product Schedule or for selecting a dispersant for use. The fact that some of the chemicals in dispersant products nevertheless have suspected or known links to cancer, neurological issues, and other debilitating effects raises questions about the procedure for listing dispersants on the Product Schedule and highlights the critical importance of proper selection of dispersants for use.

The many unknowns suggest an unacceptable lack of precaution in the listing and selection process. A precautionary approach would address uncertainties and delay listing and use until sufficient studies have been conducted to demonstrate that a dispersant is safe, or at least less toxic than oil alone. Such an approach would consider both human health and the aquatic environment, including endangered or sensitive, at-risk species (such as coral). Additionally, a precautionary process would require site-specific selection of dispersants appropriate for the affected region. Anticipatory action to prevent harm in the face of scientific uncertainty is key to preventing the scenario of unexplained health impacts and unknown environmental impacts that arose in the wake of the Deepwater Horizon disaster.

The EPA promulgates the regulations that companies must follow in order to obtain listing of their dispersant product and should make these regulations more precautionary by requiring comprehensive toxicological studies, safety criteria, and full disclosure of ingredients as a requirement for listing these products on the Product Schedule. The following recommendations are offered to help improve the listing and selection process to ensure that only the safest dispersants are used in future oil spill response.

1. EPA should require consistent and comprehensive toxicity testing as part of the application process for listing a dispersant on the Product Schedule.

a. Toxicity testing should assess the dispersant's potential impacts alone and when mixed with relevant types of oil, both short-term and chronic, across a range of doses and the full array of potential exposure routes. Impacts on human health should be studied, as well as impacts on a variety of aquatic environments and organisms that reflect the diverse conditions and regions in which dispersants may be applied. Special care should be taken to study impacts on unique, at-risk species and endangered species. The results of such research may lead to the ban of specific dispersants in certain regions where their effects are most harmful.

b. Testing and analysis for all applicants should be performed by the same independent laboratory selected by EPA to ensure that testing is consistent and results are unbiased.

2. EPA should establish minimum requirements for safety that must be met as a condition for listing on the Product Schedule. Without such requirements, the toxicity testing and studies fail to ensure that the dispersants listed for use actually are safe for people and the environment, or at least safer than exposure to oil alone.

3. EPA should require that manufacturers publicly disclose the full ingredient list, including percentage compositions of individual ingredients, as a condition for listing a dispersant on the Product Schedule. Full transparency of the chemical ingredients and formulation allows for independent scientific analysis of each product and puts valuable and needed information in the hands of the public, including oil spill response workers and health care workers.

4. The results of the comprehensive testing recommended in point (1) above should permit a multi-faceted, site specific selection process that uses only the safest dispersant for a particular spill. It should take into account the type of oil released, water temperature, the aquatic organisms present, the depth of application if used below the ocean's surface, and the other specific circumstances of the incident.

NOTES

[1] *See Corexit EC9500A*, ENVTL. PROT. AGENCY, http://www.epa.gov/osweroe1/content/ncp/products/corex950.htm (last visited Aug. 15, 2011).
[2] NAT'L RESEARCH COUNCIL, USING OIL SPILL DISPERSANTS ON THE SEA (1989), *available at* http://www.nap.edu/openbook.php?isbn=0309038898.
[3] NAT'L RESEARCH COUNCIL, OIL SPILL DISPERSANTS: EFFICACY AND EFFECTS 11 (2005), *available at http://books.nap.edu/catalog.php?record_id=11283#toc*.
[4] *Id.* at 4 (emphasis added).
[5] *Id.* at 3. Noting that "[t]here is insufficient understanding of the fate of dispersed oil in aquatic systems," the Council called for studies to estimate the relative contribution of dispersants to toxicity in representative species at different stages of life: "Sensitivity to dispersants and dispersed oil can vary significantly by species and life stage. Embryonic and larval stages appear to be more sensitive than adults to both dispersants and dispersed oil." *Id.* at 6, 207 (internal citations omitted).
[6] The Product Schedule is a list of dispersants that are eligible for use in oil spill incidents. For further information, see footnote 19 below and accompanying text.
[7] Press release, Envtl. Prot. Agency, EPA: BP Must Use Less Toxic Dispersant (May 20, 2010), http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/0897f55bc6d9a3ba852577290067f67f!OpenDocument. *See also Dispersant Monitoring and Assessment Directive – Addendum 2,* Envtl. Prot. Agency (May 20, 2010), http://www.epa.gov/bpspill/dispersants/directive-addendum2.pdf.
[8] Letter from BP to Coast Guard & Envtl. Prot. Agency (May 20, 2010), http://www.epa.gov/bpspill/dispersants/5-21bp-response.pdf.
[9] *Id.* Attachment at 3.
[10] *Id.*
[11] Lisa Jackson, Administrator, Envtl. Prot. Agency, Remarks at Press Conference, 4 (May 24, 2010), *available at* http://www.epa.gov/bpspill/dispersants/transcript-may24.pdf.
[12] *See The Use of Surface and Subsea Dispersants During the BP Deepwater Horizon Oil Spill* 11 (Nat'l Comm'n on the BP Deepwater Horizon Oil Spill and Offshore Drilling, Working Paper No. 4), *available at* http://www.oilspillcommission.gov/sites/default/files/documents/Updated%20Dispersants%20Working%20Paper.pdf.
[13] *See EPA's Toxicity Testing of Dispersants, EPA Response to BP Spill in the Gulf of Mexico*, ENVTL. PROT. AGENCY, http://www.epa.gov/bpspill/dispersants-testing.html (last visited Oct. 12, 2010).
[14] *See Dispersants Toxicity Testing – Phase I Questions and Answers*, ENVTL. PROT. AGENCY (June 30, 2010), http://www.epa.gov/bpspill/dispersants/Dispersant_Testing_Q&A_final_june302010.pdf.
[15] *See, e.g.*, Paul Quinlan, *Less Toxic Dispersants Lose Out in BP Oil Spill Cleanup*, N.Y. TIMES (May 13, 2010), *available at* http://www.nytimes.com/2010/05/13/business/energy-environment/13greenwire-less-toxic-dispersants-lose-out-in-bp-oil-spil-81183.html; Elizabeth Rosenthal, *In Gulf of Mexico, Chemicals Under Scrutiny*, N.Y. TIMES (May 5, 2010).
[16] *See Rep. Markey's Investigation into Use of Chemical Dispersants*, CONGRESSMAN ED MARKEY, http://markey.house.gov/index.php?option=com_content&task=view&id=4391&Itemid=386 (last visited Aug. 15, 2011).
[17] Nat'l Comm'n on the BP Deepwater Horizon Oil Spill and Offshore Drilling, *The Use of Surface and Subsea Dispersants During the BP Deepwater Horizon Oil Spill* 11 (Staff Working Paper No. 4, 2011), *available at* http://www.oilspillcommission.gov/sites/default/files/documents/Updated%20Dispersants%20Working%20Paper.pdf.
[18] *See, e.g.*, Wilma Subra, *Summary of Human Health Impacts of the BP Deepwater Horizon Disaster – Given at the Gulf Coast Leadership Forum* (Apr. 19, 2011), *available at* http://leanweb.org/our-work/water/bp-oil-spill/summary-of-human-health-impacts-of-the-bp-deepwater-horizon-disaster-given-at-the-gulf-coast-leadership-forum; Mike Ludwig, *Researchers Say Oil Dispersants Still an Issue in the Gulf*, TRUTHOUT (Apr. 20, 2011), http://www.truth-out.org/researchers-say-oil-dispersants-still-issue-gulf; DANIEL BROY & SHANNON DOSEMAGEN, THE BP OIL DISASTER: RESULTS FROM A HEALTH AND ECONOMIC IMPACT SURVEY IN FOUR COASTAL LOUISIANA PARISHES (Mar. 3, 2011), *available at* http://labucketbrigade.org/article.php?id=709.
[19] As of August 2011, sixteen dispersants are identified on the National Contingency Plan Product Schedule. *See Alphabetical List of NCP Product Schedule Products With Links to Technical Product Summaries*, ENVTL. PROT. AGENCY, http://www.epa.gov/osweroe1/content/ncp/product_schedule.htm (last visited Aug. 15, 2011) (nineteen dispersants are actually listed on the Product Schedule, but three – Seacare E.P.A., SF-Gold Dispersant, and ZI-400 Oil Spill Dispersant – are alternative names for already-listed dispersants). Two of the sixteen dispersants listed on the Product Schedule (Supersperse WAO2500 and Accell Clean DWD) were added to the Schedule after the Deepwater Horizon disaster. This report therefore addresses the remaining fourteen dispersant products, which were listed at the time of the Deepwater Horizon disaster: Biodisperse, Corexit EC9500A, Corexit EC9527A, Dispersit SPC 1000, Finasol OSR 52, JD-109, JD-2000, Mare Clean 200, Neos AB3000, Nokomis 3-AA, Nokomis 3-F44, Saf-Ron Gold, Sea Brat #4, and ZI 400.
[20] The 57 chemical ingredients are found in thirteen of the fourteen dispersants identified in footnote 19. Information in EPA's possession regarding Neos AB3000 included only that the product contains mineral spirits (40% of weight), nonionic surfactants (40%) and cationic surfactant (20%), and did not identify chemical ingredients by name. *See* Neos Company Limited, *Report of NEOS AB3000* (submitted to U.S. EPA Office of Emergency Management) (on file with Earthjustice). The list of 57 chemicals in the remaining thirteen dispersants is available on the Toxipedia.org website and includes chemicals such as propylene glycol, benzenemethanol, ethoxylated dodecanol, and sodium hydroxide. *See* Potential Effects of Oil Dispersant Chemicals on Human Health and the Aquatic Environment, TOXIPEDIA, http://toxipedia.org/display/toxipedia/Potential+Effects+of+Oil+Dispersant+Chemicals+on+Human+Health+and+the+Aquatic+Environment (last visited Aug. 15, 2011).
[21] EPA currently is undertaking revisions to these regulations. *See Revisions to the National Oil and Hazardous Substances Pollution Contingency Plan; Subpart J Product Schedule Listing Requirements*, OFFICE OF INFORMATION AND REGULATORY AFFAIRS, http://www.reginfo.gov/public/do/eAgendaViewRule?pubId=201010&RIN=2050-AE87 (last visited Aug. 15, 2011).
Subpart J regulations apply not only to dispersants, but also to surface washing agents, surface collecting agents, bioremediation agents, burning agents, sorbents, and miscellaneous oil spill control agents. Although dispersants are the focus of this report, the recommendations apply equally to other chemical substances used in response to oil spills.
[22] As is discussed below, the full ingredients of Corexit 9500, Corexit 9527, Dispersit SPC 1000, Mare Clean 200, Nokomis 3-AA, and Nokomis 3-F4 have been disclosed by their respective manufacturers. For the remaining dispersants on the Product Schedule, some or all ingredients have been claimed as CBI.
[23] Gulf Restoration Network, Inc. (GRN) is a non-profit network of local, regional, and national groups and individuals dedicated to protecting and restoring the natural resources of the Gulf of Mexico. *See* http://healthygulf.org/. Florida Wildlife Federation, Inc. is a non-profit conservation and education organization with approximately 13,000 members throughout Florida. The organization's mission includes the preservation, management, and improvement of Florida's marine resources, and the Federation acts on behalf of its members to protect Florida's water resources and the animals that use those waters as habitat. *See* http://www.fwfonline.org/Index.htm.
[24] TOXIPEDIA, http://www.toxipedia.org/display/toxipedia/Oil+Dispersant (last visited Aug. 15, 2011) (select an oil dispersant product name to access this material).
[25] As noted in footnote 20, these 57 ingredients actually are found in 13 dispersants, as EPA does not have in its possession the ingredients of Neos AB3000 despite its listing on the Product Schedule.
[26] As indicated in footnote 27 below, it is worth noting that no information was found for 13 of the 57 chemicals.
[27] These thirteen chemicals are:

- 2 - Propenoic acid, 2 - methyl - , 1,1' - (1,2 - ethanediyl) ester, polymer with 2 - propen - 1 - yl 2 - methyl - 2 - propenoate
- Alcohols, C12-14-secondary, ethoxylated

- Alkanes, C14-30
- Amines, tallow alkyl, ethoxylated
- Benzenesulfonic acid, (1 - methylethyl) -, sodium salt (1:1)
- D - Glucopyranose, oligomeric, C10 - 16 - alkyl glycosides
- Imidazolium compounds, 1 - 2 - (2-carboxyethoxy)ethyl - 1(or 3) - (2-carboxyethyl) - 4,5 - dihydro - 2 - norcoco alkyl, hydroxides, disodium salts
- Naphthalenesulfonic acid, methyl-, sodium salt (1:1)
- Poly(oxy - 1,2 - ethanediyl), .alpha.- (9Z)- 1 - oxo - 9 - octadecen - 1 - yl - .omega.- hydroxy-
- Poly(oxy - 1,2 - ethanediyl), .alpha. - hydro - .omega. - (9Z) - 1 - oxo - 9 - octadecen - 1 - yl]oxy] -, ether with D-glucitol (6:1)
- Poly(oxy - 1,2 - ethanediyl), .alpha. - hydro - .omega. - hydroxy - , ether with 1,2,3 -propanetriol (9Z) - 9 – octadecenoate
- Poly(oxy - 1,2 - ethanediyl), .alpha. - hydro - .omega. - hydroxy - , mono - C8 - 10 - alkyl ethers, phosphates
- Poly(oxy - 1,2 - ethanediyl), .alpha. - undecyl - .omega.- hydroxy -

[28] The health and safety studies considered here were submitted to EPA pursuant to Section 8(e) of the Toxic Substances Control Act, which requires manufacturers, processors and distributers of chemical substances or mixtures who obtain information "which reasonably supports the conclusion that such substance or mixture presents a substantial risk of injury to health or the environment" to report this information to EPA. 15 U.S.C. § 2607(e). These health and safety studies pertain to specific chemicals or mixtures of chemicals. Less than 20% of the health and safety studies provided by the EPA in the Freedom of Information Act litigation were useful sources of information about individual chemicals because a majority of the studies focused on chemical *mixtures*, making it impossible to delineate the potential effects of any single chemical within that mixture.

[29] In August 2011, in response to a request by Gulf Restoration Network and Florida Wildlife Federation, Mar-Len Supply Inc., the manufacturer of Nokomis 3-F4 and Nokomis 3-AA, voluntarily disclosed the identity of ingredients in these two dispersants. The ingredients of Nokomis 3-F4 and Nokomis 3-AA are available on Toxipedia.org.

[30] For more complete information about the impacts of these chemicals, visit the Corexit 9500 and Corexit 9527 pages on the Toxipedia website.

[31] A CAS number is a unique numeric identifier assigned by the Chemical Abstracts Service. Each CAS number designates one specific substance. The numbers "[p]rovide a reliable common link between the various nomenclature terms used to describe substances." *CAS Registry and CAS Registry Numbers*, CAS, A DIVISION OF THE AMERICAN CHEMICAL SOCIETY, http://www.cas.org/expertise/cascontent/registry/regsys.html (last visited Aug. 15, 2011).

[32] *Cameo Chemicals: Polysorbate 80*, NAT'L OCEANIC & ATMOSPHERIC ADMIN. http://cameochemicals.noaa.gov/chemical/20939 (last visited Aug. 15, 2011).

[33] *Material Safety Data Sheet: Tween® 80*, FISHER SCIENTIFIC, http://fscimage.fishersci.com/msds/40200.htm (last modified Nov. 29, 2007).

[34] *Chemical Profile for 1,4-Bis(2-Ethylhexyl) Sodium Sulfosuccinate (CAS Number: 577-11-7)*, SCORECARD: THE POLLUTION INFORMATION SITE, http://scorecard.goodguide.com/chemical-profiles/summary.tcl?edf_substance_id=577-11-7 (last visited Aug. 15, 2011).

[35] *Material Safety Data Sheet: Docusate Sodium MSDS*, SCIENCELAB.COM, INC., 1, http://www.sciencelab.com/msds.php?msdsId=9923877 (last modified Nov. 1, 2010).

[36] *Hazardous Substance Data Bank: Bis(2-Ethylhexyl) Sodium Sulfosuccinate*, U.S. NAT'L LIBRARY OF MED., http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+@rel+577-11-7 (select "Full Record" from the Table of Contents) (last modified Aug. 9, 2001).

[37] *Cameo Chemicals: Dioctyl Sodium Sulfosuccinate*, NAT'L OCEANIC & ATMOSPHERIC ADMIN., http://cameochemicals.noaa.gov/chemical/8582 (last visited Aug. 15, 2011).

[38] *Id.*

[39] *Chemical Profile for 1-(2-Butoxy-1-Methylethoxy)-2-Propanol (CAS Number: 29911-28-2)*, SCORECARD: THE POLLUTION INFORMATION SITE, http://scorecard.goodguide.com/chemical-profiles/summary.tcl?edf_substance_id=29911-28-2 (last visited Aug. 15, 2011.

[40] *Material Safety Data for: Glycol Ether DPnB*, MEGALOID LABORATORIES LIMITED, 1 (Feb. 2010), http://megaloid.ca/MSDS/Glycol%20Ether%20DPnB.pdf.

[41] *Material Safety Data Sheet: Saveclear*, FISHER SCIENTIFIC, http://fscimage.fishersci.com/msds/89683.htm (last modified Mar. 18, 2003).

[42] *Material Safety Data Sheet: CAS 64742-47-8*, ChemCAS.com (May 2005), http://www.chemcas.com/msds_archive/part2/cas/gm_msds/metprep_co_uk---oillub.asp.

[43] *Id.*

[44] *International Chemical Safety Cards: Distillates (Petroleum), Hydrotreated Light*, NAT'L INST. FOR OCCUPATIONAL SAFETY & HEALTH (Mar. 15, 2001), http://www.cdc.gov/niosh/ipcsneng/neng1379.html.

[45] *Hazardous Substance Data Bank: Ethylene Glycol Mono-N-Butyl Ether*, U.S. NAT'L LIBRARY OF MED., http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+@rel+111-76-2 (last modified Mar. 2, 2010).

[46] *Right to Know Hazardous Substance Fact Sheet: 2-Butoxy Ethanol*, N.J. DEP'T. OF HEALTH & SENIOR SERVS., 1 (Aug. 2008), http://nj.gov/health/eoh/rtkweb/documents/fs/0275.pdf.

[47] *Id.*

[48] *Id.* at 2.

[49] *Id.*

[50] Agency for Toxic Substances and Disease Registry ToxFAQs*: 2-BUTOXYETHANOL and 2-BUTOXYETHANOL ACETATE CAS # 112-07-2 and 111-76-2*, AGENCY FOR TOXIC SUBSTANCES & DISEASE REGISTRY, 2 (Aug. 1999), http://www.atsdr.cdc.gov/toxfaqs/tfacts118.pdf.

[51] *Hazardous Substance Data Bank: Bis(2-Ethylhexyl) Sodium Sulfosuccinate*, supra note 34.

[52] PAN Pesticides Database: Dioctyl Sodium Sulfosuccinate, PESTICIDE ACTION NETWORK NORTH AMERICA, http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC33310 (last visited Aug. 15, 2011).

[53] International Chemical Safety Cards: Distillates (Petroleum), Hydrotreated Light, supra note 41.

[54] *PAN Pesticides Database: Hydrotreated Paraffinic Solvent*, PESTICIDE ACTION NETWORK NORTH AMERICA, http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC33064 (last visited Aug. 15, 2011).

[55] *Hazardous Substance Data Bank: Coconut Diethanolamide*, U.S. NAT'L LIBRARY OF MED., http://toxnet.nlm.nih.gov/cgi-bin/sis/search/r?dbs+hsdb:@term+@rn+@rel+68603-42-9 (last modified Jan. 5, 2009).

[56] *Chemical Profile for (Coco Alkyl) Diethanolamides (CAS Number: 68603-42-9)*, SCORECARD: THE POLLUTION INFORMATION SITE, http://scorecard.goodguide.com/chemical-profiles/summary.tcl?edf_substance_id=68603-42-9 (last visited Aug. 15, 2011).

[57] *Haz-Map: Cocamide DEA*, U.S. NAT'L LIBRARY OF MED., *http://hazmap.nlm.nih.gov/cgi-bin/hazmap_search?queryx=68603-42-9&tbl=TblAgents* (last visited Aug. 15, 2011).

[58] *Hazardous Substance Data Bank: Coconut Diethanolamide, supra* note 52.

[59] *Haz-Map: Dipropylene Glycol Methyl Ether*, U.S. NAT'L LIBRARY OF MED., http://hazmap.nlm.nih.gov/cgi-bin/hazmap_search?queryx=34590-94-8&tbl=TblAgents (last visited Aug. 15, 2011).

[60] *Right to Know Hazardous Substance Fact Sheet: Dipropylene Glycol Methyl Ether*, N.J. DEP'T. OF HEALTH & SENIOR SERVS. 1, http://nj.gov/health/eoh/rtkweb/documents/fs/0804.pdf (last modified Feb. 2008).

[61] *Id.*

[62] *PAN Pesticides Database: Tallow Fatty Acid Amine Ethoxylate*, PESTICIDE ACTION NETWORK NORTH AMERICA, http://www.pesticideinfo.org/Detail_Chemical.jsp?Rec_Id=PC34525 (last visited Aug. 15, 2011).

[63] *Material Safety Data Sheet*, THE HALLSTAR COMPANY, 1 (Jan. 2010), http://www.hallstar.com/msds/1H024_MSDS.pdf.

[64] *Material Safety Data Sheet*, Lambent Techs. Corp., Petroferm, 1 (Mar. 11, 2004), http://www.petroferm.com/datasheets/286_MSDS.pdf.

[65] *Material Safety Data Sheet: Polysorbate 85 MSDS*, SCIENCELAB.COM, INC., 1, http://www.sciencelab.com/msds.php?msdsId=9926646 (last modified Nov. 1, 2010).

The Chaos of Clean-Up:

Analysis of Potential Health and Environmental Impacts of Chemicals in Dispersant Products