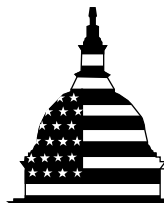


May 2012

OIL DISPERSANTS

Additional Research Needed, Particularly on Subsurface and Arctic Applications



G A O

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Why GAO Did This Study

In April 2010, an explosion onboard the *Deepwater Horizon* drilling rig in the Gulf of Mexico led to a release of approximately 206 million gallons of oil. When an oil spill occurs, responders have several options for managing the environmental impacts, including using chemical dispersants to break the oil into smaller droplets, which can promote biodegradation and help prevent oil from coming on shore. GAO was asked to review (1) what is known about the use of chemical dispersants and their effects, and any knowledge gaps or limitations; (2) the extent to which federal agencies and other entities have taken steps to enhance knowledge on dispersant use and its effects; and (3) challenges, if any, that researchers and federal agencies face in their attempts to enhance knowledge. GAO collaborated with the National Academy of Sciences to identify and recruit experts on dispersant use and conducted interviews with these experts, agency officials, and other specialists, and reviewed key documents and reports.

What GAO Recommends

GAO recommends, among other things, that the Interagency Coordinating Committee on Oil Pollution Research periodically provide updated information on key dispersant research by nonfederal sources. Also, the Interagency Committee should ensure that subsurface and Arctic applications are among the future priority research areas. The Departments of the Interior, Commerce, and Homeland Security, and the EPA generally concurred with the recommendations made to them.

View [GAO-12-585](#). For more information, contact David C. Trimble at (202) 512-3841 or trimbled@gao.gov.

OIL DISPERSANTS

Additional Research Needed, Particularly on Subsurface and Arctic Applications

What GAO Found

According to experts, agency officials, and specialists, much is known about the use of chemical dispersants on the surface of the water, but gaps remain in several research areas. For example, experts generally agreed that there is a basic understanding of the processes that influence where and how oil travels through the water, but that more research was needed to quantify the actual rate at which dispersants biodegrade. In addition, all the experts GAO spoke with said that little is known about the application and effects of dispersants applied subsurface, noting that specific environmental conditions, such as higher pressures, may influence dispersants' effectiveness. Knowledge about the use and effectiveness of dispersants in the Arctic is also limited, with less research conducted on dispersant use there than in temperate or tropical climates. For example, one expert noted that more research is needed on biodegradation rates for oil in the Arctic because the cold temperature may slow the process down.

Federal agencies have funded over \$15.5 million of dispersant-related research since fiscal year 2000, with more than half of the total funding occurring since the *Deepwater Horizon* incident. Most of these 106 projects were funded by the Department of the Interior's Bureau of Safety and Environmental Enforcement (BSEE), the National Science Foundation (NSF), and the Environmental Protection Agency (EPA). Over 40 percent of the research projects were focused at least in part on testing dispersant effectiveness. For example, BSEE funded 28 projects on the efficacy of dispersants on different types of oil and under different ocean conditions. In contrast, relatively few projects were focused on applying dispersants subsurface or in the Arctic. Specifically, NSF funded three projects looking at the use and effects of subsurface dispersant application, and BSEE and EPA funded the eight projects related to the use of chemical dispersants in Arctic or cold water environments.

Researchers face resource, scientific, and communication challenges related to dispersant research. Agency officials, experts, and specialists identified inconsistent and limited levels of funding as a challenge to developing research on the use and effects of chemical dispersants. For example, because support for dispersant research fluctuates, with temporary increases following a major spill, it is difficult for federal agencies to fund longer term studies, such as those needed to understand chronic toxicological effects of dispersants. In addition, researchers face scientific challenges with respect to dispersants, including being able to conduct research that replicates realistic oil spill conditions. Conducting research in the open ocean faces several logistical barriers, and laboratory experiments are unable to fully approximate the scale and complexity of ocean conditions. Lastly, agency officials, experts, and specialists told GAO that it can be a challenge to communicate and track research. Although some organizations have attempted to compile lists of dispersant-related research, currently there is no mechanism that tracks dispersant research across all sources and highlights past and ongoing research projects. For example, the Interagency Coordinating Committee on Oil Pollution Research—a multi-agency committee chaired by the Coast Guard—maintains a list of federally sponsored oil spill related research, but does not track or cross-reference related research that has been funded solely by industry or nongovernmental sources.

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Abbreviations

BSEE	Bureau of Safety and Environmental Enforcement
CEDRE	Centre of Documentation, Research and Experimentation on Accidental Water Pollution
CDC	Centers for Disease Control and Prevention
CRRC	Coastal Response Research Center
DHS	Department of Homeland Security
EPA	Environmental Protection Agency
HHS	Department of Health and Human Services
MSDS	Material Safety Data Sheet
NAS	National Academy of Sciences
NIH	National Institutes of Health
NIEHS	National Institute of Environmental Health Sciences
NIOSH	National Institute for Occupational Safety and Health
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
SMART	Special Monitoring of Applied Response Technologies

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United States Government Accountability Office
Washington, DC 20548

May 30, 2012

The Honorable Brad Miller
Ranking Member
Subcommittee on Energy and Environment
Committee on Science, Space, and Technology
House of Representatives

The Honorable Edward J. Markey
House of Representatives

On April 20, 2010, an explosion and fire onboard the *Deepwater Horizon* drilling rig in the Gulf of Mexico led to the largest oil spill in U.S. history, releasing approximately 206 million gallons of oil into the Gulf over a period of nearly 3 months. When an oil spill occurs in coastal waters of the United States, responders have several options for managing the environmental impacts of the spill, including the use of chemical dispersants. Dispersants do not reduce the total amount of oil entering the environment; rather, they help break down oil into small droplets that can more easily mix into the water below the surface, increasing biodegradation rates and potentially decreasing the impact of spilled oil on the shoreline. However, because chemical dispersants promote the movement of oil below the surface, their use exposes the underwater environment and the ocean floor to more of the spilled oil, where it may also have harmful effects. Therefore, decisions about whether to use dispersants involve trade-offs between the risks that untreated oil poses to the water surface and shoreline habitats and the risks that chemically dispersed oil poses to underwater environments, as well as the feasibility and limitations of alternative response options.

To help inform oil spill response efforts and decision making, government, industry, and academic scientists have conducted research on the use and effects of chemical dispersants. Research on dispersants involves a range of interdisciplinary areas, including the effectiveness of such chemicals in dispersing oil; the fate and transport of dispersants and chemically dispersed oil—that is, where they ultimately go and how they travel with the water; aquatic toxicity and other environmental effects of dispersants and chemically dispersed oil; the modeling and monitoring of dispersant use; and human health effects.

Oil spill responders have been using chemical dispersants since the 1960s. No entity precisely tracks dispersant use, but according to federal

officials, dispersants have been used about 11 times in response to spill events in U.S. waters. According to a study from the 2008 International Oil Spill Conference, dispersants were applied over 200 times globally from 1968 through 2007, though many of these applications involved small amounts of dispersant.¹ During the *Deepwater Horizon* incident, responders applied over 1.8 million gallons of chemical dispersants to the spilled oil—an unprecedented volume in the United States.²

Approximately 42 percent of this total was applied directly at the wellhead more than 5,000 feet below the ocean's surface—a method that had not previously been used or planned. According to a presidential commission that investigated the *Deepwater Horizon* incident, the future of domestic oil production relies to a substantial extent on producing oil from current offshore wells and expanding development into progressively deeper, more distant waters, perhaps including challenging environments such as the Alaskan Arctic, which will require response options that are viable in such conditions.³

In this context, you asked us to review chemical dispersant use and research. Specifically, our objectives were to examine (1) what is known about the use of chemical dispersants and their effects, and knowledge gaps about or limitations to their use, if any; (2) the extent to which federal agencies and other entities have taken steps to enhance knowledge on chemical dispersant use and its effects; and (3) challenges, if any, that researchers and federal agencies face in their attempts to enhance knowledge on chemical dispersant use and its effects.

To determine what is known about the use and effects of chemical dispersants and identify any knowledge gaps or limitations, we reviewed documents and literature, including federal regulations, government oil spill planning documents, scientific studies, and key reports on dispersant

¹A. Findlay and A. Steen, "Frequency of Dispersant Use Worldwide," *International Oil Spill Conference* (2008). The International Oil Spill Conference provides a forum for professionals from the international community, the private sector, government, and non-governmental organizations to highlight and discuss innovations and best practices across the spectrum of prevention, preparedness, response, and restoration.

²In response to the *Ixtoc* spill, which occurred in 1979-1980 off the coast of Mexico, responders applied 2.7 million gallons of dispersants to the surface of the water.

³National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling, *Deep Water: The Gulf Oil Disaster and the Future of Offshore Drilling* (Washington, D.C.: January 2011).

use to determine areas of research that inform planning and decision making regarding the use of chemical dispersants. In addition, we collaborated with the National Academy of Sciences (NAS) to identify 11 academic, industry, and other researchers recognized as experts in their respective scientific fields and capable of advising us on chemical dispersant use and research; hereafter, these scientists and researchers will be referred to as “experts.” A list of these experts can be found in appendix II. NAS staff selected these experts based on their knowledge of one or more of the following topic areas: dispersant effectiveness, toxicity of dispersants and dispersed oil, fate and transport of dispersants and dispersed oil, and monitoring actual dispersant use, among others. We conducted semi-structured interviews with these experts to discuss the state of knowledge, including gaps, regarding dispersant research. We supplemented our semi-structured expert interviews with interviews of federal officials and other oil spill or dispersant specialists, including state officials who have been involved in past response actions, human health researchers, oil spill response organizations with expertise in applying chemical dispersants, industry representatives with experience in researching oil dispersants and responding to oil spills, and other relevant non-governmental organizations, such as a regional advisory group focused on environmental protection as it relates to oil production and transportation. Statements from these groups will be identified as being from “specialists.”

To determine the extent to which federal agencies and other entities have taken steps to enhance knowledge on chemical dispersant use and its effects, and what challenges, if any, researchers have faced, we analyzed information supplied by and conducted interviews with officials from federal agencies conducting research on dispersant use and effects: the Department of the Interior’s Bureau of Safety and Environmental Enforcement (BSEE), the Department of Homeland Security’s (DHS) United States Coast Guard (Coast Guard), the Environmental Protection Agency (EPA), the Department of Health and Human Services’ (HHS) National Institutes of Health (NIH) and Centers for Disease Control and Prevention (CDC), the Department of Commerce’s National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF). We also analyzed information supplied by and conducted interviews with specialists, as identified above. In addition, we attended a NOAA-funded workshop on the future of dispersant use to gather information on both the state of knowledge and ongoing research and an industry-funded workshop of key federal, state, and local responders, academic researchers, and other stakeholders who could potentially be affected by an accidental offshore oil spill along the Eastern

seaboard of the United States. Appendix I provides a more detailed description of our scope and methodology.

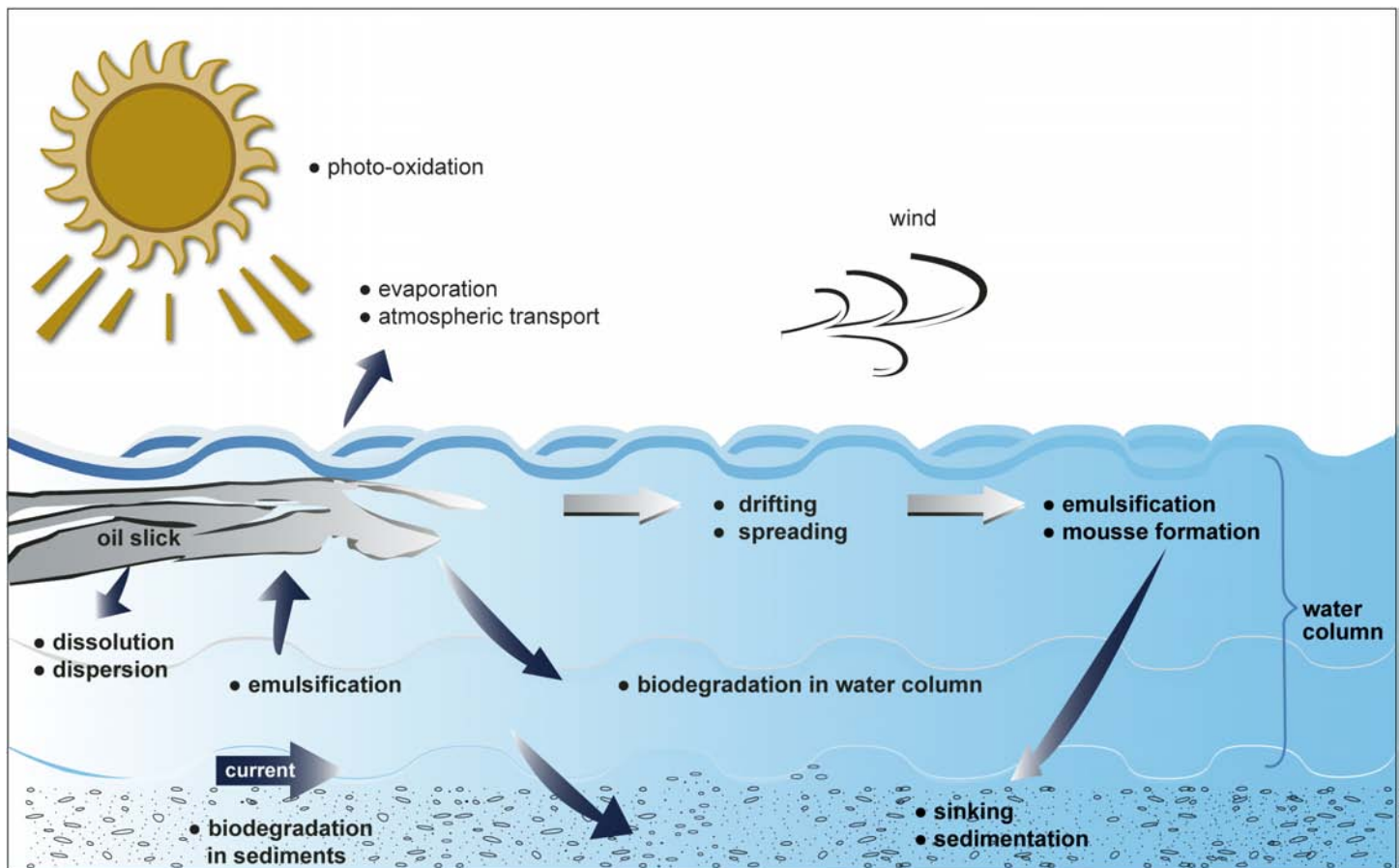
We conducted this performance audit from March 2011 through May 2012, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Crude oil is a naturally occurring substance generated by geological and geochemical processes. A variety of petroleum products, such as gasoline, diesel fuel, and heavy fuel oil are derived from this natural resource. Crude oil and petroleum products can vary greatly depending on where and how they were extracted and refined, and their unique characteristics influence how they will behave when released into water and how they will affect animals, plants, and their habitats. Because oil is typically less dense than water, oil spills on or near the surface of water will float and form slicks. An untreated slick will remain at the surface until it evaporates, disperses naturally into the water column, washes onto the shoreline, breaks up into smaller collections of oil—known as tarballs—or is recovered or removed from the water.

Oil or petroleum products spilled on water undergo a series of physical and chemical processes that may cause the oil to change—known as weathering—or migrate. Some processes cause oil to be removed from the water's surface, while others change its form on the surface. Figure 1 depicts these processes, which are further described and defined in table 1.

Figure 1: Ways in Which Spilled Oil Weathers and Migrates



Source: ExxonMobil Oil Spill Response Field Manual.

Table 1: Description of Weathering and Migration Processes That Act on Spilled Oil

Process	Description of action on spilled oil
Drifting	Physical movement of surface oil from one location to another due to the combined effects of wind, waves, currents, and tides
Spreading	Expansion of oil on the sea surface
Evaporation	Physical-chemical process resulting in transfer of hydrocarbons from the sea surface to the atmosphere
Emulsification and mousse formation	Formation of water in oil emulsions that can contain as much as 75 to 80 percent water
Dispersion	Transport of oil from the sea surface into the water column due to wave action
Dissolution	Physical-chemical process resulting in dissolution of hydrocarbons in the water column
Sinking/Sedimentation	Increase in density of oil due to weathering and interaction with suspended sediments or material of biological origin; deposition of material to the sea floor
Atmospheric transport	Transport of evaporated hydrocarbons in the atmosphere
Biodegradation	Biological-chemical process altering or transforming petroleum hydrocarbons through microbial action
Photo-oxidation	Transformation of petroleum hydrocarbons through interaction with sunlight

Source: ExxonMobil Oil Spill Response Field Manual.

Regardless of their physical and chemical properties, all oils will weather once spilled. The rate of weathering depends on the conditions at the time of the spill and the nature of the spilled oil. Most weathering processes are highly temperature dependent, however, and will often slow considerably as the temperature approaches freezing temperatures.⁴

When an oil spill occurs underwater, such as during a well blowout or pipeline rupture,⁵ it forms underwater plumes of oil droplets that billow and drift beneath the ocean's surface. Water temperature and salinity, the depth of the leak, the density of the oil, and the pressure with which it is flowing, among other things, can affect plume formation. Because oil is

⁴National Research Council, *Oil in the Sea III: Inputs, Fates, and Effects* (Washington, D.C.: 2003).

⁵A blowout is an uncontrolled release of oil or gas from a well.

less dense than water, it will float toward the surface. The speed at which it rises is based on the oil's droplet size—the larger the droplet the faster the oil rises. Once it reaches the surface, the oil forms a slick thinner than those that result from surface spills, in part because of the diffusion and dispersal of oil droplets as they rise.⁶

When an oil spill occurs, responders have several techniques for responding, including the following:⁷

- Chemical dispersants—applying chemicals to help break up the oil into smaller droplets to facilitate the movement of the oil off the surface and into the water column and enhance microbial breakdown of the oil.
- Mechanical containment and recovery—using booms, skimmers, sorbents, and other techniques to trap and remove the oil.⁸
- In-situ burning—burning spilled oil on the surface of the water.
- Shoreline clean-up—physically picking up oil and washing or chemically treating shorelines, or deploying bioremediation, which involves the addition of nutrients to enhance the ability of microorganisms to degrade the oil more rapidly.
- No action—taking no active response to the spill.

Each response technique has its own operational requirements, benefits, limitations, and potential adverse impacts. Responders must evaluate which method or combination of methods to use depending on the circumstances and conditions of the oil spill, such as the weather, sea

⁶National Research Council, *Oil in the Sea III: Inputs, Fates, and Effects* (Washington, D.C.: 2003).

⁷Well containment and source control are other response options taken after an event such as a blowout or spill to regain control of the well and capture any released oil. This response option was outside the scope of this review. See GAO, *Oil and Gas: Interior Has Strengthened Its Oversight of Subsea Well Containment, but Should Improve Its Documentation*, [GAO-12-244](#) (Washington, D.C.: Feb. 2012) for related report.

⁸Booms are floating barriers that serve to contain an oil spill; oil skimmers are devices that remove oil floating on the surface of a body of water, and sorbents are sponges used to absorb oil.

state, type and amount of oil spilled, distance of spill from shore, and potentially affected natural resources. In the United States, mechanical containment and recovery is the primary response option, since it physically removes oil from the environment. However, experience has shown that mechanical containment and recovery in open waters can be limited depending on sea conditions. Specifically, for such operations to be conducted most effectively, seas need to be relatively calm, with waves under about 3 feet, according to documents we reviewed and specialists with whom we spoke.

Oil spills inevitably have environmental impacts, and response actions may only reduce these impacts or shift them. In determining which response options are best for an individual spill, agency officials said that decision makers weigh the ecological risks and consequences with the goal of minimizing adverse effects as much as possible.⁹ For example, when considering the use of chemical dispersants as a response option, the essential question asked is whether dispersing the oil into the water column offers more benefits (i.e., causes less harm) than leaving the oil on the surface if it cannot be adequately removed by mechanical means or burned. Decision makers would collect as much information as possible to assess, for example, whether the potential harm to wetlands or waterfowl that could occur if dispersants were not applied is greater than the potential harm to marine species from chemically dispersed oil entering the water column. This evaluation of these trade-offs is sometimes called a net environmental benefit analysis.

Chemical dispersants function by reducing the surface tension between oil and water—similar to the way that dish detergents break up cooking oil on a skillet—and enhancing the natural process of dispersion by generating larger numbers of small droplets of oil that are mixed into the water column by wave energy. Thus, rather than having a surface slick of oil, one will have an underwater plume of chemically dispersed oil. Throughout this report we use the term “chemically dispersed oil” to discuss the mixture that results when chemical dispersants are applied to oil and facilitate the formation of oil droplets. A typical commercial dispersant contains a mixture of three types of chemicals: surfactants, solvents, and additives. Surfactants are the active agents that reduce oil-

⁹According to agency officials, it is important to note that there is not an expectation that any response option will be 100 percent effective. Spill responses generally involve an integrated combination of response options.

water surface tension. Surfactant compounds contain both oil-compatible and water-compatible groups on the same molecule, with the oil-compatible group interacting with oil and the water-compatible group interacting with water to make the interaction between the two easier. Solvents are added to promote the dissolution of the surfactants and additives into the dispersant mixture and then, during application, into the oil slick. Additives may be present for a number of purposes, such as improving the dissolution of the surfactants and increasing the long term stability of the dispersant formulation.

Federal statutes required the development of a National Oil and Hazardous Substances Pollution Contingency Plan that, among other things, delineates the procedures for preparing for and responding to oil spills and details the roles and responsibilities of federal agencies and others involved in dispersant decision making.¹⁰ Specifically, the National Contingency Plan is based on a framework that brings together the functions of the federal government, the affected state governments, and the party responsible for a spill under a unified command to achieve an effective and efficient response. In response to an oil spill, the National Contingency Plan calls for a Federal On-Scene Coordinator to direct and coordinate response efforts. In the case of oil spills in the coastal zone,¹¹ such as in the *Deepwater Horizon* incident, a representative from the Coast Guard serves as the Federal On-Scene Coordinator. EPA provides the Federal On-Scene Coordinator for spills occurring in the inland zone, and the designation of these zones is documented in the Regional Contingency Plans.

As part of the National Contingency Plan, EPA maintains the National Oil and Hazardous Substances Pollution Contingency Plan Product Schedule, which lists chemical dispersants that may be authorized for use

¹⁰Development of a National Contingency Plan is required by the Comprehensive Environmental Response, Compensation, and Liability Act, as amended, and the Clean Water Act, as amended.

¹¹As defined for the purpose of the National Contingency Plan, the coastal zone means all U.S. waters subject to the tide, U.S. waters of the Great Lakes, specified ports and harbors on inland rivers, waters of the contiguous zone, other waters of the high seas subject to the National Contingency Plan, and the land surface or land substrata, ground waters, and ambient air proximal to those waters. The term coastal zone delineates an area of federal responsibility for response action. Precise boundaries are determined by EPA/Coast Guard agreements and specified in federal Regional Contingency Plans.

on oil discharges.¹² Inclusion on the Product Schedule does not mean that EPA recommends the product for use; rather, it only means that certain data have been submitted to EPA and that the dispersant has a certain effectiveness. The data that a manufacturer must submit to EPA includes effectiveness and toxicity data, special handling and worker precautions for storage and application, recommended application procedures and conditions for use, and shelf life. An appendix to the regulations implementing the National Contingency Plan describes the test methods a manufacturer is to follow for measuring effectiveness and toxicity of dispersants. In terms of effectiveness, the manufacturer must demonstrate that the dispersant can disperse at least 45 percent of oil in testing. To assess toxicity, the appendix specifies the standard test for a chemical dispersant, which involves exposing two species—silverside fish (*Menidia beryllina*) and mysid shrimp (*Mysidopsis bahia*)—to varying concentrations of the dispersant, oil, and a mixture of the two, to determine mortality rates at the end of 96 hours for silversides and 48 hours for mysid shrimp. Chemical dispersant manufacturers must submit the results of effectiveness and toxicity testing to EPA, which may request further documentation or verify test results in determining whether the dispersant meets listing criteria. Both the presidential commission that investigated the *Deepwater Horizon* incident and the EPA Inspector General have recommended that EPA update the Product Schedule's testing protocols and requirements for listing.¹³ In addition, the EPA Inspector General recommended, among other things, that EPA modify the Product Schedule and contingency plans to include additional information learned from the *Deepwater Horizon* oil spill response, such as subsurface dispersant application in deep water. EPA anticipates issuing a proposed rule in winter 2012 that would revise the requirements for listing a product on the Product Schedule and is considering changes to effectiveness and toxicity testing protocols.

A National Response Team and Regional Response Teams serve as preparedness and planning organizations prior to a response and may serve as incident-specific response teams to provide support and advice to the Federal On-Scene Coordinator during a response. The National

¹²33 U.S.C. § 1321(d)(G)(i) (2006); 40 C.F.R. § 300.5 (2011).

¹³EPA, Office of Inspector General, *Revisions Needed to National Contingency Plan Based on Deepwater Horizon Oil Spill*, Report No. 11-P-0534 (Washington, D.C.: Aug. 25, 2011).

Response Team includes 20 federal departments and agencies responsible for national response and preparedness planning, for coordinating regional planning, and for providing policy guidance and support to Regional Response Teams.¹⁴ Regional Response Teams are composed of representatives of each National Response Team agency and representatives from relevant state and local governments (as agreed upon by the states) and may also include tribal governments. There are 13 Regional Response Teams corresponding to the 10 standard federal regions, plus separate teams for Alaska, Oceania in the Pacific, and the Caribbean. The Regional Response Teams develop Regional Contingency Plans establishing procedures for preparing for and responding to oil spills in the region. Within the regions, area committees composed of officials from federal, state, and local agencies have been designated to develop Area Contingency Plans.

Regional and Area Contingency Plans may address the specific situations in which chemical dispersants should and should not be used and may preauthorize their use by the Federal On-Scene Coordinator. Preauthorization plans may address factors such as the potential sources and types of oil that might be spilled, the existence and location of environmentally sensitive resources that could be affected, available dispersant stockpiles, available equipment and adequately trained operators, and means to monitor product application and effectiveness. The details and procedures for preauthorized use vary by region; however, plans generally preauthorize use of dispersants for areas at least 3 nautical miles from shore with water at least 10 meters deep, and the chemical dispersant must be listed on EPA's Product Schedule. If dispersants are not preauthorized, the Federal On-Scene Coordinator may authorize use of dispersants on the Product Schedule with the concurrence of EPA and appropriate state representatives and in consultation with the Department of Commerce and Department of the

¹⁴The 20 members include EPA; the Coast Guard; the Department of Commerce's NOAA, National Ocean Service and Office of Response and Restoration; the Department of Energy's Office of Health, Safety and Security and National Nuclear Security Administration; the Department of Health and Human Services' Centers for Disease Control and Prevention and National Institute for Occupational Safety and Health; the Department of the Interior's Office of Environmental Policy and Compliance and Minerals Management Service (now reorganized into the Bureau of Safety and Environmental Enforcement, the Bureau of Ocean Energy Management, and the Office of Natural Resources Revenue); the Departments of Agriculture, Defense, Justice, Labor, Transportation, and State; the Federal Emergency Management Agency; the General Services Administration; and the Nuclear Regulatory Commission.

Interior. The Federal On-Scene Coordinator may authorize the use of any dispersant, including products not listed on the Product Schedule, without obtaining concurrence, when, in the judgment of the coordinator, the use of the product is necessary to prevent or substantially reduce a hazard to human life. Currently, most Regional Contingency Plans include preauthorization for application of dispersants on the surface in certain areas; however, none of the plans include preauthorization for subsurface application of dispersants in deep water.¹⁵

During the *Deepwater Horizon* incident, chemical dispersants were used with and without preauthorization and were applied at various times throughout the response by airplane, boat, and deep water, subsurface injection at the wellhead. The aerial and boat applications were preauthorized, but subsurface injection of dispersants, which had never previously been used, was guided by a directive and a series of addenda to that directive. This directive and its addenda were established jointly by the Coast Guard and EPA as the spill was occurring, and these documents placed certain restrictions on dispersant use. Because of complications and uncertainties related to real time authorization of chemical dispersant use in this novel manner, the EPA Inspector General recommended in its 2011 report that EPA develop policies and procedures to govern subsurface dispersant use and to modify preauthorization plans to specifically address subsurface application of dispersants. According to agency officials, the National Response Team has drafted guidelines for subsurface dispersant monitoring and application and expects to finalize them by winter 2012.

¹⁵Four Regional Contingency Plans do not currently contain preauthorized use of chemical dispersants—Alaska, and the three regions that are inland and without access to oceans. In addition, dispersants are typically not preauthorized or used inland or in fresh water.

Much Is Known about Surface Use of Chemical Dispersants, but Gaps Remain, Particularly about Subsurface and Arctic Use

According to experts we spoke with, there is a significant body of research on the use of chemical dispersants on the surface of the water, but some gaps remain in several research areas. Moreover, experts highlighted two additional areas in which knowledge is limited and more research is needed—the subsurface application and effects of dispersants in deep water environments and the use of dispersants in Arctic and other cold water environments.

Surface Use of Dispersants Reflects a Significant Body of Research, but Gaps Remain

According to experts, agency officials, and specialists we spoke with, much is known about the use of dispersants on the surface of the water; however, they said that gaps remain in several research areas. Specifically, experts, agency officials, and specialists described the state of knowledge and gaps in the following six research areas:

- effectiveness in dispersing oil,
- fate and transport of chemically dispersed oil,
- aquatic toxicity and environmental effects of chemically dispersed oil,
- modeling of chemically dispersed oil,
- monitoring of chemically dispersed oil, and
- human health effects.

Effectiveness in dispersing oil. Most of the 11 experts we interviewed agreed that there is a large body of research on the effectiveness of chemical dispersants, and many said that there is a solid understanding of the factors that may influence the effectiveness of such dispersants when used on the surface. For a dispersant to be effective, the oil must be dispersible, and there must be sufficient mixing energy—the energy generated by movement of the water from wind and wave action—to allow formation of smaller oil droplets and to disperse these droplets into the water column. Whether these two conditions are satisfied relies on a complex set of factors, including the type of oil spilled, how long the oil has been exposed to the environment, and sea and weather conditions. One of the primary factors in the dispersability of oil is its

viscosity—the resistance of a liquid to flow. Oils that do not flow easily have a high viscosity and are more difficult to disperse; oils that flow easily have a low viscosity and tend to be more dispersible. Oil viscosity is influenced by its type and the amount of change or weathering it has undergone. For example, many experts stated that chemical dispersants are more effective in dispersing light to medium crude oils, which have a lower viscosity, than heavy oils, which have a higher viscosity. In addition, the longer oil weathers, the more viscous—and thus less dispersible—it becomes. This means chemical dispersants need to be used quickly after a spill—typically within hours to 1 to 2 days after a spill, depending on conditions—before the oil has weathered substantially. At a certain level of viscosity, dispersants are no longer effective. Many experts also told us that chemical dispersants are more effective in dispersing oil in moderately wavy seas than in calm seas because of the mixing energy such sea states provide, and dispersants would likely not be used in very stormy, wavy seas because such conditions would disperse the oil naturally and present operational difficulties. In addition, the effectiveness of a chemical dispersant depends on the ratio of chemical dispersant to oil. Planning guidelines generally recommend a ratio of 1 part dispersant to 20 parts oil. However, some experts and specialists told us that the minimum effective dispersant-to-oil ratio can also vary greatly based on the type of oil and degree of weathering. Thus, some light oils, if fresh, may only require ratios of 1:40 or less, whereas weathered or more viscous oils may require ratios above 1:20.

While there is a large body of research on the effectiveness of chemical dispersant use on the surface of the water, experts identified a number of areas in which they believe additional study is needed. Specifically, some experts told us that research on effectiveness should more closely resemble real world conditions, rather than the artificial conditions often experienced in a laboratory. For example, one expert said that some laboratory effectiveness tests involve less mixing energy than real world conditions found in the ocean, and therefore, dispersant effectiveness rates may be understated. In addition, the properties of oil can vary greatly depending on the source, and some experts said that more research should be conducted on the effectiveness of different dispersant formulations on different types of oil. Because there are hundreds of types of oil, specific dispersants may work better on certain types of oil than others. Some experts also said that more research is needed to better understand the effectiveness of dispersants on heavily weathered and emulsified oil, noting that dispersants are typically applied on the surface just once; however, applying dispersants twice may increase their effectiveness on emulsified oil.

Fate and transport of chemically dispersed oil. Many of the experts we spoke with indicated that there is a basic understanding of the processes that influence the fate and transport of chemically dispersed oil, but that fate and transport of oil are subject to many complex processes, some of which are better understood than others. Specifically, most experts whom we spoke with agreed that the use of chemical dispersants increases biodegradation rates, as dispersants help reduce the size of oil droplets, making them more accessible to microbes that feed on them. Experts differed in their views with regard to the extent to which factors such as evaporation, photo-oxidation, and dissolution influence the fate of chemically dispersed oil. For example, some experts said that dissolution—the chemical stabilization of oil components in water—increases with dispersant use; whereas, other experts said that more research is needed to understand the relationship between dispersant use and dissolution. Chemically dispersed oil is transported both vertically and horizontally through the water by wind, waves, and currents. Once droplets are dispersed vertically into the water column, most oil droplets will be positively buoyant and will rise toward the surface. The speed at which the droplets will rise depends on their diameter, with the smallest droplets rising very slowly. For example, according to a 2005 National Academy of Sciences report on chemical dispersants, a droplet with a diameter of 300 micrometers (0.3 millimeters) would take less than 8 minutes to rise 3 meters, while a droplet with the diameter of 30 micrometers (0.03 millimeters) would take over 12 hours to rise the same distance.¹⁶ Once the oil is dispersed below the surface, subsurface currents move the location of the oil droplets horizontally. In some cases, the direction the oil will travel below the surface will be different than it traveled on the surface because the direction of the currents may be different than the direction of the wind. When currents are non-uniform, mixing is produced that further dilutes and disperses oil droplets throughout the water. Many experts also told us that chemically dispersed oil, as compared with oil that is naturally dispersed, reduces the likelihood of oil droplets reforming into slicks because of the smaller droplet size—which allow for greater dispersion and slower rise rates.

The experts we spoke with also identified several research gaps related to the fate and transport of chemically dispersed oil. For example, most

¹⁶National Research Council, *Oil Spill Dispersants: Efficacy and Effects* (Washington, D.C.: 2005).

experts told us that the use of chemical dispersants increases biodegradation rates, but many told us that more research was needed to quantify the actual rate at which biodegradation occurs. Additionally, many experts said that more research is needed to understand the specifics of transport within the water column and oil droplet size, since they are important factors for determining whether the chemically dispersed oil will remain in the water column or float back to the surface. Many experts also said that more research is needed on chemically dispersed oil's interactions with suspended particulate material, interactions that occur when oil droplets attach to small particles such as sediment. Such oil-particle combinations could influence fate and transport in various ways, such as preventing the oil from recoalescing. Also, some combinations may potentially sink to the bottom, and others may remain suspended in the water column. According to a 2005 National Academy of Sciences report, gaps related to understanding the fate of chemically dispersed oil and the interaction of the dispersed oil with sediments could be addressed through the use of actual spill events to conduct research and collect data.

Aquatic toxicity and environmental effects of chemically dispersed oil. Most of the experts we interviewed agreed that there is a large amount of research on the acute toxicity of chemically dispersed oil but that less research has been done on its possible chronic effects. According to a 2005 National Academy of Sciences report, the toxicity of chemically dispersed oil typically results primarily from compounds within the oil itself—not the dispersant—as numerous studies have found dispersants to be significantly less toxic than oil or dispersed oil. Most experts we spoke with told us a large number of the completed toxicity studies have focused on the acute—rather than chronic—effects of certain aquatic species' exposure to chemically dispersed oil. Tests have shown that acute toxicity levels and sensitivity to chemically dispersed oil vary by species and life stage. For example, crustaceans, such as crabs, and mollusks, such as clams, appear to be more sensitive than fish, and larval stages of fish appear to be more sensitive than adults.¹⁷ Most of the toxicity tests have focused on a chemical dispersant product line called

¹⁷These acute toxicity tests generally measure the concentration that would cause death in 50 percent of the test population—known as LC₅₀.

COREXIT®,¹⁸ which is the most widely stockpiled dispersant in the United States. Additionally, most experts said that chemically dispersed oil can increase oil's bioavailability—how easily an organism can take up a particular contaminant from the environment—which can have varying harmful effects. For example, many experts said that chemical dispersion will alter the bioavailability of oil. Exposure to shoreline and surface oil may decrease for wildlife, such as birds or marine mammals, but exposure may increase for species living in the water column, such as certain fish or plankton.

Experts also identified several knowledge gaps and limitations in regard to information on the toxicity of chemically dispersed oil. In particular, most experts told us that research on the chronic effects of exposure has been more limited, and many identified this as an area in which more research is needed. Lack of research on chronic effects limits the understanding of how marine communities and populations—including corals, fish, and marine mammals—are affected by dispersant use over the long term. In addition, many experts said that more research is needed to understand the impact of chemically dispersed oil on marine communities and populations. For example, one expert noted that the rate of recovery for species is a key aspect for determining the trade-offs of using chemical dispersants. Furthermore, some experts questioned the usefulness of some toxicity research, noting that this research was generally not conducted using consistent methodological approaches, which limits its comparability. For example, one expert said that early toxicity research did not include chemical analysis, which limits the comparability of older studies to more recent ones that contain such analysis. Additionally, some experts noted that while there are many studies on COREXIT®, there are few studies on the toxicity of the other dispersants on the Product Schedule. In addition, some experts and specialists we spoke with questioned the applicability of the research to real world spill scenarios. Specifically, one expert said that the concentrations and durations of exposure to chemically dispersed oil often used in the laboratory do not reflect oil exposure concentrations and durations during an actual spill. Many laboratory tests use a constant

¹⁸COREXIT® EC9500A and COREXIT® EC9527A were the two dispersants used during the *Deepwater Horizon* incident. Of the approximately 973,000 gallons of aerial dispersants sprayed by responders, nearly 215,000 gallons were COREXIT® EC9527A, and the remaining 758,000 gallons were COREXIT® EC9500A. All 771,000 gallons of dispersant used for subsurface injection were COREXIT® EC9500A.

exposure level over a period of 96 hours (4 days), while during a dispersant application on a real spill, the concentration of chemically dispersed oil could be very high when first applied but will decline quickly over a matter of hours, particularly in the open ocean. Thus, some experts noted the need for more studies using realistic exposure scenarios and consistent methodologies.

Further, many experts said that research should be conducted on a broader range of species, as the majority of research has been conducted on a small number of species. For example, one expert said that it is not always possible to extrapolate from the standard test species—silverside fish and mysid shrimp—to other species, particularly from different regions or climates. Another expert noted that since it is not practical to test every species, those that are tested need to be ones that can be extrapolated to the key species in each region. In addition, according to EPA researchers, additional research is needed to better understand photoenhanced toxicity—the increase in toxic effects resulting from the synergistic interaction of components of oil accumulated by aquatic organisms and the ultraviolet radiation in natural sunlight. Recent studies demonstrate that chemically dispersed oil was substantially more toxic to early life stages of fish and invertebrates under the light wavelengths and intensity present in aquatic habitats than under the light systems used to generate toxicity data in the laboratory, but additional research is needed according to EPA researchers.

Modeling of chemically dispersed oil. Models that are used to predict how spilled oil will behave in the environment rely upon a number of inputs, but according to most experts we spoke with, modeling efforts are limited by the accuracy of inputs to the model, and the experts said that they believe that more research is needed to improve these inputs. Specifically, fate and transport models rely on a variety of inputs, including dispersant effectiveness, wind speed, and ocean currents. Some experts we spoke with questioned the accuracy of some of these inputs, which has implications for the predictive value of the model and may result in greater uncertainty with regard to the ultimate fate and transport of the dispersed oil. For example, some experts noted that more research is needed to more quantitatively measure dispersant effectiveness, including the amount of oil dispersed below the surface as droplets and the resulting droplet size distribution.

Monitoring of chemically dispersed oil. Some experts told us the monitoring protocols currently used are generally sufficient for their intended purpose of determining whether oil is dispersing. The primary

tool used to monitor this is the Special Monitoring of Applied Response Technologies (SMART) protocols,¹⁹ which were established by a multi-agency group—including Coast Guard, NOAA, EPA, CDC, and BSEE—and are implemented by the Coast Guard in spill response. These protocols establish a system for rapid collection of real-time, scientifically based data to assist in decision making related to whether additional chemical dispersants should be applied to break up remaining oil on the surface of the water. These protocols rely heavily on trained personnel to visually observe dispersed oil, collect water samples, and measure the amount of oil in the water using a fluorometer—a device that detects the presence of oil in the water column by measuring the light emitted when certain oil compounds are exposed to ultraviolet light—which helps indicate that the dispersant is having its desired effect. Some experts stated that the fluorometry equipment used for the SMART protocols is useful for determining the initial effectiveness of dispersants—that is, whether or not oil is being broken up and distributed through the water column during an oil spill response. Additionally, one expert said that the SMART protocols are simple, well defined, and standardized and are able to quickly provide information to decision makers during emergency response operations.

Many experts and a NOAA review of SMART protocol implementation also said that the protocols and the equipment used could be enhanced to provide some in-depth information to help inform research efforts to address gaps or to further assess the effectiveness of chemical dispersants. For example, some experts told us that the protocols do not provide an analysis of oil composition to determine whether and how long the dispersant remains present in the water and continues to break up the oil, making it difficult to assess the true effectiveness. Additionally, the SMART protocols were focused on providing operational guidance on dispersant effectiveness and were not designed to monitor the fate, effects, or impacts of chemically dispersed oil, but many experts said that research should be conducted to integrate monitoring of fate and effects into the protocols. Doing so would help inform research efforts to better

¹⁹The SMART protocols involve three levels, or tiers, of assessment. In general, Tier 1 involves observation by a trained observer from an aerial platform. Observations are documented and supplied to the command center. Tier 2 involves teams on a boat conducting sampling using a fluorometer and is intended to confirm visual observations obtained during Tier 1 operations. Sampling is done to determine background, pre-application, and post-application levels of oil. Tier 3 involves more sample collection and monitoring at multiple depths with instruments.

address gaps and help spill responders make better decisions. Some experts also told us that the fluorometry technology used in SMART is limited in that it only measures a portion of oil components and that the standardization and calibration of this equipment could be improved. Many experts also told us SMART could be enhanced with different, newer equipment, such as particle size analyzers to measure oil droplet size, which could better monitor chemically dispersed oil. Moreover, a February 2012 NOAA review of SMART monitoring protocol implementation during the *Deepwater Horizon* incident found that the SMART protocols were not sufficient to determine the effects of the dispersant and oil on marine life in the water column. In addition, the report found that for large spills with information needs beyond the question of whether the oil is dispersing, the protocols need to be revamped. This review concluded that the SMART monitoring methodologies used during the *Deepwater Horizon* incident lacked rigor and repeatability.

Human health effects. HHS officials and human health specialists we spoke with noted that toxicity information is available for the individual ingredients of some dispersants—particularly COREXIT® EC9500A—and those individual ingredients are generally believed to be not particularly toxic to humans. Furthermore, HHS officials and human health specialists we spoke with noted that there is little likelihood that the general public will be exposed to dispersants or chemically dispersed oil. Individuals involved in cleanup operations that directly handled dispersants or worked in the immediate area of application would likely have greater potential exposure to dispersants and therefore might have a greater risk of adverse effects. However, during the *Deepwater Horizon* incident, a National Institute for Occupational Safety and Health (NIOSH) Health Hazard Evaluation looked at the potential exposure of these highest risk groups and found that indicators of dispersant exposure were nondetectable or at levels well below applicable occupational exposure limits.²⁰ In addition, the Material Safety Data Sheet for COREXIT® EC9500A—the dispersant most used during the *Deepwater Horizon* incident response—states that potential human exposure will be low if recommended product application procedures and use of personal protective equipment such as use of hand, skin, and eye

²⁰As part of the CDC, NIOSH conducts research and develops guidance and recommendations for the prevention of work-related illnesses, injuries, disability, and death.

protection are followed.²¹ In addition, in laboratory tests following the *Deepwater Horizon* incident, NIOSH researchers found no long-term negative health effects due to short-term dermal or inhalation exposure to COREXIT® EC9500A. However, adverse effects of longer-term exposure have not been evaluated, according to HHS officials. With regard to seafood safety, studies indicate that the dispersants used during the *Deepwater Horizon* incident did not accumulate in seafood, and therefore there is no public health concern from them because of seafood consumption, according to the FDA. To ensure consumers had confidence in the safety of seafood being harvested from the Gulf, NOAA and FDA developed a chemical test for the presence of dispersant in seafood. Most of the seafood samples tested had no detectible oil or dispersant residue. For the few samples in which some residue was detected, the levels were far lower than the amounts that would cause a health concern, even when seafood is eaten on a daily basis.

Agency officials and human health specialists said that less is known about the ingredients in several other dispersants listed on the Product Schedule and that they believe more information is needed on the ingredients in these dispersants. In addition, toxicity information may be available on many of the individual ingredients in dispersants, but agency officials and human health specialists told us that there is very little data regarding the potential human health effects of the mixture of these ingredients as found in oil dispersant products. For example, the Material Safety Data Sheet for COREXIT® EC9500A states that no human health toxicity studies have been conducted on this product. In addition, agency officials and human health specialists told us that more research is needed on whether dispersants can alter the toxicological properties of the chemicals in the oil, which may increase the ability of oil or some of its constituents to permeate the skin in the event of dermal exposure to chemically dispersed oil. Agency officials and human health specialists also told us that currently there are no good biomarkers for dispersant exposure, making it difficult for researchers to fully measure the extent of human exposure and any resulting toxicological effects. In addition,

²¹A Material Safety Data Sheet (MSDS) is a detailed information bulletin prepared by the manufacturer or importer of a chemical that describes the physical and chemical properties, physical and health hazards, routes of exposure, precautions for safe handling and use, emergency and first-aid procedures, and control measures. In the United States, the Occupational Safety and Health Administration requires employers to provide information to their employees about the hazardous chemicals to which workers are exposed through a program including MSDS under its Hazard Communication regulation.

results from studies based on human samples or populations are needed to fully inform our understanding of potential health effects, according to agency officials. For example, in order to determine the likelihood of meaningful exposures and the potential for health effects to occur, it would be important to have ongoing environmental and biological monitoring, such as through the collection of blood or urine samples from oil spill response workers before and after they encounter dispersants.

Experts Highlighted Two Emerging Areas in Need of Further Research

Although much is known about the use of dispersants on the surface of the water, experts highlighted two emerging areas in which additional research is needed—specifically, the subsurface application and effects of dispersants in deep water environments and the use of dispersants in Arctic conditions and other cold water environments. As previously discussed, and according to many experts we spoke with, it will be particularly important to gain a better understanding of these environments since the future of oil production will rely to a substantial extent on producing oil from deep, offshore wells in the Gulf of Mexico and off the Alaskan Coast.

Subsurface application of dispersants. All of the 11 experts we spoke with told us that little is known about the use and effects of chemical dispersants applied subsurface in deep water environments—ocean depths of over 1,000 feet—noting that conditions there may influence the effectiveness of dispersants, such as higher pressure, lower water temperatures, and the presence of gas. Most experts characterized the subsurface application of chemical dispersants in the deep water during the *Deepwater Horizon* incident as surrounded by uncertainties, since it was the first attempt of its kind. Officials and specialists noted that monitoring efforts and visual evidence from the spill indicated subsurface application of dispersants was effective in reducing the amount of oil and volatile organic compound levels that appeared at the surface.

Experts agreed that the influence of deep water conditions on subsurface dispersant use requires further research, but they disagreed over the significance of some of the knowledge gaps. For example, some experts felt lack of knowledge about the role of high pressure in the deep water was a big gap, while others felt that, based on the knowledge of chemistry and other existing knowledge about dispersants, pressure was likely to have no influence on effectiveness. Specialists told us scientists are beginning to undertake research to validate the effectiveness of chemical dispersants applied subsurface in deep water environments and better understand how to optimize dispersant formulations, dispersant-to-oil

ratios, and application methods for these conditions. Some experts and specialists told us that since application directly at a spill source in deep water allows for direct contact with fresh oil and the force of a blowout creates substantial mixing energy, dispersants designed specifically for subsurface application could require less or no solvent and be applied at significantly lower dispersant-to-oil ratios.

Furthermore, with regard to the subsurface use of dispersants, most experts told us that there are gaps in knowledge related to fate and transport, toxicity, and monitoring. In terms of the fate and transport of dispersed oil at depth, while research and models to indicate what happens to oil released from the ocean floor exist, previous research had not taken into account the changes the addition of chemical dispersants could cause. Many experts also cited the need for more research on issues such as biodegradation, oil droplet size, and interaction with particulate material in the subsurface, deep water environment. For example, some experts noted that such research could inform the adaptation and improvement of models for tracking the fate and transport of chemically dispersed oil from subsurface dispersant use. One expert noted a particular need for research on interactions with suspended particulate material in deep water. This expert noted that there is some evidence that smaller droplets react differently with suspended particulate material in deep water and can create a substance, which can entrap organisms that cannot swim away fast enough.

With regard to toxicity related to the subsurface application of dispersants, in addition to the gaps in information on chronic effects discussed above, experts told us that little is known about the species that reside in deep water environments and how chemically dispersed oil may affect them. Also, some noted that the difficulties of conducting toxicity testing on relevant species in realistic exposure scenarios are amplified for subsurface use of chemical dispersants in deep water because bringing such species to the surface would likely kill them, and creating test conditions that would allow them to survive and serve as a reasonable simulation of that environment would be extremely challenging. Given the inability in a subsurface, deep water scenario to implement direct visual observation based monitoring, such as occurs with the SMART protocols, some experts noted the need for research to develop scientifically sound monitoring protocols and equipment for deep water use.

Use of dispersants in Arctic environments. Most experts told us that knowledge about the use of dispersants in Arctic environments is limited,

and less research has been conducted on dispersant use in the Arctic and other cold environments than in temperate or tropical climates. Specifically, some experts stated that additional research is needed to ensure that dispersant formulations are effective in the Arctic environment. For example, one expert said that dispersants are currently designed for temperate or tropical climates, and there is reason to believe that these formulations will be less effective in the Arctic environment because of environmental conditions such as cooler temperatures and the presence of ice. Specifically, sea ice introduces several potential complicating factors, which require more research. For example, ice alters the sea's state, diminishing waves, which could lead to lower mixing energy. In addition, the presence of ice and broken ice may affect application methods.

Previously discussed knowledge gaps about fate and transport of chemically dispersed oil also apply in the Arctic, with one expert noting that more research is needed on biodegradation rates in the Arctic because the cold temperatures may slow the process down. Furthermore, one expert told us that additional research is needed to enhance fate and transport models for chemically dispersed oil in icy conditions to better understand the movement of chemically dispersed oil. Some experts also noted possible differences in the toxicity of chemically dispersed oil for Arctic species as compared with temperate species. For example, one expert said that some Arctic species have different metabolism rates than species in warmer climates, and research is needed to determine how dispersant use affects Arctic species.

Federal Agencies, Industry, States, and Other Groups Have Funded Research to Enhance Knowledge on the Use and Effects of Dispersants

Federal agencies and other groups, including industry and states, have enhanced knowledge on the use of chemical dispersants and its effects by funding research projects. Specifically, six federal agencies have funded over \$15.5 million of dispersant-related research projects since fiscal year 2000,²² with about half of this total federal funding—over \$8 million—occurring since the *Deepwater Horizon* incident.²³ Over 40 percent of all federally funded dispersant research projects have focused on testing dispersant effectiveness. Appendix III provides a list of federally sponsored research projects related to dispersants since fiscal year 2000. In addition, industry has a number of past and ongoing research projects focused on the use and effects of dispersants, and states and other groups have also funded dispersant-related research.

Agencies Have Funded Over \$15.5 Million for Dispersant Research since Fiscal Year 2000, Including Over \$8 Million since the *Deepwater Horizon* Incident

Since fiscal year 2000, six federal agencies—BSEE,²⁴ Coast Guard, EPA, HHS, NOAA, and NSF—have funded 106 research projects related to chemical dispersants, at a cost of approximately \$15.6 million (see table 2). Roughly half of the total federal funding—approximately \$8.5 million—occurred in fiscal years 2010 or 2011, largely in response to the *Deepwater Horizon* incident. In general, most of the projects funded by federal agencies were conducted by nonfederal researchers, including university researchers and independent laboratories. In addition, the federal government has a committee—the Interagency Coordinating Committee on Oil Pollution Research—that helps coordinate research efforts across federal agencies. This committee was established by the Oil Pollution Act of 1990 and is currently composed of 14 federal agencies and chaired by the Coast Guard.

²²Of the \$15.6 million in total funding, approximately \$1.3 million was for 7 projects fully or partially conducted by agency staff, as opposed to given out in grants or contracts. For one of these projects, EPA was unable to provide an estimated cost.

²³This funding and research does not include studies conducted as part of the Natural Resource Damage Assessment for the *Deepwater Horizon* incident. Under the Clean Water Act, as amended, parties responsible for oil spills are liable for damages to natural resources. NOAA regulations establish a process for developing a plan to restore injured natural resources and services and having such a plan implemented or funded by responsible parties.

²⁴BSEE works to promote safety, protect the environment, and conserve resources offshore through regulatory oversight and enforcement. BSEE was created out of the reorganization of the Minerals Management Service into three new bureaus from 2010–2011: BSEE, Bureau of Ocean Energy Management, and the Office of Natural Resources Revenue.

Table 2: Federal Agencies' Dispersant Research Funding since Fiscal Year 2000

Agency	Total agency funding for all projects ^a	Number of agency-specific and joint-agency dispersant research projects
BSEE ^b	\$3,978,451	39
NSF	\$4,395,419	29
EPA	\$3,118,396	27
NOAA	\$3,256,894	15
HHS ^c	\$741,491	4
Coast Guard	\$64,000	2
Total	\$15,554,651	116^d

Source: GAO analysis of agency data.

^aResearch funding data include actual or agency-estimated amounts for completed and ongoing projects. Each agency's data include the amount identified for agency staff, grants, or contracts for all projects funded, whether funded solely by the agency or in a joint project with another agency. However, the data do not include the costs for agency staff or other technical assistance where direct funding was not provided. Additionally, the data do not include the cost for one project, for which EPA was unable to provide funding data, nor do they include funding amounts which may have been provided by federal agencies outside the scope of our review.

^bResearch attributed to BSEE includes research conducted by its predecessor agencies, the Minerals Management Service and the Bureau of Ocean Energy Management, Regulation, and Enforcement.

^cResearch attributed to HHS includes research conducted by NIH and CDC. One of these projects focused on analysis of dispersants, as well as oil. The funding included from this project covers both of these focuses.

^dThe total number of discrete projects is 106, seven of which were collaborative or jointly funded. Specifically, BSEE and EPA collaborated on three projects—one jointly funded and two funded by BSEE using EPA contractor support. In addition, projects were jointly funded by BSEE and Coast Guard, with involvement by EPA and NOAA as technical advisors; by BSEE, Coast Guard, and NOAA; by EPA and HHS; and by EPA and NOAA. Each agency's portion of funding for these projects is included in their agency funding figure above.

Details on dispersant-related research funded by the six federal agencies since fiscal year 2000 are as follows:

- BSEE has consistently funded dispersant research projects every fiscal year since 2000, and funding for most individual projects has ranged from \$10,000 to \$300,000. According to agency officials, BSEE has plans to undertake additional projects and has tentatively planned to fund studies on the impact of dispersant use on worker safety and studies on subsurface dispersant application. In addition to jointly funded projects with other federal agencies, BSEE has also funded projects jointly with industry and other groups to conduct dispersant research. For example, for one dispersant research project, BSEE was one of nine partners, including four oil companies and two oil spill response organizations, as well as Canada's

Department of Fisheries and Oceans, and Texas' General Land Office.

- NSF has funded the second largest number of projects—29 in all—and all but one of its projects were funded as a result of the *Deepwater Horizon* incident. Almost all of NSF's dispersant research funding was distributed to researchers through its rapid response grant program—a grant mechanism developed specifically to respond to unusual circumstances where a timely response is essential to achieving research results, such as in the case of the *Deepwater Horizon* incident.²⁵ NSF also had the largest total agency funding, with individual project funding ranging from \$12,878 to \$200,000, with an average funding level of \$151,566. Most of this research is still under way. Absent another oil spill, NSF does not have plans to fund further dispersant research—other than for projects submitted as individual, unsolicited proposals—according to agency officials.
- EPA, similar to BSEE, has funded at least one project in most years since fiscal year 2000. EPA's total annual funding for dispersant-related projects was generally less than \$300,000 per year. In fiscal year 2010, EPA funding increased, and the agency funded six dispersant research projects at a total of \$1.3 million. In addition, EPA has collaborated with the Canadian government on a wave tank facility in Canada, which EPA has used to support some of its dispersant-related research projects.²⁶ EPA, through its STAR grant program,²⁷ also issued a request for proposal on the environmental impact and mitigation of oil spills, including the application of dispersants as one of the mitigation measures, after the *Deepwater Horizon* incident. This grant program plans to award \$2 million to four projects by April 2012; an agency official told us that one of the projects will focus on the development of new types of dispersants.

²⁵NSF focuses on basic scientific questions and not applied research projects. Unlike many other federal research agencies, NSF does not have its own laboratories. Instead, NSF advances basic scientific research by providing grants to researchers.

²⁶A wave tank mimics ocean conditions and allows for precise measurements of different types of wave action.

²⁷STAR stands for Science to Achieve Results, which funds research grants and graduate fellowships in numerous environmental science and engineering disciplines through a competitive solicitation process and independent peer review.

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- NOAA has funded several projects over the past decade, but has not consistently funded dispersant-related research on an annual basis. A significant portion of NOAA's dispersant funding—\$1 million out of about \$3.3 million total—has been for an ongoing project, funded in fiscal year 2011, and focused on dispersant use during the *Deepwater Horizon* incident and lessons learned from that event. NOAA funded most of its past dispersant research through its partnership with the University of New Hampshire's Coastal Response Research Center (CRRRC). CRRRC projects represent 10 of the 15 NOAA-funded dispersant research projects. However, NOAA officials told us that the agency's funding for the CRRRC ended in 2007.
 - HHS has funded four research projects, all in fiscal years 2010 or 2011 and has done so as a result of the *Deepwater Horizon* incident, similar to NSF. Specifically, HHS has funded four research projects, ranging in costs from \$6,000 to \$634,000.²⁸ One of these projects was a jointly funded project with EPA, at a cost of \$77,491 to HHS. HHS officials told us that the agency currently does not have plans to fund any dispersant research in the future.
 - The Coast Guard has the most limited dispersant research program of the six key agencies, funding two joint projects since fiscal year 2000, at a total cost of \$64,000. One of these co-funded projects was the 2005 National Academy of Sciences report on dispersants.²⁹ The Coast Guard also jointly funded a project with BSEE to analyze SMART protocol monitoring data. Coast Guard officials told us that the agency has no plans to fund dispersant research projects in the future and that the agency has no formal effort under way to update the SMART monitoring protocols. In addition, although the agency has not funded a large amount of dispersant-related research since fiscal year 2000, it has focused its research efforts on other response options, such as in situ burning and mechanical recovery, in accordance with federal oil pollution research plans, according to agency officials.

²⁸For the NIH project with a cost of \$634,000, this cost represents the first two years of a five year project that will, in part, analyze the level of dispersant contamination, if any, in seafood. This project will include other testing that is broader than dispersant testing, but agency officials could not separate out the dispersant-only costs for this project.

²⁹BSEE, NOAA, and the American Petroleum Institute also provided funding for this report. The American Petroleum Institute is a national trade association that represents the nation's oil and natural gas industry.

The Interagency Coordinating Committee on Oil Pollution Research's purpose is to coordinate a comprehensive program of oil pollution research, technology, development, and demonstration among federal agencies, in cooperation and coordination with industry, universities, research institutions, state governments, and other nations as appropriate, and to foster cost-effective research, including the joint funding of research. Officials told us that the committee has never received specific funding to operate as a body. Support for the Interagency Committee's activities and responsibilities is currently subsidized by the budgets of its component member agencies. For example, the establishment and maintenance of the committee's website is being funded by the Coast Guard. The Oil Pollution Act also directed the committee to develop a comprehensive research and technology plan to lead federal oil pollution research. Among other things, the plan must assess the current status of knowledge on oil pollution prevention, response, and mitigation technologies and effects of oil pollution on the environment; identify significant oil pollution research gaps; and establish research priorities. In addition, the chair is required to report every 2 years to Congress on the committee's past activities and future plans for oil pollution research. The Interagency Committee first prepared a research and technology plan in 1992 and subsequently updated it in 1997, but it has not been revised since. According to agency officials, the plan is currently undergoing revision, and they anticipate releasing the new plan in 2013; dispersants are to be a focus area in the plan.³⁰ In March 2011, we issued a report reviewing the Interagency Committee's efforts to facilitate coordination of federal oil pollution research and made recommendations to improve these efforts.³¹ The Department of Homeland Security concurred with our recommendations and plans to address them.

³⁰Support for the research and technology plan update is also being provided by the Coast Guard.

³¹GAO, *Federal Oil and Gas: Interagency Committee Needs to Better Coordinate Research on Oil Pollution Prevention and Response*, [GAO-11-319](#) (Washington, D.C.: Mar. 25, 2011).

Over 40 Percent of Federally Funded Dispersant Research Has Focused on Effectiveness

Over 40 percent of the 106 federally funded research projects on dispersants have focused at least in part on effectiveness, with the remaining projects spread across a broad range of research areas, as noted in table 3.

Table 3: Federally Funded Dispersant Research Projects by Research Area since Fiscal Year 2000

Agency	Effectiveness	Fate and Transport	Aquatic toxicity and environmental effects	Modeling	Monitoring	Human Health	Subsurface Application in Deep water	Arctic	Alternative Dispersant Formulations	General
BSEE	28		2	1	2			6		3
Coast Guard										
EPA	12	4	3	2		1		2		
HHS						3				
NOAA		3	7	4	1					1
NSF		14	11	4			3		4	1
BSEE/Coast Guard/EPA/NOAA					1					
BSEE/Coast Guard/NOAA										1
BSEE/EPA	3									
EPA/HHS						1				
EPA/NOAA	1									
Total	44	21	23	11	4	5	3	8	4	6

Source: GAO analysis of agency data.

Note: The total number of discrete research projects is 106, seven of which were collaborative. The total number of projects in the research categories will be greater than the total number of projects overall because a project could have more than one focus.

Specifically, federally funded dispersant research since fiscal year 2000 has included the following areas of study.

Effectiveness in dispersing oil. Of the 106 research projects on dispersants, the largest number were focused on assessing the effectiveness of chemical dispersants, and BSEE and EPA have funded almost all of these. Specifically, BSEE has funded projects on the effectiveness of dispersants on different types of oil and under specific environmental conditions. For example, one such project focused on the

effectiveness of dispersant use on heavy oil,³² and another examined dispersant use in calm waters. BSEE has also conducted research to mimic at-sea conditions by using the Ohmsett wave tank testing facility in New Jersey to study the effectiveness of dispersants on light to medium oils when applied at typical application rates.³³ EPA funded several projects related to dispersant testing protocols that are used to assess effectiveness, a key criterion required to list dispersants on the Product Schedule. For example, EPA funded a study to determine the effectiveness of eight dispersants on its Product Schedule in dispersing south Louisiana crude oil. In addition, EPA funded research conducted in a wave tank in Nova Scotia, Canada, that produced quantitative estimates of the mixing energy necessary for effective chemical dispersion under various sea states.

Fate and transport of chemically dispersed oil. Half of the federal agencies we reviewed have funded projects focused on better understanding the fate and transport of chemically dispersed oil, with over half of these studies initiated since the *Deepwater Horizon* incident. In particular, fate and transport was the focus of nearly half of the NSF grant projects. For example, one NSF rapid response grantee studied the oil plume that resulted from the *Deepwater Horizon* incident using a specially designed, portable underwater mass spectrometer, which can measure minute quantities of chemicals in the ocean to determine the movement of the oil droplets. Other NSF projects focused on the interaction of oil and dispersed-oil components with sediments collected in regional sediment traps during the *Deepwater Horizon* incident, and on determining the impacts of dispersants on oil interactions with water column particulates and sedimentation. In addition, EPA has funded four projects that focus at least in part on the fate and transport of dispersed oil. For example, one project examined the impact of waves on the movement of dispersed oil and resulting oil droplet size. EPA also funded several projects focusing

³²Heavy oils have a higher viscosity; as such, these oils are more resistant to flow than lighter oils. As noted earlier, experts stated that dispersants are more effective in dispersing light to medium crude oils, which have a lower viscosity, than heavy oils.

³³Ohmsett, the National Oil Spill Response Research & Renewable Energy Test Facility, is the largest outdoor saltwater wave/tow tank facility in North America and has capabilities for full-scale oil spill response equipment testing, research, and training in a marine environment with oil under controlled environmental conditions, such as waves and different oil types. Ohmsett is operated by BSEE, and is used by the federal government, as well as industry and other groups, to conduct research.

on the biodegradation rates of different types of oil and dispersant mixtures.

Aquatic toxicity and environmental effects of chemically dispersed oil. NOAA and NSF are the two primary agencies sponsoring research projects focused on assessing the toxicity and environmental effects of chemically dispersed oil—funding 18 of the 23 projects in this area. Specifically, NOAA has funded projects that focus on both the acute and chronic effects of chemically dispersed oil on certain marine species. For example, one project examined the acute and chronic effects of crude oil and chemically dispersed oil on chinook salmon smolts. In addition, NSF funded a research project examining the potential toxic effects of chemically dispersed oil on benthic—or sea floor— environments in the Gulf of Mexico. Another NSF-funded project is investigating the effects of oil and dispersants on the larval stages of blue crabs and any subsequent impact the oil and dispersants may have on population dynamics. All of NSF's projects in this area were in response to the *Deepwater Horizon* incident. EPA and BSEE also funded projects in this category, although fewer in number. For example, one EPA project focused on how the dispersion and weathering of dispersed oil affects the exposure of marine species to dispersed and non-dispersed oil. In response to the *Deepwater Horizon* incident, EPA funded a project focused on the toxic effects of (1) crude oil alone, (2) eight different dispersants alone, and (3) a mixture of crude oil and each of the dispersants on two Gulf marine species. In addition, BSEE funded a project completed in 2005 to examine the effects of oil and chemically dispersed oil on mussels and amphipods—a type of crustacean.

Modeling of chemically dispersed oil. Most of the agencies supported research projects focused on modeling chemically dispersed oil. For example, NOAA funded a project to model the way that chemically dispersed oil particles may combine with other particulate material in the ocean. In addition, four of NSF's grants were awarded to projects to model the impacts of the *Deepwater Horizon* incident and dispersant use, such as the effects on plankton and other offshore marine organisms, and BSEE funded a project that involved validating two models developed to predict the window of opportunity for dispersant use in the Gulf of Mexico. Not specifically focused on modeling chemically dispersed oil, some projects are under way to improve three-dimensional modeling of ocean currents, which agency officials told us will be helpful in the event of a

future oil spill.³⁴ Specifically, NOAA received \$1.3 million in supplemental funding related to the *Deepwater Horizon* incident to improve its modeling capabilities to better forecast the subsurface movement and distribution of oil, taking into account the subsurface currents. According to agency officials, the three-dimensional modeling will be a significant addition to the more standard two-dimensional modeling of oil along the surface that has historically been used to track oil trajectories. Similarly, the Department of the Interior's Bureau of Ocean Energy Management currently has a \$989,000 modeling project under way to develop a new model for ocean currents and oil spills in the Gulf of Mexico. The enhanced models that both of these projects are developing may be applied in the future to model chemically dispersed oil and enhance decision making regarding its efficacy, fate, and transport.

Monitoring of chemically dispersed oil. Research in this area has been more limited, with four projects funded since fiscal year 2000, primarily by BSEE. One such project focused on SMART protocol monitoring results and the effectiveness of dispersants. Specifically, this project involved applying different ratios of dispersants to oil—ranging from ratios known to be effective at dispersing oil to ratios that were not effective at dispersing oil—to compare how well the SMART monitoring protocols were able to monitor the results of each type of application. The Coast Guard and BSEE also jointly funded a research project focused on analyzing SMART protocol monitoring data to verify the reliability of the protocols and to identify ways in which the protocols could be improved; NOAA and EPA provided assistance, but not funding, to this project. In addition, NOAA funded a project to evaluate dispersant application and monitoring techniques by using oil seeps originating naturally at the bottom of the ocean as a proxy for an oil spill.

Human health. HHS, through NIH and CDC, is the primary agency that researches possible human health effects because of the use of dispersants. For example, CDC's NIOSH conducted laboratory tests involving short-term inhalation exposure of rats to the dispersant COREXIT® EC9500A to study the pulmonary, cardiovascular, and central-nervous-system responses. NIOSH also studied the dermal effects of dispersant exposure. In addition, the National Institute of

³⁴Because these modeling efforts are more general in nature and not focused on modeling chemical dispersants specifically, they were not included in the research project summary or funding summary.

Environmental Health Sciences (NIEHS) has funded an ongoing project through an NIH initiative called the Deepwater Horizon Research Consortia that will, among other things, analyze the contaminant profiles of seafood fished by subsistence and non-subsistence fishermen in the Gulf of Mexico and will analyze the seafood samples for dispersant residues.³⁵ In addition, NIEHS funded a joint NIH research project with EPA to evaluate the extent of dispersants' effects, if any, on endocrine disruption in human cell lines, among other toxicity markers. In addition, EPA funded one research project that focused on in vitro testing of eight oil dispersants to assess four human health toxicity markers. Moreover, NIEHS launched the Gulf Long-term Follow-up (GuLF) Study to investigate potential short- and long-term human health effects associated with clean-up activities following the *Deepwater Horizon* incident.³⁶ The GuLF Study is expected to involve at least 40,000 clean-up workers and last for at least 10 years, according to agency officials, and the first 5 years of the study have been funded at \$34 million. Through its interviews with clean-up workers, the GuLF Study will examine potential exposures and health effects from a variety of substances and will also try to assess the extent of exposure to dispersants.

Research on subsurface application of dispersants. Prior to the *Deepwater Horizon* incident, federal agencies had not funded research on the subsurface application of dispersants in deep water. Since then, NSF has funded three rapid response grant projects that focus on subsurface application of dispersants and its effects. For example, one project is using specialty instruments to detect and quantify oil and dispersed oil in the deep waters of the Gulf of Mexico. Another NSF project is looking at the acute toxicity effects of oil and chemically dispersed oil on the benthic communities in the deep water of the Gulf of Mexico. The last project is studying the impact of chemical dispersants on the aggregation of oil into oil droplets in the deep water. BSEE has tentative plans to fund research on subsurface application of dispersants in fiscal year 2012. EPA, NOAA, and the Coast Guard do not have any current research related to

³⁵NIEHS is leading a trans-NIH effort known as the Deepwater Horizon Research Consortia. The 5-year, \$25.2 million grant program will focus on potential acute and long-term health effects from the *Deepwater Horizon* incident to the general public.

³⁶Because this large scale study is more general in nature, looking at a broad range of health effects and not focused specifically on dispersants, it was not included in the research project summary or funding summary.

subsurface dispersant use in the deep water, according to agency officials.

Arctic environment dispersant research. Federal research related to the use of chemical dispersants in an Arctic or cold water environment has been somewhat limited, with only eight projects undertaken since fiscal year 2000. For example, one of BSEE's six funded projects examined the effectiveness of dispersants in broken-ice conditions, which are fairly common many months out of the year off the Alaskan coast. Another project studied dispersant effectiveness in a low mixing energy environment, which could be caused by the presence of ice cover in the Arctic. Similarly, an ongoing project is examining new techniques to apply dispersants in icy environments in which the waves are smaller because of the presence of ice and, as a result, less mixing generally occurs. In addition, EPA funded two studies that focused on the fate and transport of chemically dispersed oil at different temperatures, including in cold water. EPA is also collaborating with other members of the National Response Team and the Alaska Regional Response Team to understand the unique aspects of potential Arctic oil spills with respect to the authorization and use of dispersants in order to inform and prioritize research needs.

Alternative dispersant formulations. Prior to the *Deepwater Horizon* incident, federal agencies had not funded research on alternatives to the current blends of chemical dispersants used to disperse oil. Since the *Deepwater Horizon* incident, NSF has funded four projects in this area. Specifically, one project is studying natural and synthetic biological agents as alternatives to chemical dispersants for application in marine oil spills. Another study is evaluating the potential usefulness of man-made nanofiber materials as an alternative to chemical dispersants in marine oil spills. The third study is examining the difference in efficacy of natural and synthetic surfactants, which may help with the development of less toxic dispersants. The final project is focusing on the development of bio-derived, biodegradable oil dispersants.

General. Research in this category includes efforts to synthesize information and identify broad applications of dispersant knowledge, such as improving dispersant decision making processes and educational efforts. For example, three agencies—the Coast Guard, BSEE and NOAA—provided funding for the 2005 National Academy of Sciences report. This report provided an expert evaluation of the adequacy of existing information and ongoing research regarding the effectiveness and effects of dispersants and recommended steps to be taken to better support policymakers with dispersant decision making. In addition, BSEE

funded three other general projects, including one that focused on developing a training package on the use of chemical dispersants for the Ohmsett wave tank testing facility. Another BSEE project studied the operational and environmental factors associated with the use of chemical dispersants to treat oil spills in California waters, with a goal toward expediting dispersant use decision making and planning for such spills.

Industry Has a Number of Research Projects Focused on Dispersant Use and Effects

In addition to federally funded dispersant research, the oil industry has funded a number of past and ongoing research projects related to the use and effects of chemical dispersants. These projects have been conducted collaboratively through industry trade associations or across multiple companies, by individual companies, and through an independent research initiative. According to industry representatives, the industry has committed over \$20 million to fund American Petroleum Institute and International Association of Oil & Gas Producers' dispersant programs.³⁷ These projects generally began in 2011 and are anticipated to end by 2016. Specifically, the American Petroleum Institute is currently leading a set of dispersant-related projects involving several oil companies and oil spill response organizations, among others. According to industry representatives, a significant part of this research will focus on the subsurface use of dispersants in deep water, ice-free environments. In addition, the International Association of Oil & Gas Producers is pursuing two dispersant research initiatives. One initiative—the Oil Spill Response Joint Industry Project—will focus on the fate and effects of subsurface dispersant use and the tracking and modeling of dispersed oil, among other things. A second initiative—the Arctic Oil Spill Response Technology Joint Industry Programme—includes research on dispersant use in the Arctic. Specifically, the dispersant portion of this project is investigating the fate and transport of chemically dispersed oil under ice and dispersant effectiveness testing in Arctic environments, as well as the environmental impacts of Arctic spills and options for responding to them. Shell representatives told us that there are nine oil companies participating in the Arctic research project, and that this project is building

³⁷The International Association of Oil & Gas Producers includes most of the world's publicly-traded, private and state-owned oil and gas companies, industry associations, and major upstream service companies. Its members produce more than half the world's oil and about one third of its gas.

on earlier Arctic research conducted by a Norwegian research institute called SINTEF.³⁸

Individual oil companies, including ExxonMobil and Shell, have also invested in dispersant research projects together and separately. For example, Shell, ExxonMobil, Statoil, British Petroleum, and ConocoPhillips have funded a project to study the biodegradation of physically and chemically dispersed oil and its toxicity on Arctic species in Alaska. According to Shell representatives, this project started in 2009, in response to concerns from Coast Guard and NOAA officials that the agencies did not have sufficient information to conduct an assessment of potential ecological risk for the North Slope of Alaska. The five oil companies provided funding to NewFields, a private consulting firm, and the University of Alaska at Fairbanks to conduct the research. Federal agencies—including NOAA, EPA, and the Coast Guard—are part of a technical advisory committee overseeing this research project. Shell representatives told us that this project has been funded at a total cost of about \$2.5 million. Individual oil companies have also funded chemical dispersant research. For example, industry representatives for Exxon estimated that the company has funded more than \$20 million for dispersant research since 2000.

In addition to industry-led research efforts, British Petroleum has set up an independent group, the Gulf of Mexico Research Initiative, to disburse \$500 million in research funds over 10 years to study the effects of the *Deepwater Horizon* incident, as well as other oil spills, on the Gulf of Mexico. A portion of this funding will be for dispersant research. For example, Tulane University is leading a consortium of over 40 researchers to conduct a roughly \$10 million project to examine the science and technology of chemical dispersants as relevant to deep water oil releases.

States and Others Have Also Funded Dispersant Research

States, organizations, and governments have also funded dispersant research. States—including California and Texas—have funded dispersant research on topics including the toxicity of dispersed oil on certain species, but they are not currently funding such work because of

³⁸SINTEF is an independent research institution based in Norway and the largest research institution in Scandinavia. SINTEF focuses its research on petroleum and energy issues, among other areas.

limited funding or competing research priorities. Specifically, California's Office of Spill Prevention and Response funded a number of research projects from 1993 through 2011 related to the use of chemical dispersants, at an estimated cost of about \$2 million.³⁹ For example, one project studied the physical effects on a marine bird or otter diving through a subsurface plume of chemically dispersed oil. Another funded research project focused on the acute and chronic toxic effects of dispersants on salmon larvae, according to agency officials. Texas has also funded dispersant research projects. According to a state official, the Texas General Land Office spent several million dollars on dispersant research from the mid 1990s through the early 2000s. For example, one project studied the behavior of chemically dispersed oil in a wetland environment. However, the state official told us that dispersant research is no longer a priority for Texas because federal agencies, including BSEE and NOAA, are currently conducting dispersant research and that his office prefers to spend the state's limited research funds on other aspects of oil spill response that need attention, such as improving buoys to measure waves and ocean currents in order to inform oil spill modeling.

In addition to states, other organizations and governments have funded some dispersant research projects. For example, the Prince William Sound Regional Citizens' Advisory Council has funded research projects on the effectiveness and toxicity of dispersants in the Alaskan environment, such as one project that examined the effect of photo-enhanced toxicity of chemically dispersed oil on Pacific herring eggs and larvae.⁴⁰ Officials with the council noted that not many independent groups fund dispersant research, due in part to the high costs associated with this research. In addition, international research organizations and governments have also funded dispersant research. For example, SINTEF has done a great deal of oil spill research, as well as dispersant-related research. In addition, a French organization, the Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE), has worked on enhancing knowledge about the use

³⁹California has a separate licensing program for oil spill cleanup agents, including dispersants, which may be used on state waters. In 2008, California's Office of Spill Prevention and Response issued a California Dispersant Plan, which includes information and tools to guide decision-makers on the use of dispersants.

⁴⁰The Prince William Sound Regional Citizens' Advisory Council is an independent non-profit organization established after the *Exxon Valdez* spill and works to reduce pollution from crude oil transportation through Prince William Sound and the Gulf of Alaska.

of chemical dispersants, including organizing a conference in March 2011 focused on the future of dispersant use, with experts addressing the novel uses of dispersants during the *Deepwater Horizon* incident.⁴¹ In addition, Canada's Department of Fisheries and Oceans has also funded dispersant research, such as fish toxicity studies and effectiveness studies. This department also collaborated with EPA and the Bedford Institute of Oceanography to build a 32-meter wave tank, which was completed in 2006.⁴² Both countries use this wave tank for research purposes, such as to measure the biological effects of various oil, dispersant, and sea water blends by mimicking different ocean conditions in the lab. Lastly, the United Kingdom has also funded dispersant toxicity research to establish assessment criteria for dispersant approval.

Dispersant Research Faces Resource, Scientific, and Communication Challenges

According to federal officials, experts, and specialists we spoke with, federal agencies and researchers face resource, scientific, and communication challenges in their attempts to enhance knowledge on chemical dispersant use and its effects.

Resource challenges. Agency officials, experts, and specialists identified inconsistent and limited levels of funding as a challenge to developing research related to the use and effects of chemical dispersants. Specifically, according to agency officials, experts, and industry representatives, because support for dispersant research tends to increase in the immediate aftermath of a major oil spill and decrease in the years following a spill, it is difficult for federal agencies, states, and industry to sustain a long term research program. For example, agency officials told us that while there was an increase in research funding specifically related to the *Deepwater Horizon* incident, this funding is not expected to continue in the future. Some agency officials, as well as some industry representatives and experts, told us that a similar pattern occurred after the 1989 *Exxon Valdez* oil spill, with a temporary increase in research funding following the spill. However, once those initial

⁴¹CEDRE is a non-profit organization focused on two key areas—oil spill preparedness and response—and is funded in part by the French government.

⁴²The Bedford Institute is a modern oceanographic research facility, established in 1962 by the Federal Government of Canada (the former Department of Mines and Technical Surveys, now Natural Resources Canada) and is located on the shores of the Bedford Basin in Dartmouth, Nova Scotia. Over the last 50 years it has grown to become Canada's largest center for ocean research.

research funds were allocated, very little research funding was available again until after the *Deepwater Horizon* oil spill. In addition, some industry representatives told us that maintaining a long-term focus for dispersant research can be a challenge for industry groups, as there are many different oil spill research priorities and responsibilities in addition to dispersants. According to agency officials and a National Research Council report, the lack of a consistent research funding stream also makes it difficult for federal agencies to fund longer term projects.⁴³ For example, some agency officials and experts said that to understand the chronic toxicological effects of dispersants, scientists would need to design long-term, multiyear studies of the effects of the use of dispersants on marine species; however, such longer term studies are more expensive and more complicated to conduct than short-term acute toxicity tests. Furthermore, although most of the key agencies conducting research on dispersant use and effects have identified areas in which additional dispersant-related research would be informative and aid with decision making, officials from many of these agencies told us their agencies are unable to fund this research given their limited budgets. Some state officials we spoke with echoed similar concerns and said that they have been unable to continue with research in this area.

Scientific challenges. Agency officials, experts, and specialists also identified scientific challenges, in particular, conducting research that replicates realistic oil spill conditions and obtaining oil and dispersants for testing. Every oil spill is different, and the conditions—such as weather, oil type and volume, currents, and location—surrounding any unanticipated release of oil into the ocean are highly variable. Given this variability, no one study can account for all the potential permutations. Laboratory experiments are useful for determining the chemical effectiveness of dispersants, but they are unable to approximate ocean conditions given the difference in scale. Researchers can employ alternative methods to try to replicate realistic oil spill conditions for the purposes of conducting dispersant research—use of a wave tank, use of an existing spill, or the intentional release of oil to create a new spill—but each of these have their own drawbacks.

⁴³National Research Council, *Review of the Interagency Oil Pollution Research and Technology Plan: Final Report of the Committee on Oil Spill Research and Development* (1994).

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- *Wave tanks.* As described earlier, two wave tanks are regularly used in North America—one in New Jersey and the other in Canada. The tanks provide an arena in which oil spills can be created in a body of water without risks to the environment; however, unlike the open ocean, the size of the tank and presence of walls constrain the movement of the oil and water and do not fully account for ocean currents. According to EPA researchers, the tank in Canada is able to come close in terms of simulating breaking wave action and ocean currents, and according to BSEE officials, the tank in New Jersey is able to simulate waves up to 1 meter in height. However, neither of these wave tanks is equipped to simulate the high pressure and dark conditions present in the deep water.
 - *Existing spills.* An opportunity exists to conduct research on the use of chemical dispersants during an oil spill and to obtain real world information that can help address some of the identified research gaps, but agency officials and experts told us that it is hard to conduct rigorous scientific research because of the competing needs of oil spill responders. For example, one expert told us that a research team may have access to sample and test water in a given spill location but may later be restricted from sampling from the same area because of actions being taken to respond to the spill. In addition, some agency officials told us that it is virtually impossible to conduct scientifically sound research during an oil spill emergency because there is not enough time to carefully design and execute research projects.
 - *Intentional discharges.* In the absence of an unexpected spill, another option to conduct dispersant-related research could come through the intentional discharge of oil for the express purpose of studying how the oil responds with or without the application of dispersants. However, agency officials, experts, and industry representatives told us that it is very difficult to gain approval for an intentional discharge of oil into the ocean for research purposes. EPA officials told us that states must first approve such a discharge before any applications for a permit to discharge come to EPA for review. The few applications attempted did not receive state approval. These officials also told us that EPA received and granted only one permit, in 1994, for intentional oil discharge to a U.S. water for research on a bioremediation agent. Because open ocean experiments are generally not conducted in the United States, researchers have traveled abroad, including to Norway and Canada, to do such testing. According to officials on the Interagency Coordinating Committee on Oil Pollution Research, the Ocean Energy Safety Advisory Committee, and the American

Petroleum Institute, there is growing interest in exploring intentional discharges of oil in controlled settings for research purposes.

Another scientific challenge to conducting dispersant-related research is the accessibility of oil and dispersant samples for testing. Several agency officials, specialists, and experts told us that it can be difficult and time consuming to access oil and dispersants to conduct dispersant research. For example, one expert told us that she has been waiting for several months to receive the oil she requested from an oil company for her research, thus delaying her entire project. An industry representative also told us that access to oil and dispersants could be a challenge for researchers because of liability concerns from the companies that produce them, as these companies do not want to be held responsible for any liability if a research project goes badly or either substance spills into the environment.

Communication challenges. Agency officials, experts, and specialists told us that it can be a challenge to communicate research across the different groups involved in dispersant use and research, including federal agencies, industry, and academia. Agency officials and industry representatives noted that the oil spill response research community is small and that awareness of each others' work is based on informal interactions, such as at workshops, meetings, and conferences. Agency officials and industry representatives we spoke with told us they are generally aware of each other's research, but there is additional research that may not be readily known, such as research undertaken by academia. Some officials also noted that research across these different groups can be hard to track, a task that only gets more difficult following an event like the *Deepwater Horizon* incident, when there are many new studies under way at once because of the increased attention and funding. In addition, according to agency officials, many oil spill research projects are reported in conference proceedings, such as the Arctic and Marine Oilspill Program Technical Seminar on Environmental Contamination and Response and the International Oil Spill Conference,⁴⁴ but these proceedings are not covered in commonly used search engines, such as Web of Science.

⁴⁴The Arctic and Marine Oilspill Program Technical Seminar on Environmental Contamination and Response is an international forum on preventing, assessing, containing, and cleaning up spills of hazardous materials in every type of environment. It also deals with solutions for remediating and rehabilitating contaminated sites.

Some organizations have attempted to develop lists of dispersant-related research, but there is no comprehensive mechanism or database that tracks this research across all sources, includes both past and ongoing research projects, and is regularly updated. For example, the Interagency Coordinating Committee on Oil Pollution Research maintains a list of federally sponsored oil spill related research, including research on dispersants, from which it publishes biennial reports containing short summaries of the federal research projects completed during the prior 2 years. However, these reports are intended only to summarize federal research efforts and do not track or cross-reference related research that has been funded solely by industry or non-governmental sources. Several other organizations have gathered dispersant research information in various types of databases or bibliographies, including those maintained by the Louisiana Universities Marine Consortium, the Prince William Sound Regional Citizens' Advisory Council, and the CRRC, but none of these lists include the full range of past and current federal, industry, and academic research on the topic. For example, the Louisiana Universities Marine Consortium developed a database consisting of citations found in journals, conference proceedings, and government reports covering published research on oil spill dispersants from 1960 through June 2008, but the database has not been updated. In addition, the Prince William Sound Regional Citizens' Advisory Council maintains a similar database of citations of published literature on dispersants; however, this database does not track ongoing projects. Also, CRRC's list describes approximately 100 past and current research projects but is limited in that it contains fewer research projects than the other lists.⁴⁵ According to some specialists we spoke with, a central repository for past and ongoing research would be helpful to ensure that future research plans will align with current needs and that new research undertaken will not be duplicative of prior research. It will also help ensure the transfer of knowledge and experience between different groups and generations of researchers and responders so that key lessons and insights do not get lost from one spill to the next, according to some specialists we spoke with.

⁴⁵As mentioned earlier, NOAA officials told us that the agency's funding for the CRRC ended in 2007; as a result, the future of the CRRC is uncertain.

Some agency officials, experts, and specialists expressed concerns about the independence and quality of dispersant research, which can lead to mistrust and misperception about the results. For example, one expert told us that industry research may not be fully independent in that industry groups would not want to publish research results demonstrating that dispersants are harmful in any way. Moreover, some agency officials told us there is a concern in the oil spill research community that industry researchers do not necessarily use the same peer review process for validating their results as is used by government or academia, raising concerns about the reliability of the research. Conversely, some specialists and one expert noted that because of limited experience in actual spill response, many academic researchers do not design and conduct studies that reflect realistic spill scenarios, which can skew the results or make them less helpful for making decisions during a spill. In addition, as previously mentioned, not all dispersant research is conducted using consistent methodological approaches, which limits its comparability and usefulness in drawing broader conclusions.

In addition to communication challenges that may exist among the different groups involved in dispersant research, some agency officials, experts, and specialists we spoke with noted challenges in communicating scientific information to the public. According to proceedings from a NOAA-sponsored workshop on dispersant use, communication to the public—as well as to federal, state, and local agencies—was seen as one of the largest issues during the *Deepwater Horizon* incident. For example, a series of local community meetings were held during the response at which response specialists were on hand to address specific stakeholder questions. From these sessions, it was clear to the response specialists that members of the community at these sessions had many misconceptions about dispersants, specifically with regard to their degradation, toxicity, and application, as well as ways in which to monitor them.

Conclusions

Ocean oil spills can have devastating effects on the environment, coating coastlines and wetlands and killing marine mammals, birds, fish, and other wildlife. Chemical dispersants are one tool that responders have at their disposal to try to mitigate the consequences of a spill. Much is known about the use of dispersants—particularly on the surface of the water and in temperate climates—and federal agencies, industry, states, and other groups have taken steps to enhance knowledge on dispersants. However, gaps remain, and less is known about the application and effects of dispersants applied subsurface to underwater

spills and to spills in the Arctic or colder environments. Because future domestic oil production will rely to a substantial extent on developing additional wells in challenging environments, such as deep waters and the Arctic Ocean, researching dispersant use in these environments will be key to improving decision makers' understanding of the potential consequences of using dispersants in these situations. Some research related to application below the surface and in Arctic conditions is under way, and the Interagency Coordinating Committee on Oil Pollution Research is currently working to revise its research and technology plan to address some gaps, including those related to dispersant use.

To make decisions about whether to use dispersants, decision makers need timely and reliable scientific information on the trade-offs between the risks that untreated oil poses to the water surface and shoreline habitats and the risks that chemically dispersed oil poses to underwater environments. This information must be available before a spill happens and incorporated into response planning, as the decision to use dispersants must be made quickly, and an emergency situation provides no time for designing new research. Because years may pass in between spill events, information on dispersant use must also be available to responders and researchers who may have limited experience in using and applying dispersants as a response option. Some groups, including the Interagency Coordinating Committee on Oil Pollution Research, have developed lists of past or ongoing federal research projects related to dispersants, but there currently is no mechanism that tracks dispersant research across all sources and highlights key recent and ongoing research projects. Dissemination of such information would help ensure that new federal research undertaken will not duplicate prior research and that key knowledge can more easily transfer from one spill or generation of researchers and responders to the next. Moreover, the Interagency Committee is in a prime position to request the sharing of such information from these non-federal sources in the course of fulfilling its mission to coordinate a comprehensive program of oil pollution research among federal agencies, in cooperation and coordination with industry, universities, research institutions, state governments, and other nations. Up-to-date information on the findings of key research on dispersant use and its effects is essential to ensuring that federal research priorities, as articulated in the research and technology plan currently being revised, are effectively targeting the most important research needs.

Gaining a full understanding of the effectiveness and potential environmental effects of dispersant use is difficult to accomplish in a laboratory setting, not to mention during a spill in light of the competing needs of oil spill responders. However, it is during a spill when the greatest opportunity exists to gather real world data to help address some of the identified research gaps. While some information is currently gathered during response operations, it is primarily limited to whether the oil on the surface is breaking into small droplets and entering the water column. Specifically, the SMART monitoring protocols currently used during a spill response gather information on whether chemical dispersants should continue to be used, but these protocols do not provide robust scientific information on dispersant use and effects. Furthermore, these monitoring protocols are designed for use with surface application of dispersants and do not monitor dispersed oil resulting from deep water dispersant application. NOAA recognized such limitations in its recent review of the SMART data from dispersant monitoring during the *Deepwater Horizon* incident and has acknowledged improvements could be made.

Recommendations for Executive Action

To ensure existing and ongoing dispersant research is adequately captured and broadly available to different groups and generations of researchers, to ensure that new research undertaken by the federal government will not duplicate other research efforts, and to ensure that adequate attention is given to better understanding dispersant use in deep water and Arctic environments, we recommend that the Commandant of the Coast Guard direct the Chair of the Interagency Coordinating Committee on Oil Pollution Research to take the following two actions, in coordination with member agencies:

- Ensure that in the course of revising the Interagency Committee's research and technology plan, applications of dispersants subsurface and in Arctic conditions are among the areas prioritized for subsequent research.
- As part of the Interagency Committee's efforts to help guide federal research, identify information on key ongoing dispersant-related research, including research sponsored by state governments, industry, academia, and other oil pollution research organizations. This information should be provided in the planned and future revisions to the research and technology plan. In addition, periodically update and disseminate this information, for example, as part of the Interagency Committee's biennial report to Congress on its activities.

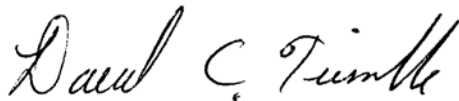
To enhance the knowledge of the effectiveness and potential environmental effects of chemical dispersants, we recommend that the Secretaries of Commerce and the Interior, the Administrator of EPA, and the Commandant of the Coast Guard direct their respective agencies, NOAA, BSEE, EPA, and the Coast Guard, to coordinate and explore ways to better obtain more scientifically robust information during spills without hindering response efforts through enhancement of monitoring protocols and development of new data collection tools.

Agency Comments

We provided a draft of this report to the Department of Commerce, the Department of Health and Human Services, the Department of Homeland Security, the Department of the Interior, the Environmental Protection Agency, and the National Science Foundation for review and comment. DHS concurred with all three recommendations made to it. Commerce and Interior concurred with the recommendation directing them to explore ways to better obtain more scientifically robust information during spills. While EPA did not directly state whether it concurred with that recommendation, the agency generally agreed, noting that it is committed to exploring ways to coordinate with other agencies to better obtain more scientifically robust information during spills, enhance monitoring protocols, and develop new data collection tools. In addition, Commerce, HHS, Interior, EPA, and NSF provided us with technical comments, which we have incorporated as appropriate. See appendixes IV, V, VI, and VII for agency comment letters from Commerce, DHS, Interior, and EPA, respectively.

As agreed with your offices, unless you publicly announce the contents of this report earlier, we plan no further distribution until 30 days from the report date. At that time, we will send copies of this report to the Secretaries of Commerce, Health and Human Services, Homeland Security, and the Interior; the EPA Administrator; the Director of the National Science Foundation; the appropriate congressional committees; and other interested parties. In addition, the report will be available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or trimbled@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made major contributions to this report are listed in appendix VIII.



David C. Trimble
Director, Natural Resources
and Environment

Appendix I: Objectives, Scope, and Methodology

Our objectives were to examine (1) what is known about the use of chemical dispersants and their effects, and knowledge gaps about or limitations to their use, if any; (2) the extent to which federal agencies and other entities have taken steps to enhance knowledge on chemical dispersant use and its effects; and (3) challenges, if any, that researchers and federal agencies face in their attempts to enhance knowledge on chemical dispersant use and its effects.

To determine what is known about the use and effects of chemical dispersants and identify any knowledge gaps or limitations, we reviewed documents and literature, including federal regulations and government oil spill planning documents, such as the National Contingency Plan, Regional Contingency Plans, and dispersant guidelines. We also reviewed scientific studies and key reports on dispersant use, such as the 2005 National Academy of Sciences (NAS) report on *Oil Spill Dispersants: Efficacy and Effects*, the National Commission on the BP Deepwater Horizon Oil Spill and Offshore Drilling report to the President, and several Coast Guard and National Oceanic and Atmospheric Administration (NOAA) reports on response actions during the *Deepwater Horizon* incident. We used these documents to determine areas of research that inform planning and decision making regarding the use of chemical dispersants. In addition, we collaborated with the NAS to identify 11 academic, industry, and other researchers recognized as experts in their respective scientific fields and capable of advising us on chemical dispersant use and research. In the report, these scientists and researchers are referred to as “experts.” NAS staff selected these experts based on their knowledge of one or more of the following topic areas: dispersant effectiveness, toxicity of dispersants and dispersed oil, fate and transport of dispersants and dispersed oil, monitoring actual dispersant use, risk assessment of dispersant use, other environmental effects of dispersant use, and challenges to dispersant research. In addition, NAS staff sought experts representing a wide range of viewpoints, including some experts who had experience with the *Deepwater Horizon* incident. In developing the list of experts, NAS staff consulted with NAS Ocean Studies Board members and volunteers from past and ongoing NAS studies on relevant topics to identify potential experts. NAS staff also performed literature reviews and targeted Internet searches based on the topic areas and questions identified by GAO. NAS staff composed the list of experts by identifying a range of expertise among prospective experts and then performing short interviews with them to discuss potential biases and any possible conflicts of interest, ensure that viewpoints were balanced, and confirm that some of the experts had experience with the *Deepwater Horizon* incident.

GAO conducted semi-structured interviews with these experts to discuss the state of knowledge, including gaps, regarding dispersant research. We used a standard set of questions, asking the same questions in the same order to each expert. We carefully documented and analyzed expert responses to address our objectives and establish common themes. We used the following categories to quantify the responses of experts: “some” refers to responses from 2 to 4 experts, “many” refers to responses from 5 to 7 experts, “most” refers to responses from 8 to 10 experts, and “all” refers to responses from all 11 experts. We supplemented our semi-structured expert interviews with interviews of federal officials and other oil spill or dispersant specialists, including state officials who have been involved in past response actions, human health researchers, oil spill response organizations with expertise in applying chemical dispersants, industry representatives with experience in researching oil dispersants and responding to oil spills, and other relevant non-governmental organizations, such as a regional advisory group focused on environmental protection as it relates to oil production and transportation. Statements from these groups are identified as being from “specialists.” During the course of our review, we spoke with 37 specialists. For the purposes of our interview analysis, in cases where multiple specialists were present during one interview but each provided their own views, we counted each specialist separately. We used the following categories to quantify the responses of specialists: “some” refers to responses from 2 to 4 specialists, “several” refers to responses from 5 to 8 specialists, and “many” refers to responses from 9 or more specialists.

To determine the extent to which federal agencies and other entities have taken steps to enhance knowledge on chemical dispersant use and its effects, and what challenges, if any, researchers have faced, we analyzed information on federal research efforts since fiscal year 2000 supplied by the key federal agencies conducting research on dispersant use and effects: the Department of the Interior’s Bureau of Safety and Environmental Enforcement (BSEE), the Department of Homeland Security’s United States Coast Guard, the Environmental Protection Agency (EPA), the Department of Health and Human Services’ (HHS) National Institutes of Health (NIH) and Centers for Disease Control and Prevention (CDC), the Department of Commerce’s NOAA, and the National Science Foundation (NSF). This information included titles, funding levels, and a brief description of agency research projects. To assess the reliability of agency-supplied data, we asked the agencies to describe how they gathered this information, including their data reliability controls; we also checked the lists that the agencies provided to us

against other publicly available lists of dispersant research projects to help ensure consistency and completeness. We then categorized each of the dispersant research projects into one or two research areas and sent these categorizations back to the agencies for their concurrence. We also conducted interviews with federal officials from these agencies to obtain their perspectives on the extent and focus of their research efforts and what challenges, if any, they have faced. In addition, we analyzed information supplied by, and conducted interviews with, specialists to obtain their perspectives on dispersant research efforts and potential associated challenges. In addition, we attended a NOAA-funded workshop on the future of dispersant use to gather information on both the state of knowledge and ongoing research. We also attended an industry-funded workshop of key federal, state, and local responders, academic researchers, and other stakeholders who could potentially be affected by an accidental offshore oil spill along the Eastern seaboard of the United States. At these workshops we collected written materials, listened to presentations, and spoke with specialists in attendance.

We conducted this performance audit from March 2011 through May 2012, in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Appendix II: List of Experts Selected by the National Academy of Sciences

Michel Boufadel, *Temple University*

James Clark, *Independent Consultant (retired - ExxonMobil Research and Engineering)*

Cortis Cooper, *Chevron Energy Technology Company*

Sara Edge, *Harbor Branch Oceanographic Institute*

Merv Fingas, *Independent Consultant (retired - Environment Canada)*

Kenneth Lee, *Fisheries and Oceans Canada*

Judith McDowell, *Woods Hole Oceanographic Institution*

Francois Merlin, *Centre of Documentation, Research and Experimentation on Accidental Water Pollution (CEDRE)*

Jacqueline Michel, *Research Planning, Inc.*

Chris Reddy, *Woods Hole Oceanographic Institution*

Ronald Tjeerdema, *University of California, Davis*

Appendix III: Listing of Federally Sponsored Research on Dispersants since Fiscal Year 2000, by Research Category and Agency

The following is a listing of federally sponsored research projects related to dispersants. The title and initial funding year for each dispersant project was supplied by the respective agency.¹ We asked for this information from the following agencies: the Department of the Interior's Bureau of Safety and Environmental Enforcement (BSEE), the Department of Homeland Security's United States Coast Guard (Coast Guard), the Environmental Protection Agency (EPA), the Department of Health and Human Services' (HHS) National Institutes of Health (NIH) and Centers for Disease Control and Prevention (CDC), the Department of Commerce's National Oceanic and Atmospheric Administration (NOAA), and the National Science Foundation (NSF).

Table 4: Federally Sponsored Research on Dispersants since Fiscal Year 2000, by Research Category and Agency

Effectiveness		
Agency	Title of dispersant project	Fiscal year
BSEE	TAR 350: Laboratory Study to Compare the Effectiveness of Chemical Dispersants when Applied Dilute versus Neat	2000
BSEE	TAR 375: Feasibility of Using Ohmsett for Dispersant Testing and Research	2000
BSEE	TAR 160: Study of Oil Spill Chemical Treating Agents	2000
BSEE	TAR 436: Chemical Characteristics of an Oil and the Relationship to Dispersant Effectiveness	2002
BSEE	TAR 450: Dispersant Effectiveness Testing in Cold Water	2002
BSEE	TAR 476: Ohmsett 2003 Cold Water Dispersant Effectiveness Experiments	2003
BSEE	TAR 506: Analysis of IFO-180 and IFO-380 Oil Properties for Dispersant Window of Opportunity	2004
BSEE	TAR 507: Correlating Results of Ohmsett Dispersant Test with At-Sea Trials: Workshop to Coordinate Publications and Prioritize Follow-up Research	2004
BSEE	TAR 477: Correlating Results of Dispersants Effectiveness at Ohmsett with Identical At-Sea trial: Effects of Oil Viscosity and Dispersant to Oil Ratios	2003
BSEE	TAR 513: Laboratory Testing to Determine Dispersant Predictability of the Baffle Flask Test (BFT) and Swirling Flask Test (SWT)	2004
BSEE	TAR 514: Dispersant Effectiveness testing on Heavy OCS Crude Oils a Ohmsett	2004
BSEE	TAR 526: Correlate Ohmsett Dispersant Tests with At Sea Trials; Supplemental Tests to Complete Test Matrix	2005
BSEE	TAR 563: Understanding the Effects of Time and Energy on the Effectiveness of Dispersants	2005

¹The year listed represents the first year in which the project was funded. Joint or collaborative projects are entered under each relevant agency as supplied by that agency. If a project had more than one research focus, it appears under each of the applicable section's headers.

**Appendix III: Listing of Federally Sponsored
Research on Dispersants since Fiscal Year
2000, by Research Category and Agency**

Effectiveness		
Agency	Title of dispersant project	Fiscal year
BSEE	TAR 529: Analysis of Dispersant Effectiveness of Heavy Fuel Oils and Weathered Crude Oils at Two Different Temperatures Using the Baffled Flask Test	2005
BSEE	TAR 527: The Effect of Warming Viscous Oils Prior to Discharge on Dispersant Performance	2005
BSEE	TAR 542: Dispersant Effectiveness Testing on Realistic Emulsions at Ohmsett	2005
BSEE	TAR 545: Calm Sea Application of Dispersants	2005
BSEE	TAR 568: Research at Ohmsett on the Effectiveness of Chemical Dispersants on Alaskan Oils in Cold Water	2006
BSEE	TAR 595: Identification of Window of Opportunity for Chemical Dispersants on Gulf of Mexico Crude Oils	2007
BSEE	TAR 546: Chemical Dispersibility of OCS Crude Oils in Non-Breaking Waves, Part 1 Determining the Limiting Oil Viscosity for Dispersion in Non-Breaking Waves	2005
BSEE	TAR 590: Changes with Dispersant Effectiveness with Extended Exposure in Calm Seas	2007
BSEE	TAR 589: Investigation of the Ability to Effectively Recover Oil Following Dispersant Application	2007
BSEE	TAR 615: Chemical Dispersant Research at Ohmsett	2008
BSEE	TAR: 635 Literature Review on Chemical Treating Agents in Fresh and Brackish Water	2009
BSEE	TAR 637: Validation of the Two Models Developed to Predict the Window of Opportunity for Dispersant Use in the Gulf of Mexico	2009
BSEE	TAR 663: Heavy Oil Dispersion Research	2010
BSEE	TAR 638: Chemical Dispersant Research at Ohmsett: Phase 2	2009
BSEE	TAR 666: Baffled Flask Dispersant Effectiveness Testing	2010
BSEE	TAR 685: Operational Chemical Dispersant Research at Ohmsett	2011
BSEE	TAR 681: Laboratory-Scale Investigation of a Method for Enhancing the Effectiveness of Oil Dispersants in Destabilizing Water-in-Oil Emulsions	2011
BSEE	TAR 427: Dispersant Effectiveness Test Protocol Development for Ohmsett	2000
EPA	Oil Spill Dispersant Effectiveness Protocol	1998 ^a
EPA	The Baffled Flask Test for Dispersant Effectiveness: A Round Robin Evaluation of Reproducibility and Repeatability	2001
EPA	Evaluation of Energy Dissipation Rates in Laboratory Flasks Simulating Various Sea States	2001
EPA	Testing the Dispersant Effectiveness of a New Dispersant Using the Swirling Flask Test	2002
EPA	Evaluation of Dispersant Effectiveness in a Wave Tank	2003
EPA	Evaluation of Dispersant Effectiveness in a Wave Tank	2004
EPA	Dispersant Effectiveness of Commercial Dispersants on Two Heavy Fuel Oils	2004
EPA	Laboratory Testing to Determine Dispersant Predictability of the Baffle Flask Test (BFT) and Swirling Flask Test (SWT)	2004
EPA	Dispersion Effectiveness as a Function of Turbulence and Particle Size	2005
EPA	Dispersant Effectiveness as a Function of Turbulence	2005
EPA	Dispersion of Crude Oil and Petroleum Products in Freshwater	2006
EPA	Dispersant Effectiveness as a Function of Turbulence Under Continuous Flow Conditions	2007
EPA	Dispersant effectiveness of 20 crude and fuel oils by Corexit 9500 in lab	2010

**Appendix III: Listing of Federally Sponsored
Research on Dispersants since Fiscal Year
2000, by Research Category and Agency**

Effectiveness		
Agency	Title of dispersant project	Fiscal year
EPA	Use of the Baffled Flask Test to Determine the Dispersant Effectiveness of the Eight NCP Product Schedule Dispersants on S. Louisiana Crude Oil at Two Temperatures	2010
EPA	Dispersant Effectiveness Data	2001
EPA	Develop Extended Dispersant Data on for a Suite of Environmental Conditions	2006
NOAA	Wave Tank Studies on Dispersant Effectiveness as a Function of Energy Dissipation Rate and Particle Size Distribution	2006
Fate and transport		
EPA	Biodegradability of Dispersed Oil	2004
EPA	Biodegradability of Dispersed Oil at 2 Temperatures	2005
EPA	Biodegradability of Dispersants and Dispersed Oil at Two Temperatures	2010
EPA	Impact of Waves on Oil and Dispersed Oil	2001
NOAA	Effects of Dispersants on Oil-SPM Aggregation and Fate in US Coastal Waters	2006
NOAA	Measurements and Modeling of Size Distributions, Settling and Dispersions Rates of Oil Droplets in Turbulent Flows	2007
NOAA	Field Verification of SIMAP Oil Spill Fate and Transport Modeling and Linking CODAR Observation Systems Data with SIMAP Predictions	2006
NSF	Development of a Pyrolysis GC/MS Facility for Characterizing Oil-Contaminated Water, Sediment and Seafood Samples	2010
NSF	MRI RAPID: Acquisition of Two Cavity Ringdown Spectrometers to Quantify Hydrocarbon Conversion in Deep Waters of the Gulf of Mexico	2010
NSF	MRI RAPID: Deepwater Oil/Gas Well Blowout Simulator to Study Oil/Gas Dispersion and Mitigate Gas Hydrate Formation in the Gulf Oil Spill	2010
NSF	RAPID for Gulf of Mexico Oil Spill: Interactions of Crude Oil with Dispersants and Naturally Occurring Particles	2010
NSF	RAPID Response in Gulf of Mexico: Sediment Trap Investigations	2010
NSF	RAPID/MRI: Acquisition of a Triple-Quad Mass Spectrometer for Quantitative Identification of Dispersants and Water-Soluble Oil in the Gulf of Mexico	2010
NSF	RAPID: Hydrocarbon Dissolution Fluxes from the Deepwater Horizon Oil Plume: GCxGC Chemical Analysis and Mass Transfer Modeling	2010
NSF	RAPID: Multi-phase Buoyant Plumes in Stratified Water Study relevant to Oil Spill Implications for the Gulf oil spill distribution	2010
NSF	RAPID: Self Assembly of Chemical Dispersant Systems in the Treatment of Deep Water Hydrocarbon Releases	2010
NSF	RAPID: 3-D Model Forecast of the Vertical and Horizontal Distributions of the Oil Plumes Arising From the Deepwater Horizon Spill	2010
NSF	RAPID: Assessing the Impact of Chemical Dispersants on the Microbial Biodegradation of Oil Immediately following a Massive Spill	2010
NSF	RAPID: Collaborative Research: Deepwater Horizon Oil Spill, Marine Snow and Sedimentation	2010
NSF	RAPID: Evaluation of the near term impact of the Deepwater Horizon blowout to the South Florida coast	2010
NSF	RAPID: Photochemical Fate of Oil Dispersants Used in the Gulf Oil Spill Clean-up	2010

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Research on Dispersants since Fiscal Year
2000, by Research Category and Agency**

Effectiveness		
Agency	Title of dispersant project	Fiscal year
Aquatic toxicity and environmental effects		
BSEE	TAR 449: Effects of Chemically Dispersed and Biodegraded Oils	2002
BSEE	TAR 662: Combining Mineral Fines with Chemical Dispersants to Disperse Oil in Low Temperature and Low Mixing Energy Environments	2010
EPA	In vitro Testing of Eight Oil Dispersants for In Vitro Assessment of Estrogenicity, Androgenicity, Anti-Androgenicity and Cytotoxicity	2010
EPA	Toxicity of Eight Oil Dispersants, Louisiana Crude Oil (LSC), and Dispersed LSC to Two Gulf Species	2010
EPA	Toxicity of Dispersed Oil to Marine Organisms	2008
NOAA	Effects of Dispersed Oil on Ecologically Relevant Aquatic Organisms using a Salt-Marsh Mesocosm	2011
NOAA	Acute and Chronic Effects of Crude Oil and Dispersed Oil on Chinook Salmon Smolts (<i>Oncorhynchus tshawytscha</i>)	2003
NOAA	Acute and Chronic Effects of Oil, Dispersant and Dispersed Oil to Symbiotic Cnidarian Species	2005
NOAA	Dispersants as an Oil Spill Countermeasure for Remediation and Restoration in Sensitive Coastal Habitats	2003
NOAA	Guidance for Dispersant Decision Making: Potential for Impacts on Aquatic Biota	2008
NOAA	The Relationship Between Acute and Population Level Effects of Exposure to Dispersed Oil, and the Influence of Exposure Conditions using Multiple Life History Stages of an Estuarine Copepod, <i>Eurytemora affinis</i> , as Model Planktonic Organisms.	2006
NOAA	Lack of Biological Effects of Water Accommodated Fractions of Chemically-and Physically-Dispersed Oil on Molecular, Physiological, and Behavioral Traits of Juvenile Snapping Turtles following Embryonic Exposure.	2005
NSF	RAPID: Collaborative Proposal: Spatially-explicit, High-resolution Mapping and Modeling to Quantify Hypoxia and Oil Effects on the Living Resources of the Northern Gulf of Mexico	2010
NSF	RAPID: Deepwater Horizon Oil Spill: Impacts on Blue Crab Population Dynamics and Connectivity.	2010
NSF	RAPID: Collaborative Research: <i>Nematostella</i> as an Estuarine Indicator Species for Assessing Molecular and Physiological Impacts of the Deepwater Horizon oil spill.	2010
NSF	RAPID: Assessing the Impact of Chemical Dispersants on the Microbial Biodegradation of Oil Immediately Following a Massive Spill	2010
NSF	RAPID: Assessment of the Impacts of the Deep Horizon Oil Spill on Bluecrab, <i>Callinectes Sapidus</i> , Spawning and Recruitment in the Northcentral Gulf of Mexico.	2010
NSF	RAPID: Collaborative Proposal: Acute Response of Benthic Hardbottom Communities to Oil Exposure in the Deep Gulf of Mexico	2010
NSF	RAPID: Collaborative Research: Genetic Impact of the Deepwater Horizon Oil Release	2010
NSF	RAPID: Community-level Wetland Stressors, Northern Gulf of Mexico	2010
NSF	RAPID: Rapid Assessment of Extent and Photophysiological Effects of the Deepwater Horizon Oil Spill	2010
NSF	RAPID: Resolving Higher Trophic-level Change within the Northern Gulf of Mexico Ecosystem as a Consequence of the Deepwater Horizon Oil Spill	2010
NSF	RAPID-Attachment of Crude Oil and Washability of Sand Beaches and Marsh Lands: Effects of Berms and Dispersants	2010

**Appendix III: Listing of Federally Sponsored
Research on Dispersants since Fiscal Year
2000, by Research Category and Agency**

Effectiveness		
Agency	Title of dispersant project	Fiscal year
Modeling		
BSEE	TAR 637: Validation of the Two Models Developed to Predict the Window of Opportunity for Dispersant Use in the Gulf of Mexico	2009
EPA	Wave Modeling of Oil Slicks	2006
EPA	Development of ERO3S Model	2001
NOAA	Guidance for Dispersant Decision Making: Potential for Impacts on Aquatic Biota	2008
NOAA	Effects of Dispersants on Oil-SPM Aggregation and Fate in US Coastal Waters	2006
NOAA	Measurements and Modeling of Size Distributions, Settling and Dispersions Rates of Oil Droplets in Turbulent Flows	2007
NOAA	Field Verification of SIMAP Oil Spill Fate and Transport Modeling and Linking CODAR Observation Systems Data with SIMAP Predictions	2006
NSF	RAPID Collaborative Proposal: Spatially-explicit, High-resolution Mapping and Modeling to Quantify Hypoxia and Oil Effects on the Living Resources of the Northern Gulf of Mexico	2010
NSF	RAPID: Multi-phase Buoyant Plumes in Stratified Water Study relevant to Oil Spill Implications for the Gulf oil spill distribution	2010
NSF	RAPID: 3-D Model Forecast of the Vertical and Horizontal Distributions of the Oil Plumes Arising From the Deepwater Horizon Spill	2010
NSF	RAPID: Evaluation of the Near Term Impact of the Deepwater Horizon Blowout to the South Florida Coast	2010
Monitoring		
BSEE	TAR 477: Correlating Results of Dispersants Effectiveness at Ohmsett with Identical At-Sea trial: Effects of Oil Viscosity and Dispersant to Oil Ratios	2003
BSEE	TAR 598: Upgrade of SMART Dispersant Effectiveness Monitoring Protocol	2007
BSEE	TAR 697: Assessment of Dispersant Effectiveness using Ultrasound to Measure Oil Droplet Particle Size Distributions	2011
Coast Guard	Updating Special Monitoring of Alternative Response Technologies (SMART) Protocol	2007
EPA	Upgrade of SMART Dispersant Effectiveness Monitoring Protocol	2007
NOAA	Use of Natural Oil Seeps for Evaluation of Dispersant Application and Monitoring Techniques	2002
NOAA	Upgrade of SMART Dispersant Effectiveness Monitoring Protocol	2007
Human Health		
EPA	In Vitro High Throughput Screening of Eight Oil Dispersants in ToxCast Assays for Estrogenicity, Androgenicity, Anti-Androgenicity, Other Endocrine Related Endpoints, and Cytotoxicity	2010
EPA	In Vitro Testing of Eight Oil Dispersants for In Vitro Assessment of Estrogenicity, Androgenicity, Anti-Androgenicity and Cytotoxicity	2010
HHS	NIOSH Emergency Preparedness and Response Office-Technical Assistance and Advancing Research—Research on Airborne Concentrations of Corexit 9500A	2010
HHS	NIOSH Emergency Preparedness and Response Office-Technical Assistance and Advancing Research – Dermal Exposure Studies to Assess Immune Responses in Lab Rats to Exposure to Dispersant (Corexit 9500A)	2010
HHS	In Vitro High Throughput Screening of Eight Oil Dispersants in ToxCast Assays for Estrogenicity, Androgenicity, Anti-Androgenicity, Other Endocrine Related Endpoints, and Cytotoxicity	2010

**Appendix III: Listing of Federally Sponsored
Research on Dispersants since Fiscal Year
2000, by Research Category and Agency**

Effectiveness		
Agency	Title of dispersant project	Fiscal year
HHS	Human Health Impact of Deepwater Horizon Spill in Eastern Gulf Coast Communities. Sub-project title—Seafood Hydrocarbon Residues and Coastal Community Health Risks.	2011
Subsurface/Deep water applications		
NSF	MRI RAPID: Acquisition of Two Cavity Ringdown Spectrometers to Quantify Hydrocarbon Conversion in Deep Waters of the Gulf of Mexico	2010
NSF	RAPID: Self Assembly of Chemical Dispersant Systems in the Treatment of Deep Water Hydrocarbon Releases	2010
NSF	RAPID: Collaborative Proposal: Acute Response of Benthic Hardbottom Communities to Oil Exposure in the Deep Gulf of Mexico	2010
Arctic		
BSEE	TAR 450: Dispersant Effectiveness Testing in Cold Water	2002
BSEE	TAR 476: Ohmsett 2003 Cold Water Dispersant Effectiveness Experiments	2003
BSEE	TAR 563: Understanding the Effects of Time and Energy on the Effectiveness of Dispersants	2005
BSEE	TAR 527: The Effect of Warming Viscous Oils Prior to Discharge on Dispersant Performance	2005
BSEE	TAR 568: Research at Ohmsett on the Effectiveness of Chemical Dispersants on Alaskan Oils in Cold Water	2006
BSEE	TAR 662: Combining Mineral Fines with Chemical Dispersants to Disperse Oil in Low Temperature and Low Mixing Energy Environments	2010
EPA	Biodegradability of Dispersed Oil at 2 Temperatures	2005
EPA	Biodegradability of Dispersants and Dispersed Oil at Two Temperatures	2010
Alternative Dispersant Formulations		
NSF	Collaborative Research: Characterization of Lipo-peptides for Use as Bio-dispersants to Clean-up Oil Spills	2010
NSF	MRI RAPID: Acquisition of High-Rate Nanomanufacturing System for Accelerated Development of Novel Materials and Processes for Oil Spill Remediation	2010
NSF	RAPID: Water-based, Natural Polymer Surfactants: Implications for Deepwater Horizon Oil Spill Dispersions	2010
NSF	Air: First Stage Commercialization of Oil Anti-Deposition Dispersant Technology for Spilled Oil	2011
General Research		
BSEE	TAR 349: Technology Assessment of the Use of Dispersants on Spills from MMS-Regulated OCS Facilities	2000
BSEE	TAR 413: Assessment of the Use of Dispersants on Marine Oil Spills in California	2001
BSEE	TAR 493: Understanding Oil Spill Dispersants: Efficacy and Effects	2003
BSEE	TAR 613: Development of a Training Package on the Use of Chemical Dispersants for Ohmsett—The National Oil Spill Response Test Facility	2008
Coast Guard	Report: National Research Council's Committee on Understanding Oil Spill Dispersants: Efficacy and Effects	2004
NOAA	Future of Dispersant Use in Spill Response	2011
NOAA	NOAA's Support for 2005 NRC Report on Dispersants	2003
NSF	RAPID: Responsive Oil Spill Outreach Based in Science	2010

Source: Project listings supplied by each agency.

^aThis project began in 1998, and continued past 2000.

Appendix IV: Comments from the Department of Commerce



UNITED STATES DEPARTMENT OF COMMERCE
The Secretary of Commerce
Washington, D.C. 20230

May 16, 2012

David C. Trimble
Director
Natural Resources and Environment
U.S. Government Accountability Office
441 G Street NW
Washington, DC 20548

Dear Mr. Trimble:

Thank you for the opportunity to review and comment on the Government Accountability Office's draft report entitled *Oil Dispersants: Additional Research Needed, Particularly on Subsurface and Arctic Applications* (GAO-12-585). I have enclosed the National Oceanic and Atmospheric Administration's programmatic comments to the draft report.

If you have any questions, please contact me or Jim Stowers, Acting Assistant Secretary for Legislative and Intergovernmental Affairs at (202) 482-3663.

Sincerely,

A handwritten signature in black ink, appearing to read "John E. Bryson".

John E. Bryson

Enclosure

**Department of Commerce
National Oceanic and Atmospheric Administration
Comments on the Draft GAO Report Entitled
“Oil Dispersants”
(GAO 12-585 / May 2012)**

General Comments

The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) appreciates the opportunity to review the Government Accountability Office's (GAO) draft report on oil dispersants. The draft report on oil dispersants is a very thorough and balanced summary of the status of oil spill dispersant understanding and research needs. NOAA believes this report will add clarity to the discussions over future R&D needs and will be a useful public resource when another large spill occurs and dispersants are again considered as a response tool.

Commerce Response to GAO Recommendation

Recommendation 2: "To enhance the knowledge of the effectiveness and potential effects of chemical dispersants, we recommend that the Secretaries of Commerce and Interior, the Administrator of EPA, and the Commandant of the Coast Guard direct their respective agencies: NOAA, BSEE, EPA, and Coast Guard, to coordinate and explore ways to better obtain more scientifically robust information during spills without hindering response efforts through enhancement of monitoring protocols and development of new data collection tools."

Commerce Response: Commerce agrees with this recommendation. The Secretary of Commerce will direct NOAA to immediately contact their counterparts at BSEE, EPA, and Coast Guard to schedule discussions on the possibility of enhanced monitoring protocols and the development of new data collection methods. NOAA will continue to coordinate with the other federal agencies through the Interagency Coordinating Committee on Oil Pollution Research, and other mechanisms.

Appendix V: Comments from the Department of Homeland Security

U.S. Department of Homeland Security
Washington, DC 20528



**Homeland
Security**

May 16, 2012

Mr. David C. Trimble
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Re: Draft Report GAO-12-585, "OIL DISPERSANTS: Additional Research Needed,
Particularly on Subsurface and Arctic Applications"

Dear Mr. Trimble:

Thank you for the opportunity to review and comment on this draft report. The U.S. Department of Homeland Security (DHS) appreciates the U.S. Government Accountability Office's (GAO's) work in planning and conducting its review and issuing this report.

The U.S. Coast Guard has been designated by the National Oil and Hazardous Substances Pollution Contingency Plan as the Federal On-Scene Coordinator for marine pollution incidents within the Coastal Zone. The Coast Guard also researches new methods and techniques for responding to oil spills, and serves as the Chair of the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR). In these roles, the Coast Guard engages in issues related to the use of dispersants as a response tool for oil spills; however, federal research involving dispersants involves many government agencies and is not strictly a Coast Guard responsibility.

DHS concurs with all three recommendations in the draft report. Specifically, GAO recommended that the Commandant of the Coast Guard:

Recommendation 1: Direct the Chair of the ICCOPR in coordination with member agencies to ensure that, in the course of revising its research and technology plan, application of dispersants subsurface and in Arctic conditions are among the areas prioritized for subsequent research.

Response: Concur. The ICCOPR is currently updating its 1997 Oil Pollution Research and Technology Plan to focus on anticipated research priorities projected for the next 5 years. Dispersant research needs will be analyzed and discussed in this update. Estimated Completion Date: June 30, 2013.

Recommendation 2: Direct the Chair of the ICCOPR in coordination with member agencies to, as part of its efforts to help guide federal research, identify information on the key ongoing dispersant-related research, including research sponsored by state governments, industry, academia, and other oil pollution research organizations. This information should be provided in the planned and future revisions to the research and technology plan. In addition, periodically

update and disseminate this information, for example, as part of the committee's biennial report to Congress on the activities carried out by the committee.


Response: Concur. The ICCOPR has and continues to access and employ several sources of information to better understand ongoing dispersant research needs and activities. These include the consistent attendance of ICCOPR members to recurring major conferences and workshops including: the International Oil Spill Conference, Interspill, Spillcon, Clean Gulf, Clean Pacific, and the Arctic and Marine Oil Spill Program Technical Seminar on Environmental Contamination and Response. Additionally, the ICCOPR regularly invites outside speakers and researchers to its quarterly meetings to update the membership on ongoing research activities in academia, industry, and the government. The ICCOPR relies heavily on its Web site (www.iccopr.uscg.gov) to disseminate information about the committee's activities as well as new research news and documents. In addition to public communications on its Web site and through its congressional biennial reports, the ICCOPR will continue to explore new means for sharing and tracking information about ongoing dispersant research needs and activities.

Recommendation 3: Direct the Coast Guard to coordinate and explore ways to better obtain more scientifically robust information during spills without hindering response efforts through enhancement of monitoring protocols and development of new data-collection tools.

Response: Concur. The Coast Guard supports efforts to identify new technologies and data-gathering procedures to obtain additional scientific information during spills. This support can be leveraged through the Coast Guard's participation in the ICCOPR, National Response Team, and Regional Response Teams, and within our own research and development program.

Again, thank you for the opportunity to review and comment on this draft report. Please feel free to contact me if you have any questions. We look forward to working with you on future Homeland Security issues.

Sincerely,



Jim H. Crumpacker
Director
Departmental GAO-OIG Liaison Office

Appendix VI: Comments from the Department of the Interior



United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, DC 20240

MAY 17 2012

David C. Trimble
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Trimble:

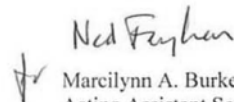
Thank you for the opportunity to review and comment on the Government Accountability Office (GAO) draft report entitled, *OIL DISPERSANTS: Additional Research Needed, Particularly on Subsurface and Arctic Applications* (GAO-12-585). The draft GAO report includes one recommendation for the Secretary of the Interior to implement in conjunction with other Federal agencies. Specifically, the GAO recommends that the Secretaries of Interior and Commerce, in conjunction with the Administrator of the Environmental Protection Agency (EPA), and the Commandant of the United States Coast Guard (USCG), direct their respective responsible agencies to coordinate and explore ways to better obtain more scientifically robust information during spills without hindering response efforts through enhancement of monitoring protocols and development of new data collection tools.

The Department of the Interior (DOI) concurs with the recommendations in the draft report and agrees that intergovernmental coordination among agencies is essential for maximizing the Government's knowledge of the effectiveness and potential environmental impacts of chemical dispersants. Within DOI, the Bureau of Safety and Environmental Enforcement (BSEE) Oil Spill Response Division has responsibility for conducting oil spill dispersant research. BSEE has a long history of oil spill response research. As noted in your draft report, BSEE and its predecessor Minerals Management Service (MMS) has consistently funded dispersant research projects every fiscal year since 2000 and has been a primary or joint sponsor of 39 dispersant research projects, six of which related to the effectiveness of dispersant use in Arctic conditions.

BSEE is also an active member of the Interagency Coordinating Committee on Oil Pollution Research and the National Response Team's Science and Technology Committee, as are EPA, the USCG, and the National Oceanic and Atmospheric Administration. In both of these committees, BSEE seeks to coordinate research activities, which include the development of enhanced monitoring protocols and data collection tools. BSEE will continue to engage in any new or expanded interagency forum on these efforts.

We appreciate your suggestions for improving Federal oil dispersant research. The enclosure contains technical comments for your consideration. If you have any questions, please contact John Keith, Chief of the Office of Policy and Analysis at 202-208-3236.

Sincerely,


Marcilynn A. Burke
Acting Assistant Secretary
Land and Minerals Management

Appendix VII: Comments from the Environmental Protection Agency



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460

MAY 18 2012

Mr. David C. Trimble
Director
Natural Resources and the Environment
U.S. Government Accountability Office
Washington, DC 20548

Dear Mr. Trimble:

Thank you for the opportunity to review and comment on GAO's draft report "Oil Dispersants: Additional Research Needed, Particularly on Subsurface and Arctic Applications." The Environmental Protection Agency (EPA) generally agrees with the findings and conclusions reached by the GAO. Your draft report included three recommendations, one of which was addressed to the EPA. The purpose of this letter is to provide our Agency response to this particular recommendation.

As your draft report highlights, gaps remain in our knowledge about the application and effects of subsurface injection of dispersants to underwater blowouts and of the use of dispersants in Arctic environments. The EPA believes research can be helpful in determining the extent of lasting dispersed oil during a simulated oil blowout comparing chemically and physically dispersed oil. The EPA also believes and strongly encourages learning more about the differences in fluorescence properties between oil and dispersed oil so that more informed decisions are possible during a deep sea spill response. This belief is predicated on the fact that the fluorescence signal of chemically dispersed oil differs significantly from undispersed or physically dispersed oil. In addition, the EPA believes research is needed on the short and long-term toxicological effects of dispersants through direct and indirect exposures.

Studying the effects of dispersant use under Arctic conditions is of great importance. The EPA is actively engaged in conducting laboratory studies on the biodegradability of oils of various weights and viscosities with and without the use of dispersants. This research is taking place now at cold and warm temperatures. Canada, our northern neighbor, has the same objectives and needs, and we have aligned ourselves very closely with them in the conduct of important research in this and other related areas.

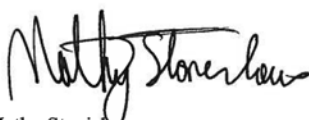
In addition, we would like to point out that the EPA is collaborating with the member agencies of the National Response Team (NRT) and the Alaska Regional Response Team (ARRT) to understand the unique aspects of certain oil spill situations, locations, and time-of-year in the Arctic with respect to the authorization and use of dispersants. This effort will inform and help prioritize research needs. We ask that you include this information in your final report, as appropriate, in the section currently titled "*Roughly Half of Federally Funded Research Has Focused on Effectiveness.*"

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GAO Recommendation #3 (only one addressed to EPA): *To enhance the knowledge of the effectiveness and potential environmental effects of chemical dispersants, we recommend that the Secretaries of Commerce and Interior, the Administrator of EPA, and the Commandant of the Coast Guard direct their respective agencies, NOAA, BSEE, EPA, and Coast Guard, to coordinate and explore ways to better obtain more scientifically robust information during spills without hindering response efforts through enhancement of monitoring protocols and development of new data collection tools.*

EPA Response: The EPA is committed to exploring ways to coordinate with other agencies to better obtain more scientifically robust information during spills, enhance monitoring protocols, and develop new data collection tools. The EPA has submitted two proposals to the Department of Interior's Bureau of Safety and Environmental Enforcement (BSEE) in response to a Broad Agency Announcement (BAA-BSEE Oil Spill Response Research- Solicitation # E12PS00012). The EPA is engaged with the Science and Technology Committee of the National Response Team, and discussions are being held to address new and improved fluorescence monitoring research and develop a better understanding of deep sea dispersant injection. Finally, the EPA will continue to engage the federal family, under the auspices of the Interagency Coordinating Committee on Oil Pollution Research (ICCOPR), to enhance monitoring protocols and develop new data collection tools that can be used to obtain more scientifically robust information without hindering response efforts if and when a future spill should occur.

In closing, thank you for the opportunity to review and respond to the draft GAO report. If you have any questions, please contact Deborah Heckman at (202) 564-7274.



Mathy Stanislaus
Assistant Administrator
Office of Solid Waste and Emergency Response

Sincerely,



Erik Kadel
Acting Assistant Administrator
Office of Research and Development

Appendix VIII: GAO Contact and Staff Acknowledgments

GAO Contacts

David C. Trimble, (202) 512-3841 or trimbled@gao.gov

Staff Acknowledgments

In addition to the individual named above, Elizabeth Erdmann (Assistant Director), Antoinette Capaccio, Margaret Childs, Cindy Gilbert, Ryan Gottschall, Rebecca Makar, Alison O'Neill, and Jena Sinkfield made key contributions to this report.

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