DTox: a Worldwide Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil

A Final Report Submitted to

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Submitted by

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Abstract

The *Deepwater Horizon* oil spill revived much of the discussions on the use of dispersants as one of the tools considered in offshore oil spill response. Much of this discussion focused on concerns about the toxicity of dispersants and chemically dispersed oil to water column organisms. The ability to rapidly assess the toxicity of dispersants and chemically dispersed oil require unrestricted and rapid access to available toxicity data, a need shared by government, industry, consultants, and academic groups involved in oil spill response. While toxicity data on dispersants and both physically and chemically dispersed oil have been generated since the 1970s, the practical use of this information has been hindered by the lack of a centralized data repository. As a result, the Dispersant and Chemically Dispersed Oil Toxicity Database (DTox) is created to address that shared need of the oil spill community.

The main objectives of this project are to: 1) identify, evaluate, compile, and integrate all available toxicity data on dispersants and chemically dispersed oil, and 2) generate an interactive tool that can assist the oil spill response community in their assessments and management decisions regarding the use of dispersants. The ultimate goal of this effort is the synthesis of information in a meaningful way to improve scientific decision-making as well as to provide rapid access to centralized toxicity data. DTox includes information on over 35 data attributes (e.g., species scientific name, life stage tested, dispersant name, exposure type, oil weathering stage, exposure duration, etc.), compiled through a careful review of existing data extracted from the peer-review and gray literature. Data considered for inclusion in DTox are rigorously evaluated following a strict set of rules aimed at selecting the best available and suitable data that are further evaluated through detailed Quality Assurance/Quality Control (QA/QC) procedures, which included a review of at least 15% of all records in the database. Each data source in DTox is further evaluated and given an applicability score based on its relevance to oil spills, and not on its scientific merits. Key criteria in the determination of source applicability include exposure type, reported effects concentrations, and reported analytical chemistry. Data from 400 papers (peer-review and gray literature) were evaluated for their potential inclusion into the database, and data extracted from +160 of these sources. Information in DTox is integrated into a user-friendly tool that allows for on-the-fly data searches and data plotting in the form of Species Sensitivity Distributions, based on the specific needs of an end-user. This tool can assist with the development of risk estimates related to oil spills by allowing the selection of data that most closely match the needs of an end-user.

The effectiveness, usefulness, and transferability of DTox to oil spill response are evaluated through oil spill drills, dispersant-related workshops, and dispersant-related assessment. These exercises showed that, despite existing data limitations, DTox provides information that can be used to inform tradeoff decisions based on the current state of knowledge. Data in DTox have the potential to contribute to a better understanding of the biological effects of dispersants and oil in the aquatic environment, and can provided useful information to both environmental assessments and decision making efforts. Future efforts will focus on maintaining and updating DTox and expanding its use capabilities in oil spill response community.

Keywords: Dispersant, DTox, Oil spill response, Chemically dispersed oil, Species Sensitivity Distributions.

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1.0 Introduction

During the *Deepwater Horizon* oil spill an unprecedented volume of dispersants was used as a response tool to accelerate the natural biodegradation of oil and help minimize the impacts of oil on sensitive nearshore and shoreline habitats and resources (Lubchenco et al., 2012). This exceptional use of dispersants raised concerns among the public and many scientists about the toxicity of dispersant and chemically dispersed oil to water column organisms. While aquatic toxicity testing of dispersants and chemically dispersed oil has been conducted under laboratory and field conditions for at least four decades (e.g., NRC, 1989, 2005, and more recent studies) the practical use of this information, particularly to communicate risks and to address misconceptions about the use of dispersants, was limited by the lack of a centralized data repository (a data gap identified by CRRC et al., 2012). While aquatic toxicity databases contain toxicity data on dispersants and petroleum products (e.g., CAFÉ-NOAA/ERD, AQUIRE-USEPA), a database solely dedicated to consolidating in a meaningful way decades of existing toxicity data on dispersants and both physically and chemically dispersed oil was nonexistent at the time. As a result, Dispersant and Chemically Dispersed Oil Toxicity Database (DTox) is developed to address the shared need of the national and international oil spill community for access to toxicity data. The main objectives of this project are to review and integrate all available toxicity data on dispersants and chemically dispersed oil into an interactive tool that can assist the oil spill response community in their management decisions regarding the use of dispersants.

While it is clear that additional research is needed to improve our understanding of the biological, toxicological, and ecological effects of dispersants and chemically dispersed oil to a wide range of aquatic species (CRRC et al., 2012), and despite data limitations, decades of research in this field can provide valuable information to the oil spill response community and practitioners. As evident during the *Deepwater Horizon* oil spill, the ability to assess the toxicity of chemically dispersed oils is a goal shared by oil spill responders, where a common requirement is the unrestricted and rapid access to the available toxicity data, compiled following a detailed Quality Assurance/Quality Control plan.

2.0 Objectives

The main objectives of this project are to identify, evaluate, compile, and integrate all available toxicity data on dispersants and both physically and chemically dispersed oil generated under laboratory and field conditions, and to generate an interactive tool that can assist the oil spill response community in management decisions regarding the use of dispersants. The ultimate goal of this effort is the synthesis of information in a meaningful way to improve scientific decision-making as well as to provide rapid access to centralized toxicity data. The specific objectives of this project are to:

1. Identify documents and peer-review and gray literature (e.g., field, laboratory, mesocosm, accidental oil spills) reporting toxicity data (acute and chronic) of dispersants and chemically dispersed oil;
2. Rigorously evaluate each data source for quality and potential for inclusion in the DTox database;

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3. Compile all quantitative information including all relevant fields (e.g., species, exposure conditions, oil type and weathering, etc.);
4. Integrate the above information into a tool that can be used by the end-user to guide management decisions regarding the use of dispersants; and
5. Test the suitability of the compiled quantitative data for use in spill response at two pilot study areas.

3.0 Methods

The identification of peer-review and gray literature documenting the toxicity of dispersants and physically and chemically dispersed oil was done via a combination of online searches, visits to web sites of government agencies, industry, and research institutions, and direct contact with leading researchers in the field. Hard copies or electronic versions of each data source were obtained and cataloged in EndNote® prior to their review. Each data source was rigorously evaluated for their potential for inclusion in DTox following the Quality Assurance/Quality Control (QA/QC) plan developed for this project (see Appendix A for details). Examples of data criteria are shown in Table 1.

Table 1. Examples of some of the criteria used to evaluate each data source for their potential inclusion in DTox. Studies not satisfying these requirements are not included.

Criteria	Requirement/Inclusions	Limitations/Exclusions
Dispersant	Documented commercial name	Not documented
Oil	Documented fresh/weathered oil name or source	Not documented
Species	Aquatic invertebrates, vertebrates, marine bacteria	Mammals, reptiles
	Documented taxonomic information verifiable against standard taxonomic sources	Species or common name not documented
Effect/ Response	Biological effect on live, whole organisms	Dead organisms; in-vitro studies
	Adverse acute or chronic effects	Beneficial, nutritional effects
Exposure conditions	Water only exposures	Sediment, other exposures
	Acceptable control survival (at least 70%), or acceptable control endpoints	Poor control survival or unacceptable control endpoints
	Documented experimental conditions (e.g., flow through, static)	Not documented
	Documented exposure durations conditions associated with biological effects (e.g., flow through, static)	Unverifiable duration, not reported
	Documented effects concentrations	Not documented

Data were entered into a carefully designed database template in a systematic and consistent fashion. Examples of database elements (see Appendix A for details) included: 1) species attributes: taxonomic group, common name, scientific name, life stage, species distribution; 2) experimental conditions and settings: study type, water type, oil name and weathering condition, dispersant name, dispersant-to-oil ratio, exposure type, exposure duration; 3) endpoints: acute,

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subacute, effects concentration, effects concentration units, analyte name, analytical methods; and 4) data source: author name, publication year, article title. Whenever possible, entries were standardized facilitating further sorting and treatment of the existing data. An additional field was created to score the applicability of each data source (e.g., High, Moderate, Low) to spill response. Source applicability is based on the relevance of each data source to oil spill response, and not on the overall scientific merit of individual sources (see Appendix A for details). Data entered into the database template went through several QA/QC evaluations to ensure that each record accurately represented the information and data of the original data source (see Appendix A for details). Critical steps of the QA/QC process included the review of currently accepted scientific species names, standardization of column content and applicability criteria, and identification of duplicate data (e.g., several papers by the same author(s) reported in several report/manuscripts). Identifying duplicate data is an important step because it affects the values per species plotted on Species Sensitivity Distributions (SSD) (see below). Consequently, duplicate data are not removed from the database, but are not used in SSD calculations. The revised dataset is then migrated into a database program (FileMaker® Pro 12) with expanded capabilities, allowing the development of an interactive, searchable, and user-friendly tool that allows for visual exploration and examination of data (suggested citation Bejarano and Dahlin, 2013).

4.0 Results

4.1 Compiled Toxicity Data

Over 400 papers from peer review and gray literature were initially screened for their potential inclusion into the database. The complete list of citations of all papers reviewed as part of this project was compiled into an EndNote® library. This library is available to the larger oil spill community through the PI and/or CRRC. Although many of the data sources originally reviewed contained important information, many are not included in DTox because these were not the original data source and, therefore, the quality of these papers could not be judged based on the information provided (see Appendix A for details). Of these initially screened papers, data were extracted from +160 sources amounting to +3500 rows of records. A graphic representation of the type of data currently in DTox is shown in Figure 1. To date, this database contains toxicity data for +100 oils, +120 dispersants, and +190 unique aquatic species, amounting to +3,500 toxicity records. The large majority of records are for species with subtropical distributions (+1,200 records), followed by temperate species (+900 records). Cold-water species and tropical species are the most underrepresented group by geography (+800 records combined). Most currently available toxicological records are for species (and life stages) found in the water column (+2,400 records), while a considerably lower number of records are available for species from the other two general habitats (benthos and epibenthos) (+1,500 records combined). When looking at the number of records by taxonomic group, most records are for fish (+1,500 records) followed by crustaceans (+1,400 records), while other groups, especially corals are underrepresented in the database. At least one third of all records are for 13 U.S. standard test species (+1,300 records), with data for mysid shrimp (*Americamysis bahia*) and inland silverside (*Menidia beryllina*) comprising nearly 50% of all standard test species records.

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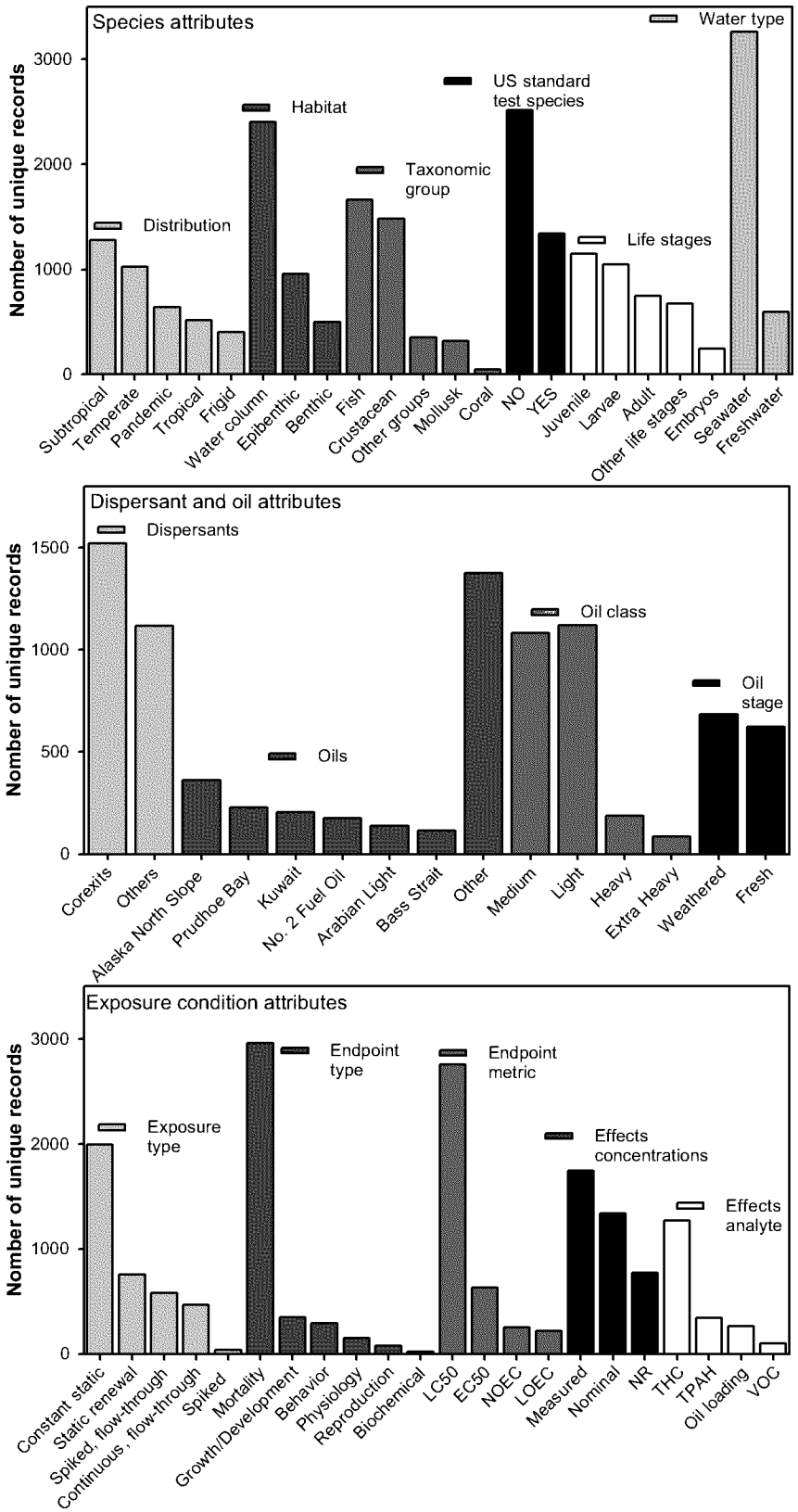

Figure 1. Breakdown of final QA/QC data and information currently in DTox by species attributes (top); oil/dispersant attributes (middle); and exposure conditions (bottom).

Based on the currently available information, it is clear that there was a surge of toxicity studies on dispersants and oil in the mid 1970s, declining drastically through the 1980s. Since the late 1980s, there have been a variable number of studies, as reflected in the number of records in DTox. Nearly one fifth of all records (+700 records) has been generated since 2010, likely driven by the *Deepwater Horizon* oil spill[1]. The most studied dispersants are the Corexits (+1,500 records; specifically Corexit 9500, Corexit 9527 and Corexit 7664), while the most studied oils are Alaska North Slope, Prudhoe Bay, and Kuwait oil (+700 records combined). The large majority of oil records (+2,000) are for light and medium oils (based on API gravity), while heavy and extra heavy oils are underrepresented in the database (+200 records combined). A large percentage of records (70%) are derived from 48- and 96-hour exposures (+2,500 records), and via static exposures (+2,400 records). Of the 171 peer-review and gray literature papers included in DTox, 37, 52, 72 were given High, Moderate and Low Applicability scores, respectively. Ten data sources were rejected.

It is important to note that there are additional data sources not currently in DTox (e.g., data currently under peer review, data unavailable because of confidentially agreements, data under litigation, older reports requiring company approval for release, etc.), and it is hoped that these data would be included in future updates of the existing database. Specifically, NOAA/BP data from the *Deepwater Horizon* oil spill are not currently available for inclusion into the database, but requests have been made to ensure that upon their release from embargo, these data will be entered into DTox following the same procedures and QA/QC plan developed during this project.

4.2 DTox-Version 1

The ultimate goal of this effort is the synthesis of information in a meaningful way to improve scientific decision-making as well as to provide rapid access to centralized toxicity data. As a result, a user-friendly tool was created to facilitate data querying. This tool is designed to allow the end-user to navigate through a series of screens where data selections can be made, narrowing the type and amount of information used in data plotting. Prior to the distribution of the first version of DTox to a selected number of end-users, a beta version of DTox was extensively tested both internally and externally by a number of individuals (testers). This step was critical to ensure that the tool met the requirements expected of an interactive tool. During the testing window, recommendations were made to improve the appearance and functionality of the tool, and a series of glitches and technical issues were identified and addressed. These early evaluations allowed the project team to address any outstanding issues and improve the presentation of the tool prior to its public release. The end-result is the production of a DTox-Version 1 tool (suggested citation Bejarano and Dahlin, 2013). Examples of the navigation windows of the first version of DTox are shown in Figure 2. Note that the first window includes a clear disclaimer, and a request for reporting of errors and inconsistencies. A window is also included to clearly acknowledge the funding source. More detailed information regarding DTox-Version 1 is provided in Appendix B, a document that is also included as a pdf within the interactive tool.

[1] Data generated through to support NRDA from the *Deepwater Horizon* oil spill are not currently included in the database.

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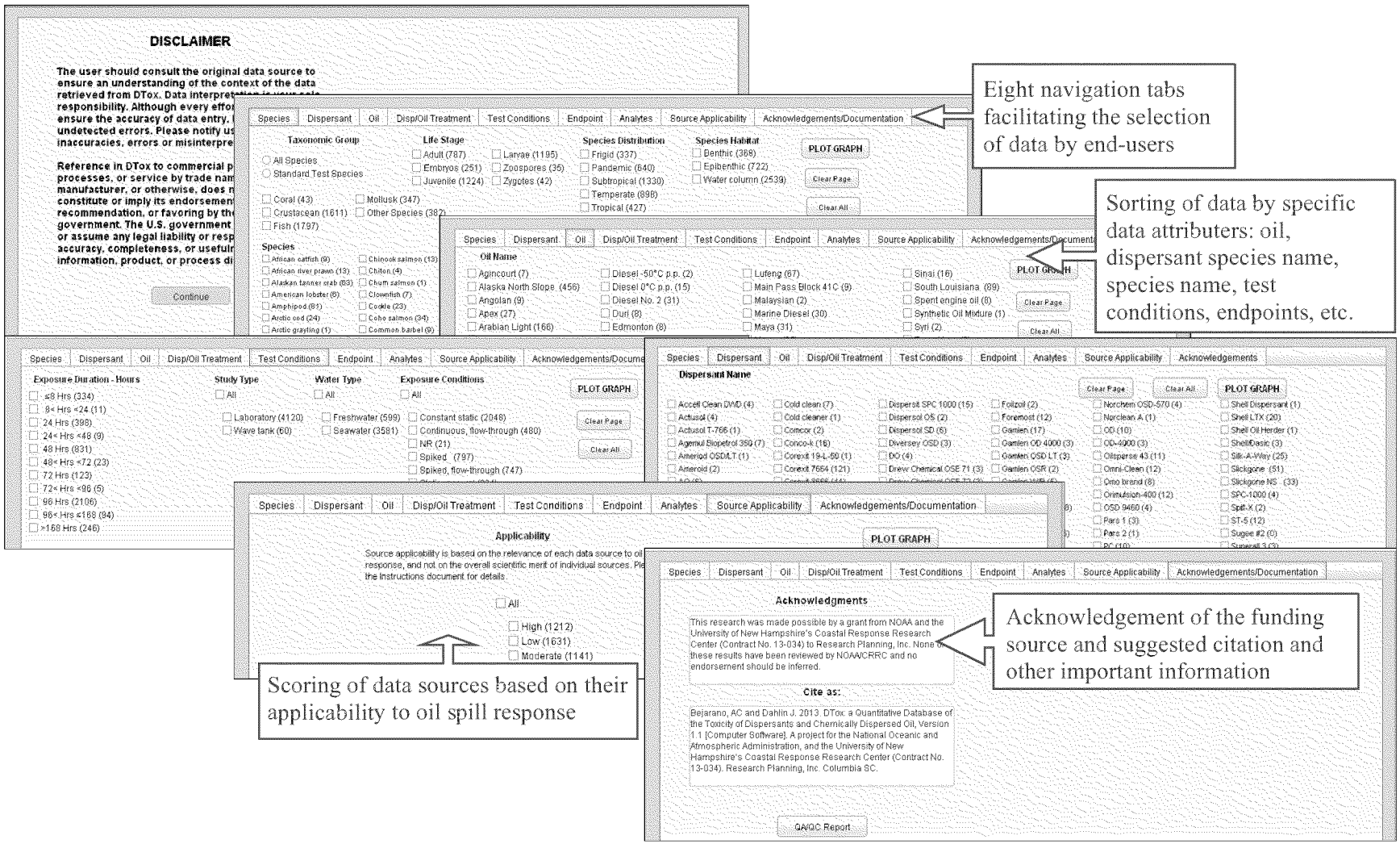

Figure 2. Examples of navigation tabs where the end-user can query the available data. A total of nine navigation tabs are currently available in DTox (Version 1).

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Following data selection from the navigation windows, the remaining data are plotted in separate windows in the form of Species Sensitivity Distributions (SSDs) (Figure 3). SSDs are probabilistic models that describe the relative sensitivity of species to a particular compound or compound mixture (Posthuma et al., 2002), where species are ranked, based on their relative sensitivity, from the least to the most sensitive. As a result, each dot on a SSD represents a unique species, specifically the geometric mean of reported toxicity values. In DTox, SSDs are generated for datasets with a minimum of 5 species by fitting the empirical toxicity data to a logistic function defined by $F(x) = \frac{1}{1 + e^{-(x-\mu)/\sigma}}$, $x \in R$, with parameters μ(location) and σ (scale). SSDs are advantageous in that these allow for comparison of the sensitivity of different species to the same type of exposure (e.g., dispersant only, oil only, chemically dispersed oil), and can be used to derive benchmarks or hazard concentrations (HC) (Posthuma et al., 2002). Some of the most commonly used HCs are the HC1 and HC5 equivalent to the concentrations at which 1% and 5%, respectively, of the species in the SSD may not be protected. When enough data are available for curve fitting, the SSDs also display the estimated HC1 and HC5 values from the logistic curve.

The current version of DTox (Version 1) allows for up to two SSDs per display window (Dispersant Only, Dispersant and Oil, Oil Only) based on the following data fields: exposure duration, dispersant name, or oil name. When only one curve is plotted, common names are displayed to facilitate data interpretation. For better visualization and interpretation of data, the queried data are displayed based on color coding the selections (e.g., by taxonomic group; by species distribution). All SSDs are plotted over a colored background representing a common scale used to rank the relative toxicity of contaminants (http://www.epa.gov/oppefed1/ecorisk_ders/toera_analysis_eco.htm#Ecotox) (see Figure 3 for details). Other features of DTox include a selection criteria tab that displays the selections made through the navigation tabs, and a report tab displaying the information used to plot the SSDs with the option of exporting both SSDs and summary data to a pdf file. DTox also contains the complete QA/QC plan used in the development of the tool (Appendix A), and a "How To" document (Appendix B), guiding end-users how to navigate and understand navigation tabs and query options, and providing examples on how to use outputs generated from this tool. This document also highlights some of the existing limitation with the current version of DTox. DTox also contains the EndNote® library with the complete list of citations of all papers reviewed as part of this project.

Throughout the development of DTox, care was taken to address individuals with disabilities (Section 508 29 U.S.C. '749d) particularly by selecting color palettes (whenever possible) designed to be readable by individuals with color blindness. A stand-alone executable file of DTox (Versions 1), which can be run in desktop and laptop computers, was made available to a selected number of end-users. As mentioned previously, prior to the distribution of DTox (Version 1), the tool was extensively tested both internally and externally by a number of testers. While these early evaluations allowed the project team to address issues prior to its public release, it is acknowledged that the organization of copious amounts of toxicity data into a practical, versatile, and logical system was challenging. However, the tool may still contain issues not currently identified. During training sessions with end-users (see Section 7.1) the PI encouraged participants to report any issues with the tool so that these can be addressed in future

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iterations of DTox. To date, comments have been provided which are summarized in Table 2. Development of additional access forms (e.g., html) may be developed in consultation with NOAA, as this agency may be in charge of the long-term maintenance and future updates of this database.

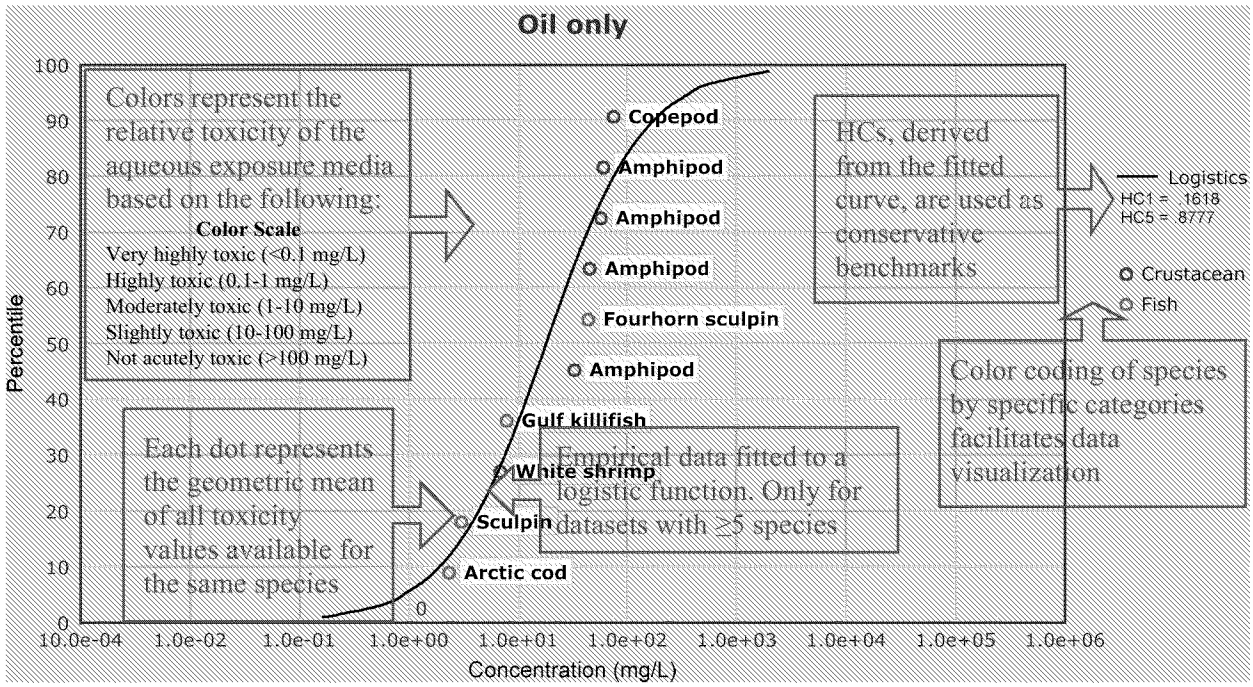

Figure 3. Example of a SSD generated following data queries, where dots represent the empirical data. Hazard Concentrations, HC1 and HC5, represent the benchmark concentrations assumed to be protective of 99% and 95%, respectively, of the species in the SSD.

Table 2. Strengths and limitation of DTox (Version 1) based on feedback provided by end-users.

Strengths
Easy to use (e.g., check boxes, tabs) and intuitive design
Clear display of data in separate tabs according to attributes
Total count of records (in parentheses) are informative
Helpful "Clear Page" and "Clear All" button on each tab
Warning appears when there are not enough data
Single and double plots are informative and well designed
The summary query tab is helpful, particularly when many data selections are made
Both plots and raw data used in plots are easily exported
Well documented tool (complete QA/QC and Instructions documents)
Limitations
Too many selection options
Applicability and life stage are not a shading options
Only common names are displayed. Scientific names should be an option
Names do not appear in double plots
Not enough information displayed on graph output section
Goodness of fit tests are not available (as pointed out by the authors)

4.2.1 DTox-Query Demonstration

In this section a series of queries are performed to demonstrate the usability of DTox (additional queries are presented in Section 4.3).

- Query 1a: Dispersant – Corexit 9500 and Corexit EC9500A; Oil – Prudhoe Bay and Alaska North Slope; Exposure conditions – Constant static, Flow through, Static renewal; Exposure duration – 96-hours; Endpoint metric– LC50, EC50; Concentration – Measured; Analyte – All options containing Total Hydrocarbon Content (THC); Applicability – Moderate, High.
- Query 1b: Identical as Query 1a, but without dispersant selection.
- Query 1c: Identical as Query 1a, but changing Exposure conditions to – Spiked, Spiked-flow-through.

As shown in Figure 4 (Top), the concentration assumed to be protective of 95% of the species in the SSD (HC5) is 0.1 milligrams of total hydrocarbons per liter (mg THC/L) in aqueous exposures to Prudhoe Bay and Alaska North Slope oils that were chemically dispersed with Corexit 9500 and Corexit EC9500A. By comparison, aqueous exposures to the same physically dispersed oils (without dispersants) (Figure 4, Middle) produce an HC5 of 0.3 mg THC/L. While the estimated HC5 values from aqueous exposures to chemically dispersed oil are smaller than those from physically dispersed oil, these two curves are likely not different from each other. These results are consistent with previous conclusions (NRC, 1989, 2005) indicating that there is no strong scientific evidence that the toxicity of chemically dispersed oil is substantially greater than that of physically dispersed oil. Note that Figure 4 (Middle) displays several amphipod species. A tab within DTox (not shown) allows the end-user to determine which amphipod species (scientific name) are included. In this case, *Anonyx nugax*, *Boeckosimus edwardsi*, *Gammarus setosus* and *Onisimus littoralis*.

Data in DTox are also queried to compare the impact of exposure conditions (static-Query1a vs. spiked-Query1b) on toxicity values. As shown in Figure 4 (Bottom), the concentration assumed to be protective of 95% of the species in the SSD (HC5) is 1.66 mg THC/L for spiked exposures, which is an order of magnitude larger (less toxic) than the HC5 value from constant exposures (0.1 mg THC/L). As a result, assessments based on toxicity data from tests performed under constant static exposures may overestimate toxicity, when compared to assessments based on spiked exposures. The latter type of laboratory settings represents more realistic field environmental exposures because these address the dilution that occurs in open waters by reproducing under laboratory conditions rapid changes in concentrations in the water column (Aurand and Coelho, 2005; Clark et al., 2001; George-Ares et al., 1999; NRC, 1989, 2005; Singer et al., 1995).

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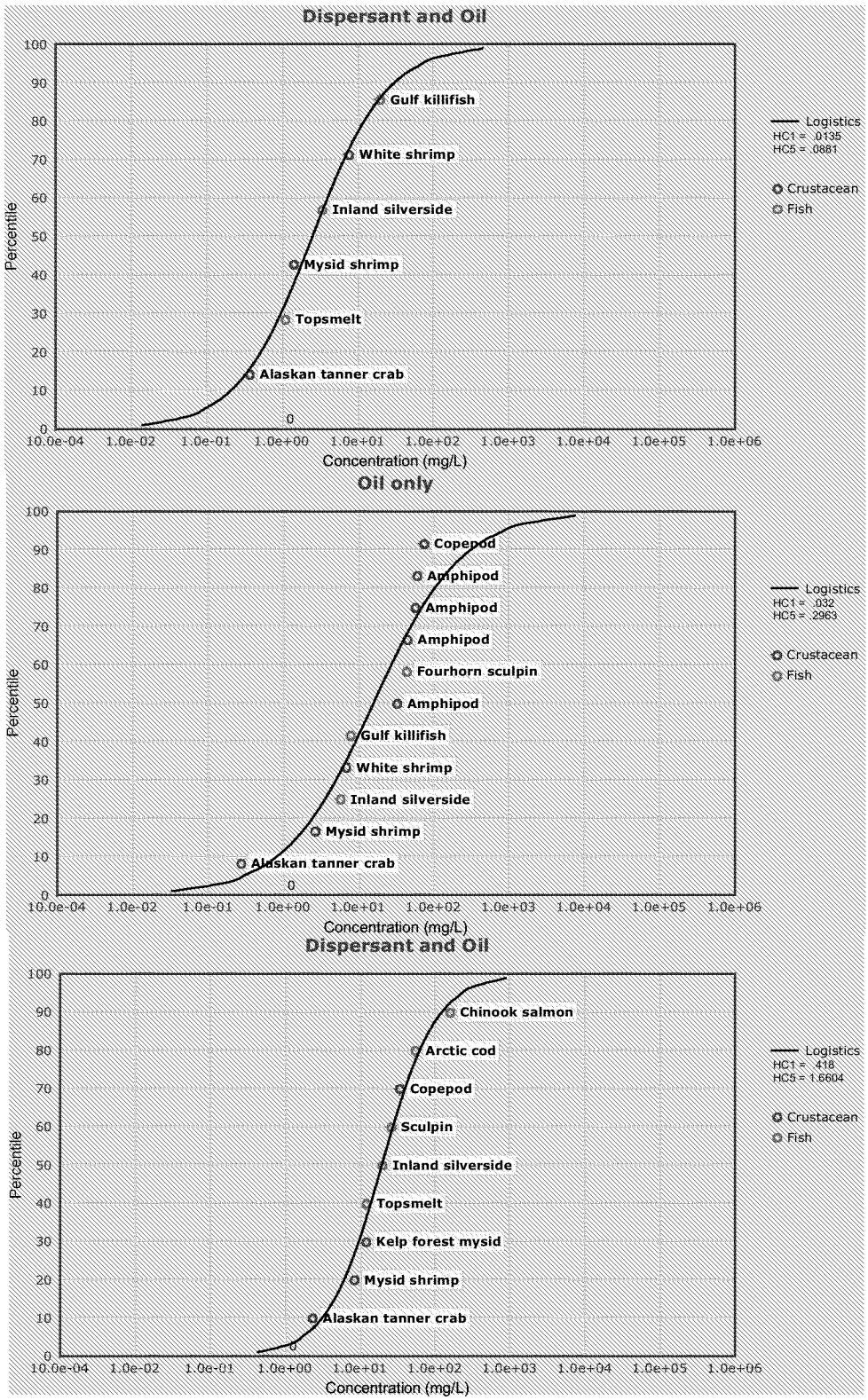

Figure 4. Example of a SSD generated following data queries in DTox. Dots represent the available empirical data. Hazard concentrations, HC1 and HC5, represent the benchmark concentrations assumed to be protective of 99% and 95%, respectively, of the species in the SSD. Top: Query 1a; Middle Query 1b; Bottom: Query 1c. See text for details.

4.3 DTox Applicability to Oil Spill Response and Planning

A database is only useful for storing information if people can correctly and efficiently query, update, and manipulate existing data to inform decisions or to perform assessments. Consequently, critical steps in assessing the effectiveness and usefulness of DTox dealt with its transferability to drills, or real oil spill situations, as well as its ability to provide information that can help inform decisions based on the current state of knowledge. To assess the applicability and transferability of this tool in spill response, two scenarios with different biological and oceanographic conditions are used to test the usefulness of DTox. The location and oil spill volume associated with each of these scenarios was provided by NOAA/ERD, and were based on either planned or past oil spill drills. Testing the applicability and transferability of DTox consists of performing data queries and selecting the appropriate receptor species with associated toxicological data, or user-specified query criteria, from which levels of concern for representative groups of species in these two areas are derived.

Steps involved in assessing the suitability of this database include:

1. Describing a spill scenario, including the location of the spill;
2. Determining the species/groups of species at risk, or species of concern;
3. Selecting the appropriate environmental and search criteria;
4. Conducting data query/queries considering Steps 1-3;
5. Deriving potential levels of concern or risk estimates; and
6. Describing data gaps and sources of uncertainty.

Note: The drills below are for demonstration purposes only and should not be taken out of context. Results and conclusions should not be used beyond the scope of this exercise, which is intended to demonstrate the applicability of DTox in oil spill response and planning.

4.3.1 Drill 1: Bay of Fundy, Maine

Spill scenario (Drill). "At 1200 ADT on Tuesday, June 18, 2013, the tank vessel *M/T NERITINA*, with a full cargo of 1,092,000 barrels (bbl) of Kuwait crude oil is transiting inbound in the Bay of Fundy collided with a cargo vessel. This collision resulted in spill of 35,000 bbl (~4,775 tonnes/1.47 million US gallons) of crude from the *M/T NERITINA*, with a potential secondary release of 50,000 bbl." This scenario is identical to the Canadian/U.S. Joint Response Team full scale exercise for the Atlantic Region (CANUSLANT) (June 17-20, 2013).

Resources at Risk. The islands of coastal Maine support a high diversity and abundance of marine life including birds and marine mammals. Nearshore areas also support productive commercial fisheries for fish and invertebrate species. Because of the ecological importance of nearshore waters to numerous marine species, the use of dispersants is not taken lightly as there are several federally threatened and endangered species (protected under the Endangered Species Act), as well as species of special concern, and species of local significance. A summary of these biological resources of concern is summarized in Table 3.

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Table 3. Biological resources at risk from a release of oil from the *M/T NERITINA*, with focus on nearshore/offshore waters. U.S. Status: FT = Federal threatened; FE = Federal endangered; ST = State threatened; SE = State endangered, SC= State species of special concern. Canada Status: CA-FE = federal endangered; CA-FSC: federal species of special concern.

Species Group	Species Subgroup (Status)	Seasonal Presence	Comments
Birds	Arctic terns (ST)	Nests May-Jun	
	Atlantic puffin (ST)	Nests Apr-Aug	
	Double-crested cormorant	Nests Apr-Jul	
	Harlequin ducks (ST)	Wintering Oct-Mar	
	Leach's storm petrel (SC)		
	Least tern (FE, SE)	Nests May-Aug	
	Piping plover (FT; CA-FT; SE)	Nests May-Aug	
	Razorbill (ST)	Mar-Sep; nests May-Jun	
	Red knot	Migration Jun-Jul	
	Roseate tern	Nests May-Aug	
Marine mammals	Atlantic white-sided dolphin	Calve Jun-Jul	
	Fin whale (FE; CA-FSC)	Peak abundance Apr-Oct	Most frequently found in waters over the continental shelf
	Gray seals	Pup Dec-Feb	
	Harbor porpoise	Calve May-Jun	Found throughout the Bay of Fundy
	Harbor seals	Pup May-Jun	
	Harp seals	Jan-May	
	Humpback whale (FE; CA-FSC)	Moderate abundance Summer	Most frequently found in waters over the continental shelf
	Minke whale		
	North Atlantic right whale (FE, CA-FE)	Peak abundance May-Sep	Found in shallow nearshore waters
	Sei whale (FE, CA-FE)	Peak abundance May-Sep	Most frequently found in waters over the continental shelf
Fish	American plaice		
	Atlantic cod		
	Atlantic halibut		
	Atlantic herring		Offshore spawning areas
	Atlantic salmon (FE; CA-FE)	Apr-Nov	Coastal/inland Maine critical habitat for this species under ESA. Present in the outer Bay of Fundy
	Bluefin tuna	Migration July	
	Halibut		
	Winter and Witch flounder		
Invertebrates	American lobster	Inshore migration Summer	Species of local economic importance
	Northern shrimp	Spawn Nov-May	
	Rock crabs		
	Sea scallop		

One of the main resources of concern in the area is the American lobster (*Homarus americanus*), which is an iconic commercial species harvested since the 18th century. While most life stages of this species are associated with the substrate (benthic), three of the four stages of

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lobster larvae are found in the water column (pelagic) between late spring to early fall (May to October), where they are transported by surface water from offshore to coastal waters before settling to the bottom (MacKenzie and Moring, 1985). Recent work by Incze (2010) reported, based on a spatially explicit population model, that larvae stages I-III are generally found in the top 15 meters (m) of the water column concentrating in the coastal shelf (<50 m to 100 m isobaths), with vertical distribution varying depending on water column stratification. A related paper (Annis, 2005) also documented that post-larvae (stage IV) concentrate in the upper 2 m of the water column, spending the large majority of their time near the surface (0-0.5 m) closer to shore. Consequently, an oil spill of large magnitude coinciding with peak distributions of larvae in the top few meters of the water column may have impacts on a fraction of the lobster population. While there are reasonable concerns regarding the potential impact of oil to early life stages of lobster, only a small number of studies (Capuzzo et al., 1984; Wells, 1972; Wells and Sprague, 1976) have documented their sensitivity to physically dispersed oil.

Modeled Expected Environmental Concentrations. For the purpose of this exercise, two scenarios for this ***drill*** are run to characterized potential oil concentrations associated with this release using the General NOAA Operational Modeling Environment (GNOME) (Beegle-Krause, 2001; NOAA/ERD, 2013): 1) a scenario allowing the released oil to disperse physically without the use of dispersants; and 2) a scenario treating the released oil with dispersants, under the assumption that 50% of the oil is effectively dispersed. Note that this is an ***extreme*** case of dispersant effectiveness, and is intended here to provide a worst-case exposure condition of aquatic organisms to chemically dispersed oil. While dispersant effectiveness under field conditions is highly variable, dispersant effectiveness has been reported to vary between 5% and 30% (NRC, 2005). The hypothetical spill of Kuwait oil is assumed to take place offshore in an area between the 60 and 200 m isobaths.

GNOME was run under the following environmental conditions.

- Light to Medium crude (API 34)
- Environmental conditions:
    - Wind: variable, range 2 to 12 knots from various directions
    - Mixed layer: 10 m depth
    - Breaking wave height: variable, range 0.009 to 0.33 m
    - Contour depth: 0 to 5 m

GNOME modeled oil trajectories (Figures 5 and 6) showed that physically dispersed oil would impact coastal shorelines north east of Blacks Harbour within 48 hours post release, with large quantities of oil entering the western section of Bay of Fundy 48 to 96 hours post release. At 96 hours post release, oil would reach south eastern sections of the Bay (e.g., Roosevelt Campobello International Park, Clark Gregory Nature Preserve). By comparison, modeled trajectories of the oil chemically treated with dispersants showed generally the same trends, except that the extent of shoreline oiling would be substantially lower. However, larger amounts of oil are entrained in the top few meters of the water column. Under the chemically dispersed scenario, peak oil concentrations in the water column would be localized north of Grand Manan Island.

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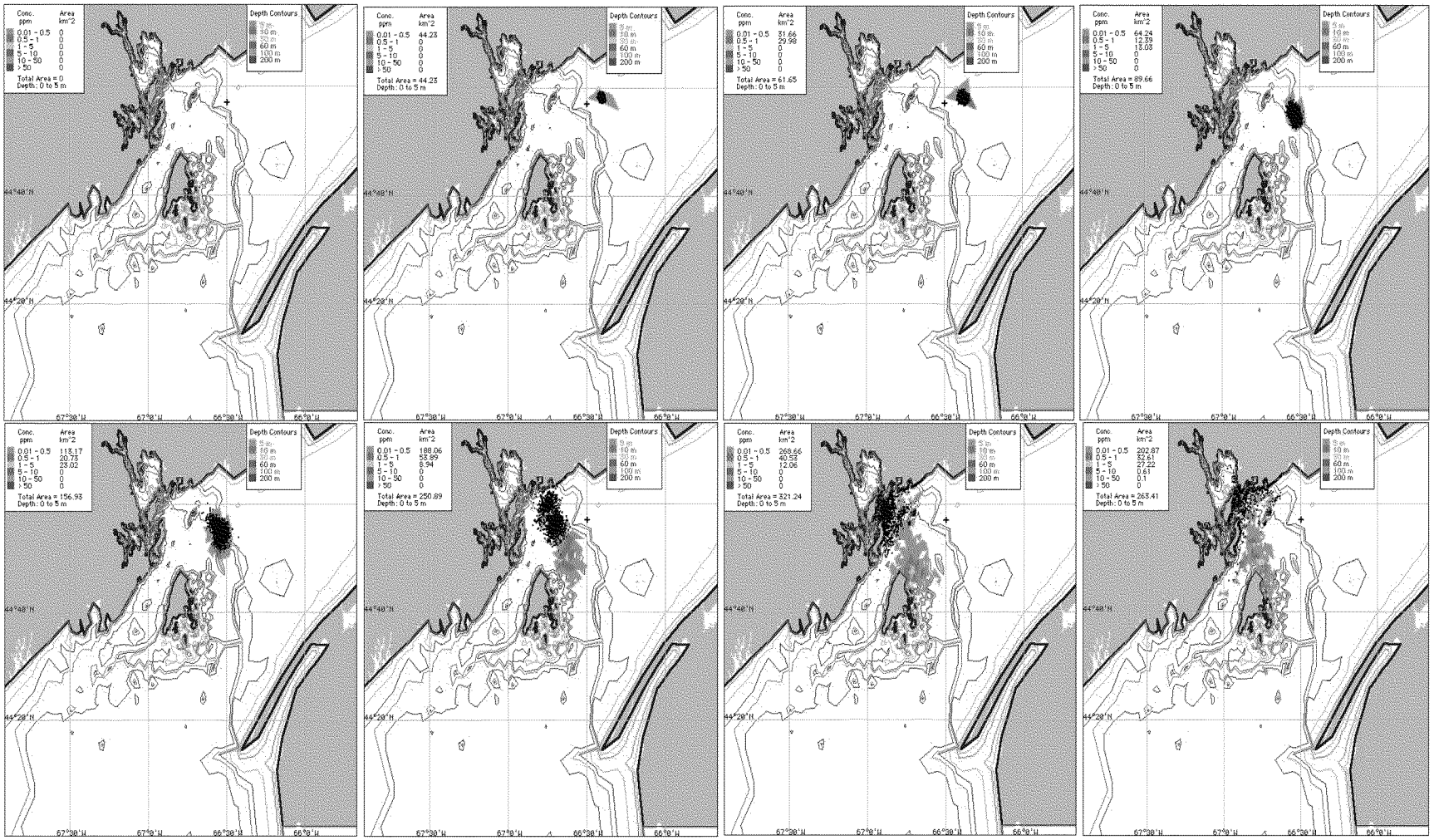

Figure 5. Spill trajectory snap shots of a physically dispersed plume of Kuwait crude oil (1.47 million gal) released into Bay of Fundy by the tank vessel *M/T NERITINA* ***(drill)***. Top and bottom, and left to right, represent GNOME model outputs 0, 3, 6, 12, 24, 48, 72, and 96 hours post release. Colors represent modeled oil concentrations in the top 5 m of the water column. Data provided by A. Mearns, NOAA ERD.

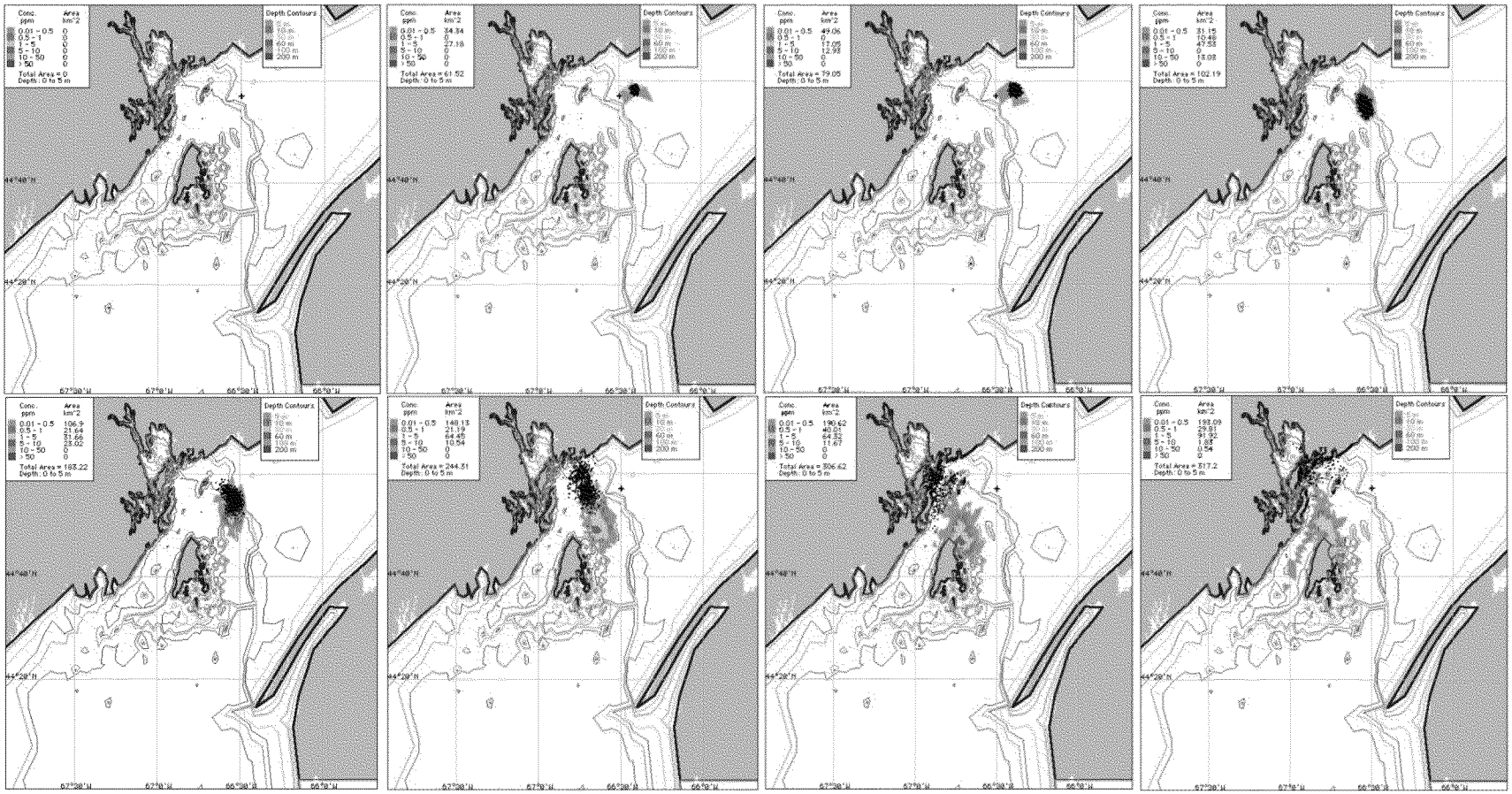

Figure 6. Spill trajectory snap shots of a chemically dispersed plume of Kuwait crude oil (1.47 million gal) released into Bay of Fundy by the tank vessel *M/T NERITINA* ***(drill)***. Top and bottom, and left to right, represent GNOME model outputs 0, 3, 6, 12, 24, 48, 72, and 96 hours post release. Colors represent modeled oil concentrations in the top 5 m of the water column. Data provided by A. Mearns, NOAA ERD.

Oil budgets for the two scenarios of this ***drill*** (Figures 7) indicated that physically dispersed oil would remain in large quantities floating on the water surface during the first 24 hours post release (48% of the oil released), following by large quantities of oil stranding on shoreline habitats (up to 25% of the oil released) between 48 and 96 hours post release. Under this scenario, 37% of the oil would evaporate, and up to 30% would be physically dispersed into the water column. By comparison, a relatively small amount of the released oil (4%) would be present on the water surface following chemical treatment of oil slicks. Under this scenario, a large proportion of the released oil (60%) would disperse into the water column (mostly into the top 10 m of the water column) within the 24 hours post release, but a relatively small proportion (13%) would impact coastal shorelines. Under this scenario, 19% of the oil would dissipate via evaporation.

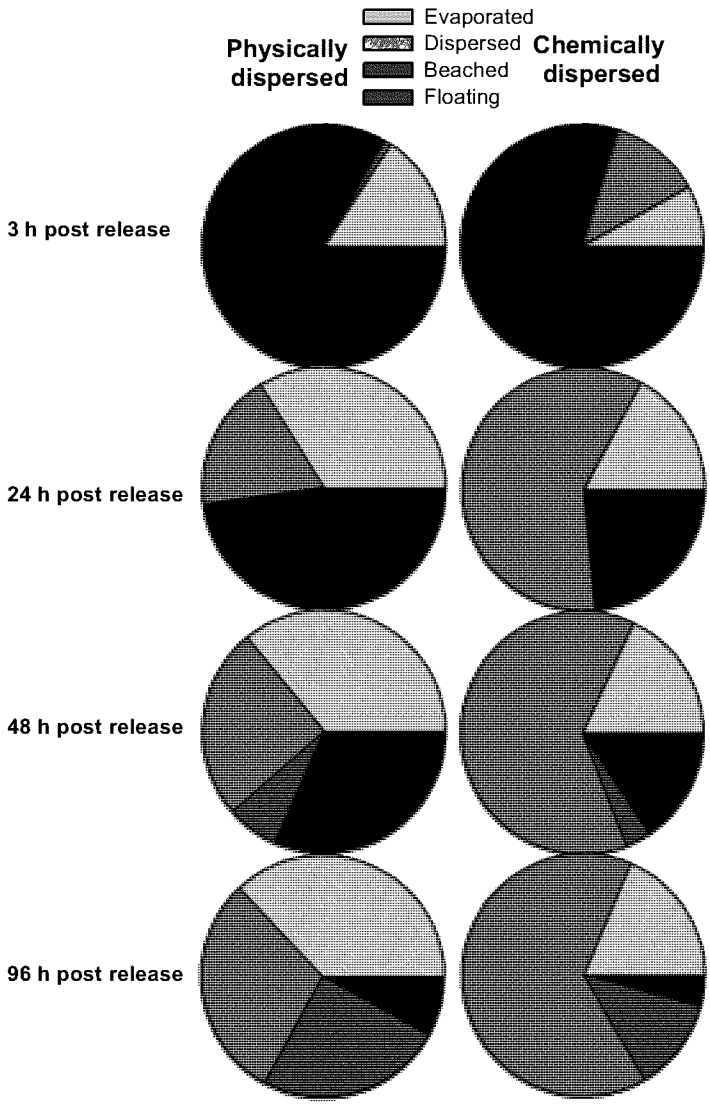

Figure 7. Oil budgets comparison as a function of time between the physically and chemically dispersed scenarios from a release of Kuwait crude oil (1.47 million gal) into Bay of Fundy by the tank vessel *M/T NERITINA* ***(drill)***. Note that the chemically dispersed scenario assumes an extremely high dispersant effectiveness (50%), which is intended here to provide a worst-case exposure condition to aquatic organisms. Data from GNOME provided by A. Mearns, NOAA ERD.

Two summary statistics are obtained from GNOME to characterize oil concentrations for this ***drill***. These are the average and maximum (worst-case) concentrations in the top 5 m of the water column for each 30 min interval over the entire model run period (0 to 96 hours). Average and maximum (worst-case) modeled oil concentrations in the water column (covered in detail in a later section) under the physically dispersed scenario are generally low (Figure 8) (Average: mean 0.29 mg/L, median, 0.30 mg/L, maximum 0.43 mg/L; Maximum (worst-case): mean 1.29 mg/L, median, 1.54 mg/L, maximum 2.19 mg/L). By comparison, the average and maximum modeled oil concentrations in the water column under the chemically dispersed scenario are in the 1.5- 3 mg/L range, with some exceptions (Average: mean 0.79 mg/L, median, 0.89 mg/L, maximum 1.97 mg/L; Maximum: mean 2.39 mg/L, median, 2.56 mg/L, maximum 3.62 mg/L).

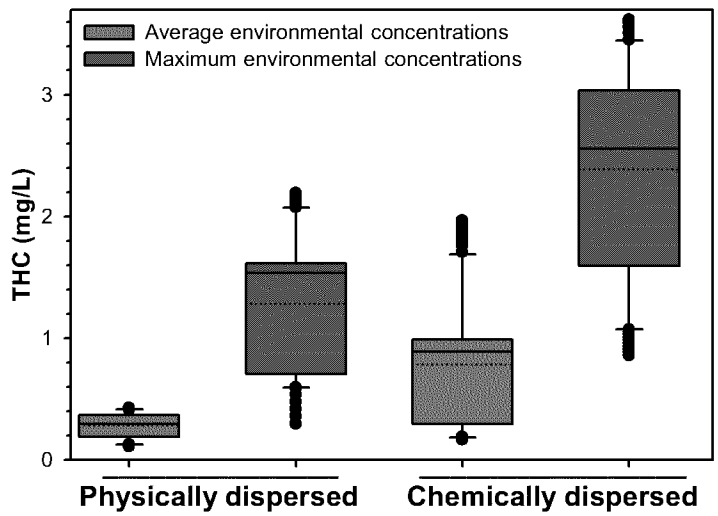

Figure 8. General box-plot overview of the expected oil concentrations of physically and chemically dispersed scenarios from a release of Kuwait crude oil (1.47 million gal) into Bay of Fundy by the tank vessel *M/T NERITINA (**drill**)*. Data from GNOME. Note that the chemically dispersed scenario assumes an ***extremely high*** dispersant effectiveness (50%), and intended here to provide a worst-case exposure condition to aquatic organisms. Oil concentrations are the average and maximum concentrations in the top 5 m of the water column for each 30 min interval over the entire model run period (0 to 96 hours). The length of the box represents the distance between the 25th and the 75th percentile concentrations, while the whiskers represent the 5th and 95th percentile concentrations. The solid and dashed horizontal lines in the box represents the median and mean respectively. The closed circles indicate outliers.

Estimated Environmental Concentrations of Concern. A query was performed in DTox to facilitate the understanding of the potential impact of physically and chemically dispersed oil on lobster larvae. To ensure reproducibility of the analyses presented here, a complete list of relevant fields queried and selected in DTox is provided below (Figure 9):

- Query #1: Life stage – embryos, larvae, juvenile; Habitat – water column; Taxonomic group – fish and crustaceans; Dispersant/Oil Treatment – Oil only, and Dispersant and Oil; Exposure duration – 96-hours (*assumed to be a worst case exposure*); Exposure conditions – Spiked, Spiked-flow-through; Endpoint metric – LC50, EC50; Effects

concentration analyte – All options containing Total Hydrocarbon Content (THC); Concentration –Measured; Paper Applicability– Moderate, High

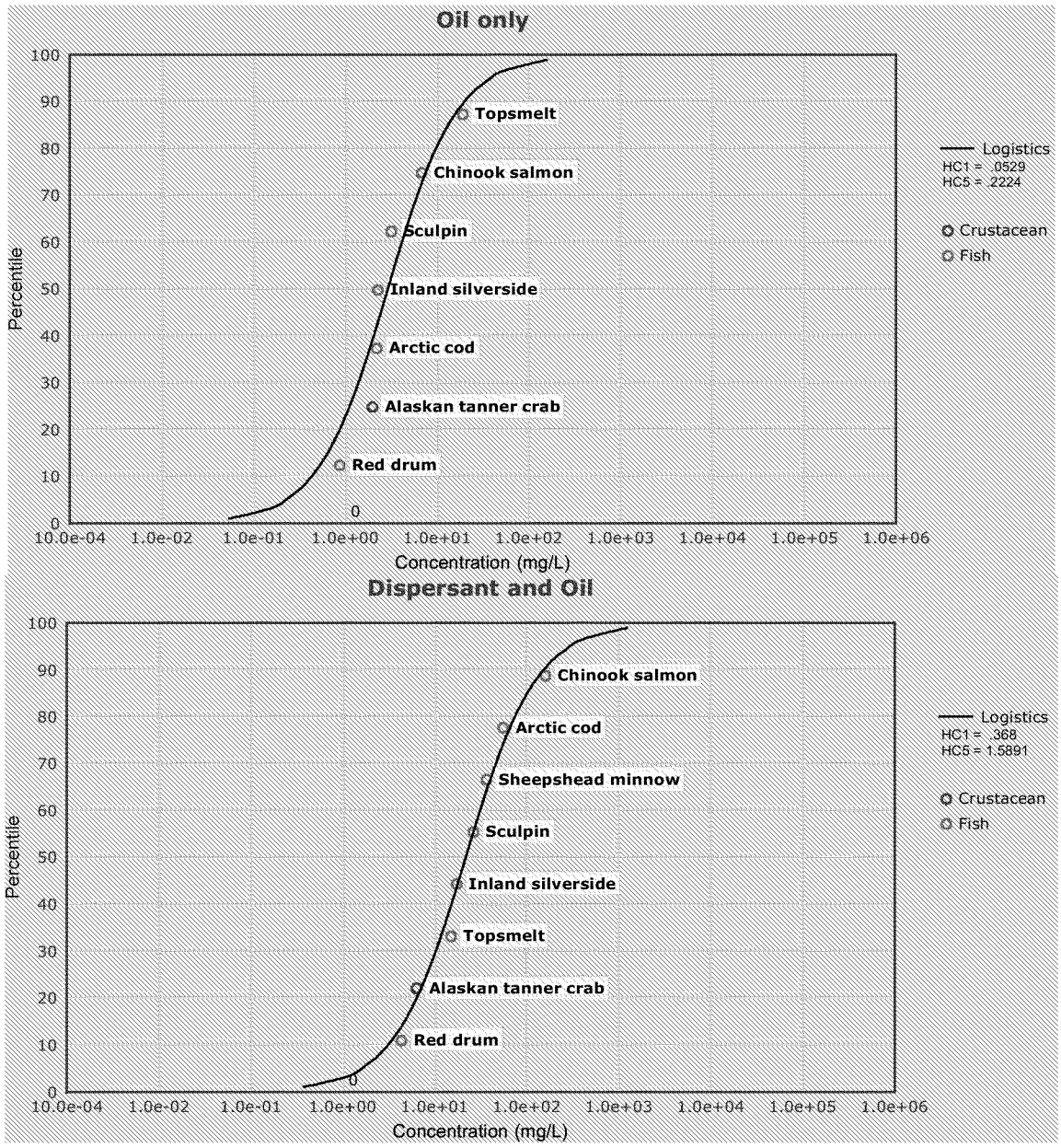

Figure 9. SSD generated following a data query in DTox for the ***drill*** in Bay of Fundy involving the tank vessel *M/T NERITINA*.

For the purpose of this ***drill***, the SSD with the most conservative 5 percentile hazard concentration (HC5=0.22 mg/L) (Figure 9, top) is used in further interpretations. Note that the only toxicity data available for larvae of the American lobster are from Wells and Sprague (1976) who reported a 96-h LC50 (based on measured reported concentrations) of 0.86 mg/L to first-stage larvae. HC values of the most conservative plot are also protective of first-stage larvae.

Potential Environmental Impacts. Average and maximum (worst-case) oil concentrations for the physically dispersed ***drill*** scenario overlap 5% and 40%, respectively, of the most conservative 96h-SSD (Figure 10). A different pattern is observed with the ***drill*** scenario involving chemical dispersion of the released oil. Average and maximum (worst-case) oil concentrations for the chemically dispersed scenario overlap 20% and 60%, respectively, of the most conservative 96h-SSD. Under the chemical dispersion scenario, 60% and 97% of the average and maximum (worst-case) oil concentrations, respectively, exceeded the HC5. Exposures above the HC5 are limited to the first 60-70 hours post release for the average scenario, and >90 hours post spill for the maximum oil concentrations scenario. All of these exceedances are limited to the top 10 m of the water column, mostly within the top 2 m (data not shown).

While these comparisons are useful, without a spatial context these can lead to overestimation of risks. The areal extent of the water surface with modeled oil concentrations is also further analyzed for the chemically dispersed scenario. As shown in Figure 11, the areal extent of the concentration bracket exceeding the HC5 (0.5-1 mg/L, 1-5 mg/L and >5 mg/L) grew from 27.18 km^2 3 hours post release to 124 km^2 120 hours post release. By contrast, most of the areal extent of the impacted water surface had concentrations in the 0.01-0.5 mg/L range (range: 34 km^2 3 hours post release to 193 km^2 120 hours post release). As shown in this exercise, the area of potential impact is relatively small (0.07% of the Gulf of Maine/Bay of Fundy system, 180,000 km^2) and concentrated into an area 24 times the size of a standard football field. This information (and Figure 7) demonstrate that while there is an increased risk to water column organisms from dispersant use to mitigate the impacts of this particular ***drill*** (albeit concentrated into a relatively small area and to depths <10 m), the greatest environmental tradeoff is the reduced impact to shoreline habitats (physically vs. chemically dispersed oil on shorelines, 368,088 gal vs. 183,456 gal, respectively), and reduced amounts of floating oil (physically vs. chemically dispersed oil on water surface 117,306 gal vs. 60,270 gal, respectively) which can pose adverse risks to surface marine species (e.g., birds and marine mammals).

As mentioned before, one of the main resources of concern is the American lobster, which under this spill scenario may be exposed to potentially toxic oil concentrations in the top few meters of the water column. The extent of potential adverse lethal and sublethal effects to this species and its local population depends on both the encounter rate of oil at concentrations above those assume to cause adverse effects, and exposure duration to those oil concentrations. Under the assumption that larvae are evenly distributed in the top 10 m of the entire Bay of Fundy area, and assuming that the entire area with concentrations ≥0.01 mg/L (physically dispersed scenario1,188 km^2; chemically dispersed scenario 1,294 km^2) would overlap the distribution of larvae, an estimated 0.7% of the lobster larvae in the entire Bay of Fundy would encounter oil in the water column.

While potential toxicological consequences to water column organisms may be expected, these assessments are conservative as the benchmark used here is biased towards overprotection or marine species (i.e., based on 96-h exposure toxicity data). This degree of conservatism added to the fact that oil biodegradation is not taken into account suggests that oil concentrations would likely be lower than those predicted by the GNOME model.

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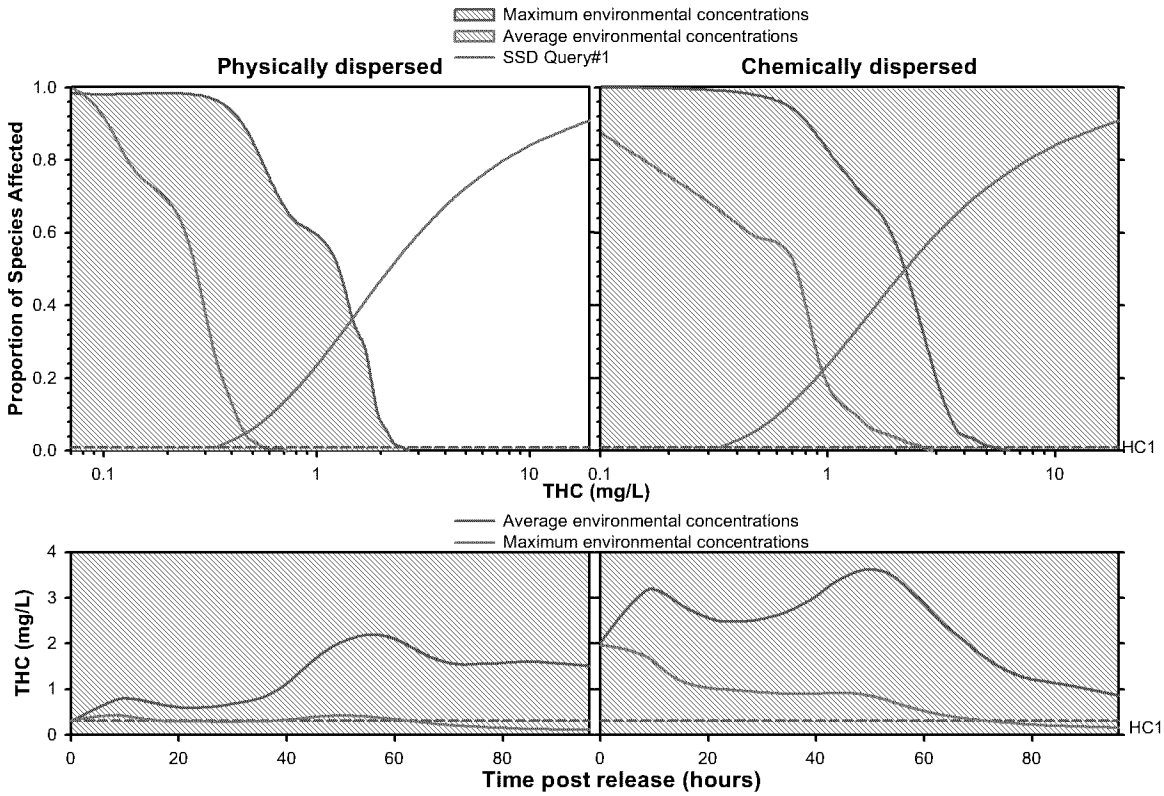

Figure 10. Cumulative average and maximum (worst-case) modeled oil concentrations relative to 96 h-SSDs (top), and average and maximum modeled oil concentrations as a function of time post release for a physically (left) and chemically dispersed (right) plume of a Kuwait crude oil into Bay of Fundy by the tank vessel M/T NERITINA (***drill***). As a reference, the benchmark for this drill is HC5=0.22 mg/L

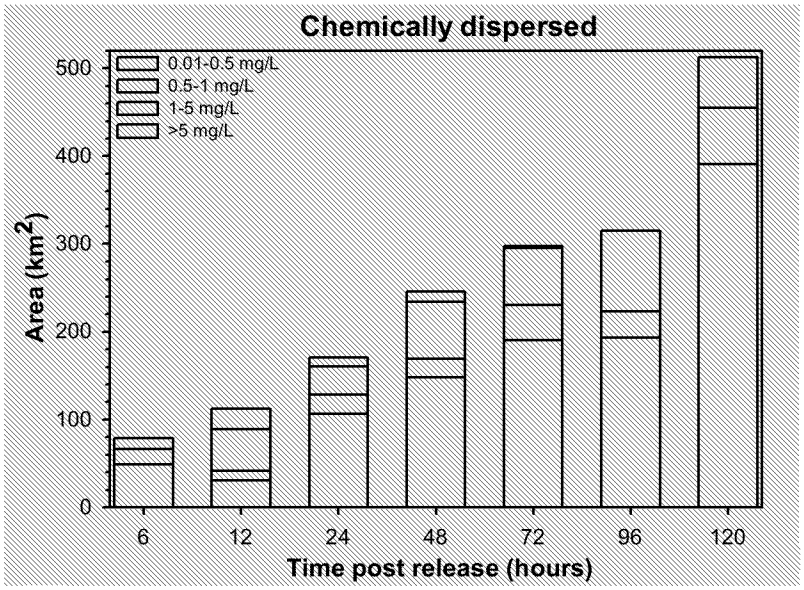

Figure 11. Water surface area impacted by a spill of Kuwait crude oil (1.47 million gal) into Bay of Fundy (***drill***), as a function of time post release (hours), and average oil concentrations. As a reference, the benchmark for this drill is HC5=0.22 mg/L.

4.3.2 Drill 2: Area offshore from Charleston Harbor, South Carolina

Spill scenario (Drill). On May 23, 2013 at 5:00 pm EDT a spill of 5,000 bbl (210,000 gal) of Qua Iboe Nigerian Crude is released offshore from Charleston Harbor, South Carolina. Qua Iboe Nigerian Crude (API 34) is a light to medium weight crude oil, which may coat intertidal habitats, as well as wildlife on the water surface. The oil may also result in water column and benthic impacts if mixed into the water column by waves, or if it strands in large amounts in shallow, sheltered areas with limited water exchange.

Resources at Risk. During spring and summer, shoreline habitats along the South Carolina coast support a high number of nesting seabirds, and beaches provide nesting habitat for several species of sea turtles. Marshes in the area provide important habitat for a variety of shorebirds, as well as terrestrial and aquatic mammals (mink, river otter, beaver, and raccoon). Nearshore and offshore areas also support productive commercial fisheries for fish and invertebrate species. Because of the ecological importance of nearshore waters to numerous marine species, the use of dispersants is not taken lightly as there are several federally threatened and endangered species (protected under the Endangered Species Act), as well as species of special concern, and species of local significance. These biological resources of concern are summarized in Table 4.

Table 4. Biological resources at risk from a release of oil off Charleston Harbor, South Carolina, with focus on nearshore/offshore waters. U.S. Status: FT = Federal threatened; FE = Federal endangered; ST = State threatened; SE = State endangered, SC= State species of special concern.

Species Group	Species Subgroup (Status)	Seasonal Presence	Comments
Birds	American oystercatchers		Largest wintering concentration on the east coast
	Bufflehead		Present in coastal and offshore areas
	Brown pelicans		Present in coastal and nearshore areas
	Cormorants		
	Great blue heron	Nesting peak May-Aug	
	Gull-billed terns and	Nesting peak Apr-Aug	
	Black skimmers	Nesting peak Apr-Aug	
	Least tern (FE; ST)		Present in marshes, and on tidal flats in the area
	Piping plover (FT; ST)		Most frequently found during winter
Reptiles	Green sea turtle (FE; SE)	Present year-round, peak Apr-Dec Nesting May-Aug Hatching July-Oct	Found in offshore waters
	Leatherback sea turtle (FE; SE)	Present year-round, peak Apr-Dec Nesting Mar-Jul Hatching May-Oct	Present in nearshore and offshore waters
	Loggerhead sea turtle (FT; ST)	Present year-round, peak Apr-Dec	Present in nearshore and offshore waters

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Species Group	Species Subgroup (Status)	Seasonal Presence	Comments
		Nesting Jun-Nov Hatching Jul-Dec	
Marine mammals	Bottlenose dolphin	Present year-round, Breeds year-round	Found in shallow nearshore waters and offshore waters
	Mink whale		Most frequently found in waters over the continental shelf. Occasionally present
	Humpback whale (FE; SE)		Most frequently found in waters over the continental shelf. Occasionally present
	North Atlantic right whale (FE)	Calving Nov-Mar	Found in shallow nearshore waters
Fish	Atlantic croaker	Larvae and juveniles may be present	Most frequently found in tidal creeks
	Atlantic menhaden	Eggs/larvae/post-larvae may be present	Adults most frequently found in offshore waters throughout the water column
	Red drum	Larvae and juveniles may be present	Adults most frequently found in coastal waters
	Red snapper	Eggs/larvae Jun-Oct Juveniles may be present	
	Shortnose sturgeon (FE)		Found in coastal rivers
	Spanish mackerel		Most frequently found in coastal and offshore waters
	Summer flounder	Larvae and juveniles may be present	Adults most frequently found in coastal waters
	Southern flounder	Larvae and juveniles may be present	Adults most frequently found in coastal waters
	Spot	Larvae and juveniles may be present	Adults most frequently found in coastal waters
Invertebrates	American oysters		Spawn in tidal creeks and on sheltered tidal flats
	Blue crab	Larvae and juveniles may be present	Found in offshore waters
	Brown shrimp	Eggs/larvae may be present Spawning Jan-Dec	Found in offshore waters
	Pink shrimp		Found in offshore waters. Not very common.
	Spiny lobster		Found in offshore waters
	Stone crab	Spawning Mar-Oct, peak May-Aug Larvae and juveniles may be present	Adult oyster, including females incubating eggs, found on bars and mud flats
	White shrimp	Spawning May-Jun	Found in offshore waters
		Larvae/juveniles may be present	

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While the area off South Carolina harbors a high diversity of aquatic species, their exposure to physically and chemically dispersed oil depends on their spatial distribution and on their habitat distribution within the water column. Consequently, the primary resources of concern are those commonly found offshore at the water surface or in the upper few meters of the water column. Specific examples include adults and early life stages of commercially important free-swimming shellfish (brown shrimp, white shrimp, and blue crab), and fishery resources that spawn in the water column (e.g., Atlantic menhaden).

Modeled Expected Environmental Concentrations. For the purpose of this exercise, two scenarios for this ***drill*** are run to characterize potential oil concentrations associated with this release using GNOME) (Beegle-Krause, 2001; NOAA/ERD, 2013): 1) a scenario allowing the released oil to disperse physically without the use of dispersants; and 2) a scenario treating the released oil with dispersants, under the assumption that 80% of the oil is effectively dispersed. Note that this is an ***extremely high*** case of dispersant effectiveness, and is intended here to provide a worst-case exposure condition of aquatic organisms to chemically dispersed oil. While dispersant effectiveness under field conditions is highly variable, dispersant effectiveness has been reported to vary between 5% and 30% (NRC, 2005).

GNOME was run under the following environmental conditions.

- Light to Medium crude (API 34)
- Environmental conditions:
  - Wind: 15 knots from the South
  - Mixed layer: 5 m depth
  - Breaking Wave Height: 1 m
  - Contour depth: 0 to 5 m

GNOME modeled oil trajectories (Figures 12 and 13) showed that physically dispersed oil would impact coastal shorelines north east of the harbor (e.g., Sullivan's Island and Isle of Palms) within 24 hours post release, with large quantities of oil entering Charleston Harbor between 24 and 48 hours post release. Coastal habitats south west of the harbor (e.g., Morris Island and Folly Beach) would be oiled >24 hours post release. By comparison, modeled trajectories of the oil that is chemically treated with dispersants showed generally the same trends, except that the extent of shoreline oiling would be substantially lower. However, larger amounts of oil are entrained in the top few minutes of the water column.

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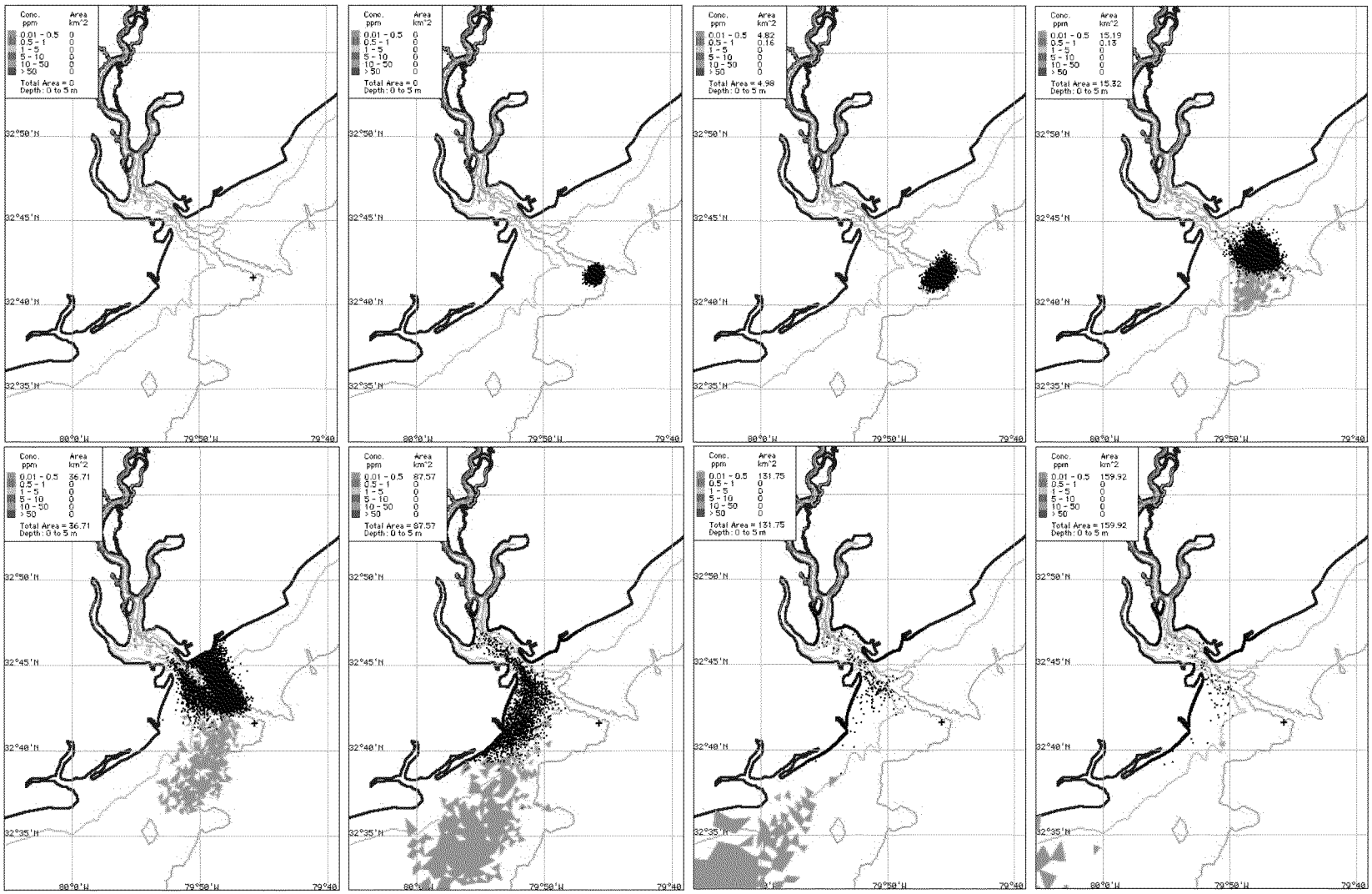

Figure 12. Spill trajectory snap shots of a physically dispersed plume of Qua Iboe Nigerian crude oil (210,000 gal) (***drill***) released offshore from Charleston Harbor. Top and bottom, and left to right, represent GNOME model outputs 0, 3, 6, 12, 24, 48, 72, and 96 hours post release. Colors represent modeled oil concentrations in the top 5 m of the water column. Data provided by A. Mearns, NOAA ERD.

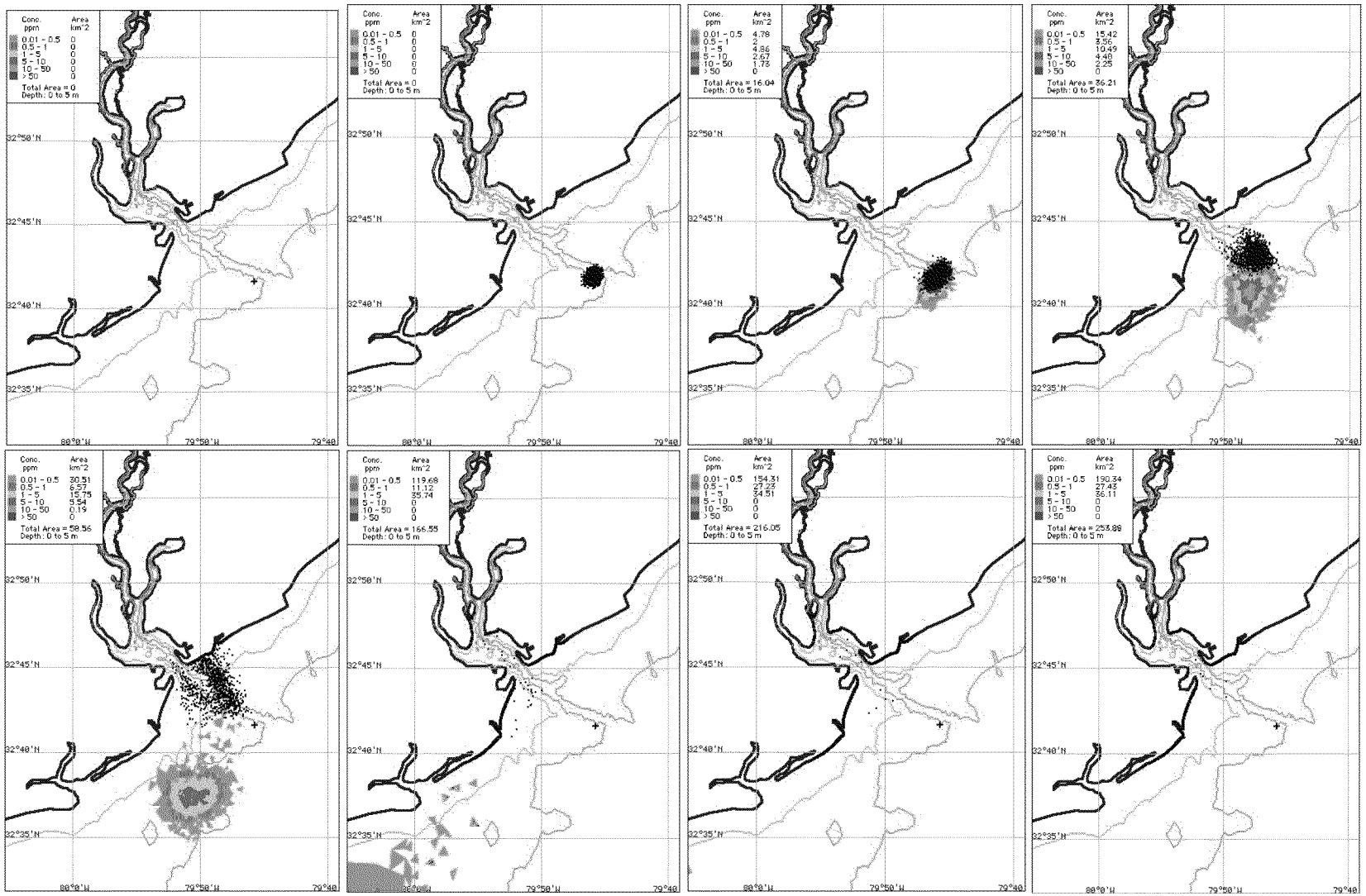

Figure 13. Spill trajectory snap shots of a chemically dispersed plume of Qua Iboe Nigerian crude oil (210,000 gal) (***drill***) released offshore from Charleston Harbor, assuming an extremely high dispersant effectiveness (80%). Top and bottom, and left to right plots represent GNOME model outputs 0, 3, 6, 12, 24, 48, 72, and 96 hours post release. Colors represent modeled oil concentrations in the top 5 m of the water column. Data provided by A. Mearns, NOAA ERD.

Oil budgets for the two scenarios of this ***drill*** (Figure 14) indicated that physically dispersed oil would remain in large quantities floating on the water surface during the first 24 hours post release (>50% of the oil released), following by large quantities of oil stranding on shoreline habitats (>30% of the oil released) between 48 and 96 hours post release. Under this scenario, 35% of the oil would evaporate, and <5% would be physically dispersed into the water column. By comparison, a relatively small amount of the released oil (14%) would be present on the water surface following chemical treatment of oil slicks. Under this scenario, a large proportion of the released oil (65%) would disperse into the water column (mostly into the top 5 m of the water column) within the 24 hours post release, but a relatively small proportion (11%) would impact coastal shorelines. Under this scenario, 20% of the oil would dissipate via evaporation.

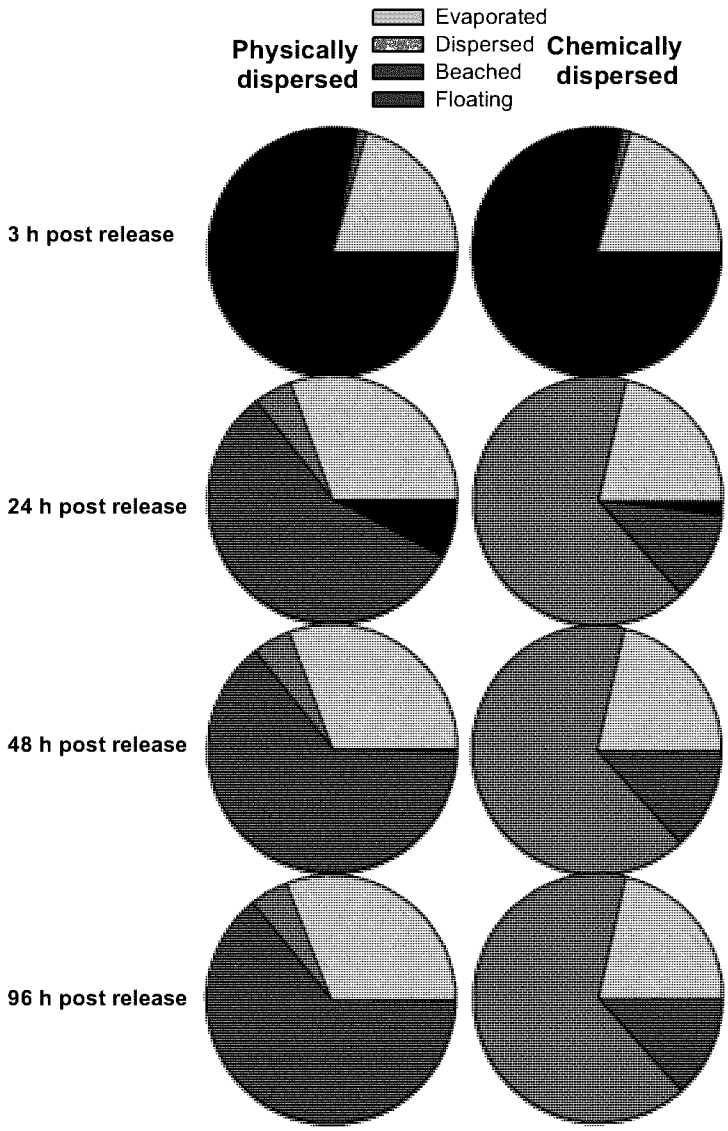

Figure 14. Oil budgets comparison as a function of time between the physically and chemically dispersed scenarios from a release of Qua Iboe Nigerian crude oil (210,000 gal) (***drill***) offshore from Charleston Harbor. Note that the chemically dispersed scenario assumes an extremely high dispersant effectiveness (80%)%), which is intended here to provide a worst-case exposure condition to aquatic organisms. Data from GNOME provided by A. Mearns, NOAA ERD.

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Two summary statistics are obtained from GNOME to characterize oil concentrations of hydrocarbon for this ***drill***. These are the average and maximum (worst-case) concentrations in the top 5 m of the water column from each 30 min interval over the entire model run period (0 to 96 hours). Average and maximum (worst-case) modeled oil concentrations in the water column (cover on detailed in a later section) under the physically dispersed scenario are generally low (Figure 15) (Average: mean 0.07 mg/L, median, 0.05 mg/L, maximum 0.28 mg/L; Maximum (worst-case): mean 0.374 mg/L, median, 0.27 mg/L, maximum 0.73 mg/L). By comparison, the average and maximum (worst-case) modeled oil concentrations in the water column under the chemically dispersed scenario are in the 1- 3 mg/L range, with some exceptions (Average: mean 0.96 mg/L, median, 0.63 mg/L, maximum 3.2 mg/L; Maximum (worst-case): mean 2.92 mg/L, median, 1.59 mg/L, maximum 13.15 mg/L).

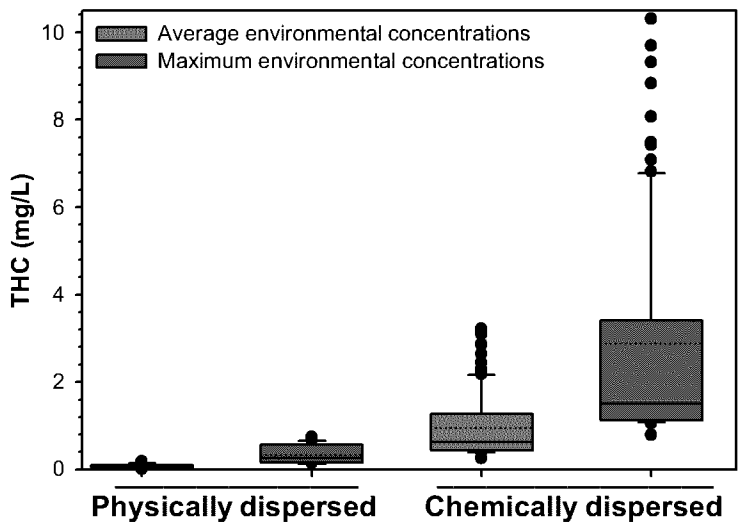

Figure 15. General box-plot overview of the expected oil concentrations physically and chemically dispersed scenarios from a release of Qua Iboe Nigerian crude oil (210,000 gal) (***drill***) offshore from Charleston Harbor. Note that the chemically dispersed scenario assumes an ***extremely high*** dispersant effectiveness (80%), and intended here to provide a worst-case exposure condition to aquatic organisms. Oil concentrations are the average and maximum concentrations in the top 5 m of the water column for each 30 min interval over the entire model run period (0 to 96 hours). The length of the box represents the distance between the 25th and the 75th percentile concentrations, while the whiskers represent the 5th and 95th percentile concentrations. The solid and dashed horizontal lines in the box represents the median and mean respectively. The closed circles indicate outliers.

Estimated Environmental Concentrations of Concern. Two queries are performed in DTox to facilitate the understanding of the potential impact of physically and chemically dispersed oil on species of interest off Charleston Harbor, South Carolina: selected species query, and shrimp query regardless of their global distribution. To ensure reproducibility of the analyses presented here, a complete list of relevant fields queried and selected in DTox is provided below (Figure 16):

- Query #1: Species – all shrimp-like species, plus sheepshead minnow, gulf killifish and longnose killifish (species of the genus, *Fundulus*), Inland silverside, and Red drum (25 species total); Exposure duration – 96-hours (*assumed to be a worst case exposure*); Endpoint metric – LC50; Oil name – All light and medium oils; Dispersant name – Corexit 9500, EC9500A, 9527, and EC9527A; Effects concentration analyte – all options containing Total Hydrocarbon Content (THC); Concentration – Measured; Paper Applicability – Moderate, High

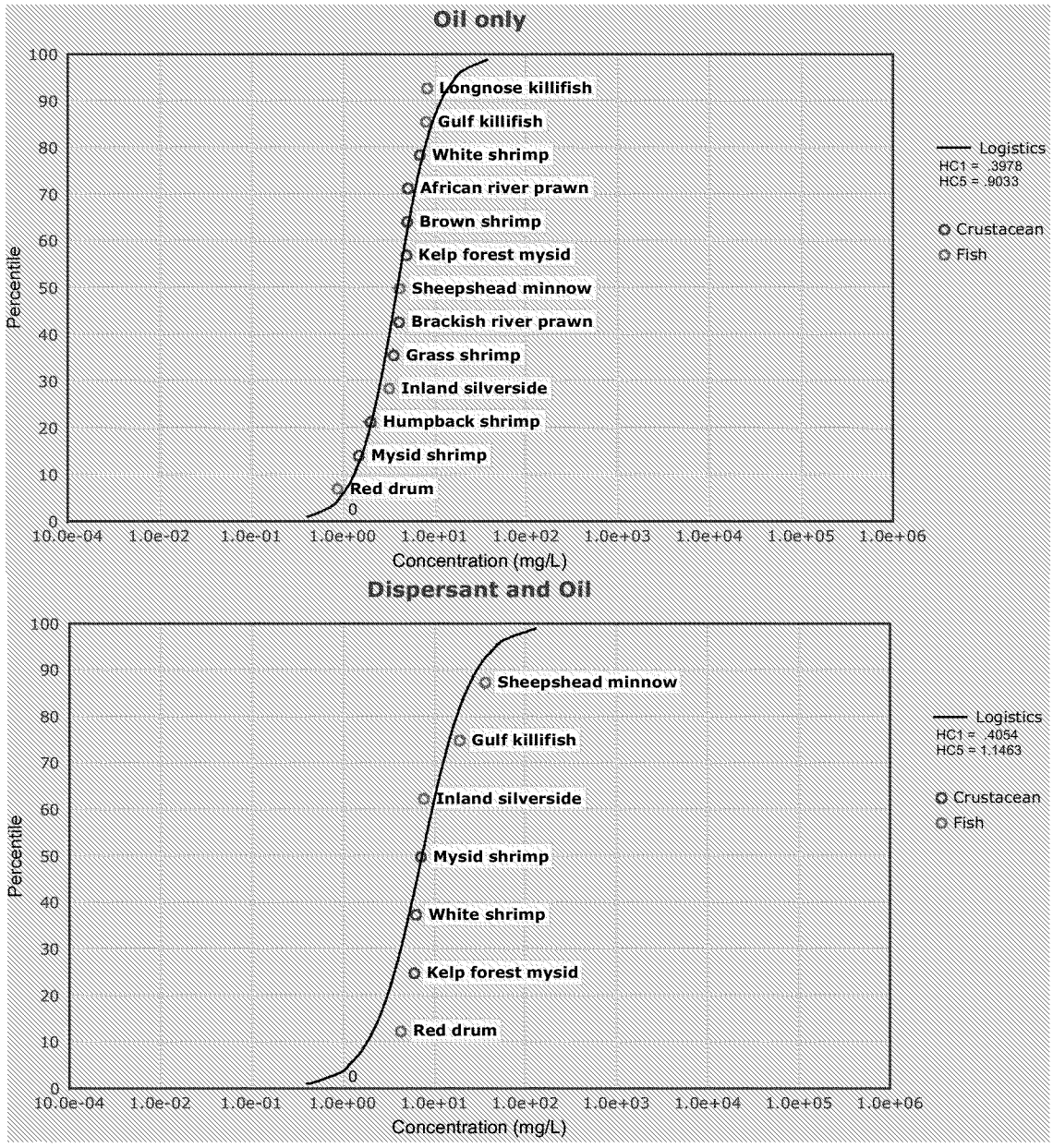

Figure 16. SSD generated following a data query in DTox for the ***drill*** off Charleston Harbor.

For the purpose of this ***drill***, the SSD with the most conservative hazard concentration (HC1=0.4 mg/L) (Figure 16, top) is used in further interpretations.

Potential Environmental Impacts. Average and maximum (worst case) oil concentrations for the physically dispersed ***drill*** scenario overlap 0% and 10%, respectively, of the most conservative 96h-SSD (Figure 17). A different pattern is observed with the ***drill*** scenario involving chemical dispersion of the released oil. Average and maximum (worst case) oil concentrations for the chemically dispersed scenario overlap 40% and 70%, respectively, of the most conservative 96h-SSD. Under the chemical dispersion scenario, 60% and 95% of the average and maximum (worst case) oil concentrations, respectively, exceeded the HC1. Exposures above the HC1 are limited to the first 40-50 hours post release for the average scenario, and >90 hours port spill for the maximum (worst case) oil concentrations scenario. All of these exceedances are limited to the top 5 m of the water columns (data not shown).

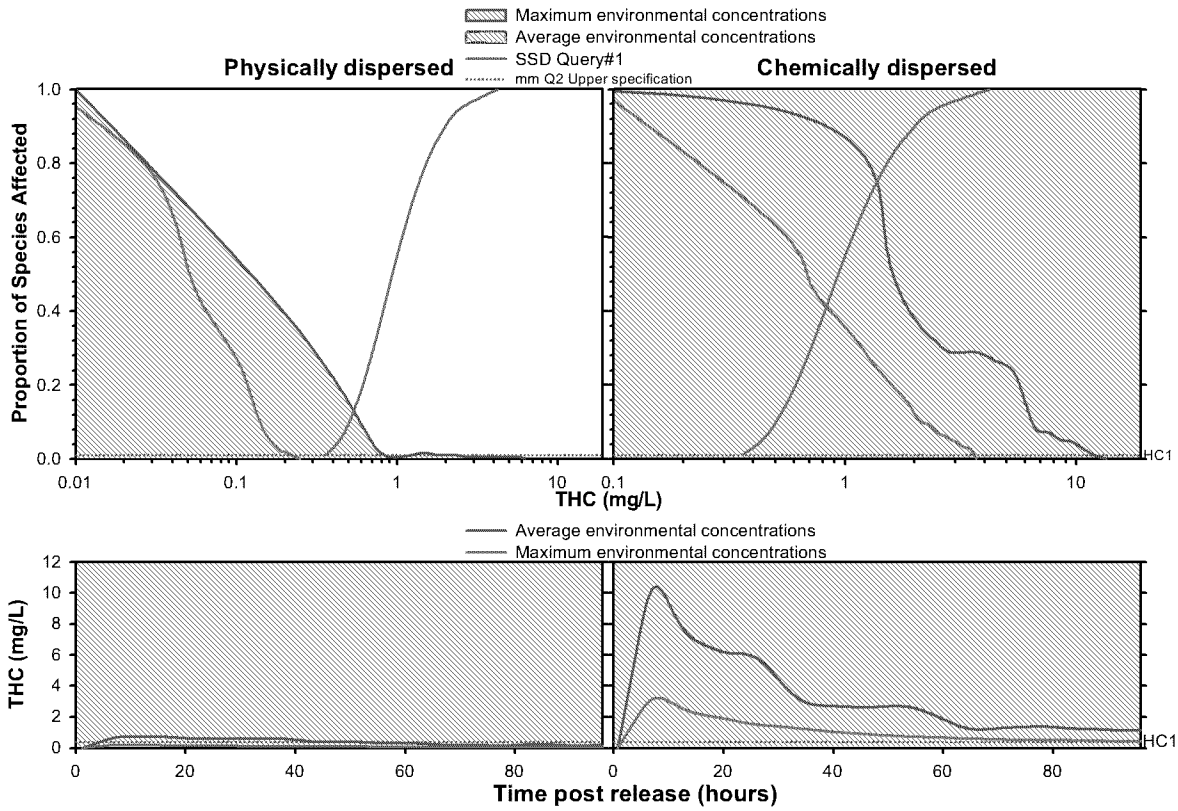

Figure 17. Cumulative average and maximum (worst-case) modeled oil concentrations relative to 96 h-SSDs (top), and average and maximum modeled oil concentrations as a function of time post release for a physically (left) and chemically dispersed (right) plume of a Qua Iboe Nigerian Crude spill off Charleston Harbor, SC (***drill***). As a reference, the benchmark for this drill is HC1=0.4 mg/L.

While these comparisons are useful, without a spatial context, these can lead to overestimation of risks. The areal extent of the water surface with modeled oil concentrations is also further analyzed for the chemically dispersed scenario. As shown in Figure 18, areal extent of the concentration bracket containing and exceeding the benchmarks (0.5-1 mg/L, 1-5 mg/L and >5 mg/L) grew from 11 km^2 6 hours post release to 63 km^2 120 hours post release. By contrast, most of the areal extent of the impacted water surface had concentrations in the 0.01-0.5

mg/L range (range: 5 km^2 6 hours post release to 190 km^2 120 hours post release). As shown in this exercise, the area of potential impact is relatively small and concentrated into an area 12 times the size of a standard football field. To put the information above into perspective (see also Figure 14) under the physical dispersion scenario, 85 km of coastal shoreline would be directly impacted, with maximum estimated oil stranded concentrations up to 47 gallons of oil per meter of shoreline (A. Mearns, pers. comm.). By comparison, under the chemical dispersion scenario, 64 km of coastal shoreline would be directly impacted, with maximum estimated oil stranded concentrations up to 10 gallons of oil per meter of shoreline. This information, and data presented in Figure 14, demonstrate that while there is an increased risk to water column organisms from dispersant use to mitigate the impacts of this particular spill (***drill***) (albeit concentrated into a relatively small area and to depths <5 m), the greatest environmental tradeoff is the reduced impact to shoreline habitats (both on extent and degree of oiling), and reduced amounts of floating oil which can pose adverse risks to surface marine species (e.g., birds and marine mammals).

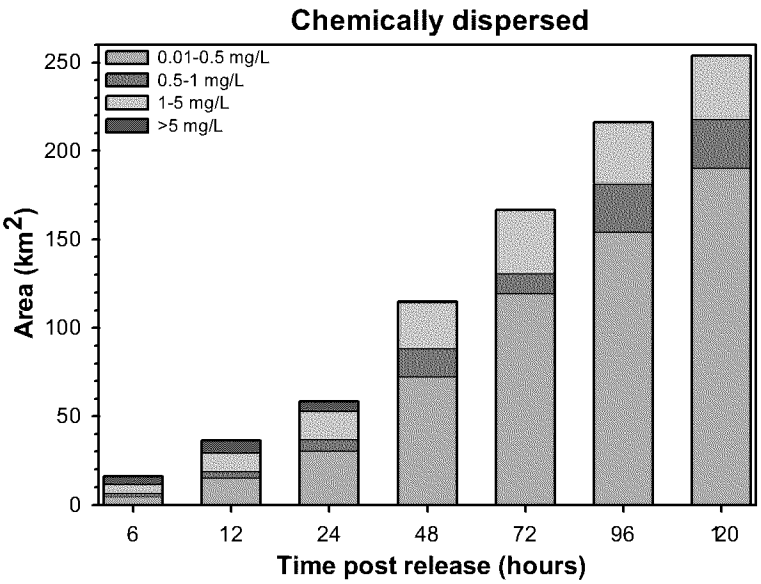

Figure 18. Water surface area impacted by a spill of Qua Iboe Nigerian Crude off Charleston Harbor, SC (***drill***), as a function of time post release (hours), and average oil concentrations. As a reference, the benchmark for this drill is HC1=0.4 mg/L.

While potential toxicological consequences may be expected from worst-case oil concentrations (e.g., maximum oil concentrations), these assessments are conservative as the benchmark used here is conservative and biased towards overprotection or marine species (i.e., based on 96 h exposure toxicity data). This degree of conservatism added to the fact that oil biodegradation is not taken into account suggests that oil concentrations would likely be lower than those predicted by the model.

5.0 Discussion and Importance to Oil Spill Response and Damage Assessment and Restoration

5.1 DTox - Data Compilation, Demonstration, and Application

The primary intent of the exercises presented in Section 4.3 is to demonstrate the applicability of DTox as a tool to aid assessment performed during an oil spill response (spills or drills), and not to support or discourage the use of dispersants as a countermeasure to respond to off shore oil spills. Important to note is the fact that both drill scenarios involved large releases of oil and high dispersant effectiveness, leading to exceedances of benchmark values. It is also important to note that a conservative approach is used, by deriving benchmark values derived from 96-h toxicity data, which is assumed to be a worst case exposure scenario. Specific data limitations identified though drills in Section 4.3 include:

Drill #1:

- Queried data does not contain data on the species of interest (American lobster)
- There are insufficient data for Kuwait crude oil and the queried data contain only a few records for a related oil (Forties)
- Larvae and other early life stages of crustaceans are underrepresented in the database

Drill #2:

- Queried data contained toxicity data for species found in the Charleston Harbor area, including species listed in Table 4. However, queried data does not contain toxicity data for other relevant species of concern
- There are insufficient data for Qua Iboe Nigerian Crude
- Larvae and other early life stages of crustaceans are underrepresented in the database

One of the greater limitations encountered during the development of SSDs to support decision-making for these two drills is the lack of toxicity data for shorter exposures (e.g., <24 hours). Data for spiked flow-through exposures, which are intended to address the dilution that occurs in field conditions, are also limiting. These types of information are important because oil concentrations are expected to peak immediately after release, especially immediately after chemical treatment with dispersants, and these conditions are not adequately addressed in most tests for which toxicity data are available. Another great limitation is that the large majority of studies on oil toxicity typically report measured concentrations of the exposure media on the basis of petroleum hydrocarbons, without providing a detailed chemical characterization of the fractions that most contribute to toxicity, polycyclic aromatic hydrocarbons (PAHs). Despite existing data limitations, the exercises about showed that DTox provides information that can be used to inform tradeoff decisions based on the current state of knowledge.

As discussed above, one of the greatest limitations of the existing toxicity data and, consequently, on the results and applicability of this project to oil spill response and damage assessment and restoration, deals with the lack of data derived from environmentally realistically exposures. This issue is not new and has been extensively discussed in the past (Aurand and Coelho, 2005; Barron and Ka'aihue, 2003; NRC, 2005; Singer et al., 1995). Consequently, deriving toxicity data from laboratory conditions that address dilution, water mixing, and changing exposure concentrations over time, continues to be a large data gap. Equally important is the reporting of toxicity data on the basis of measured exposure concentrations (specially for a complex mixture such as oil), instead of nominal concentrations, as this is the only reliable metric that allows for appropriate characterizations of potential risks (e.g., Coelho et al., 2013; NRC, 1989, 2005). The importance of reporting measured concentrations was not taken lightly during the development of DTox, as reflected in the applicability score given to each data source.

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Another source of data uncertainty emerging from this project is related to toxicity of dispersants and physically and chemically dispersed oil to untested species (see for example Section 4.3), or to species protected under the Endangered Species Act. While lack of toxicity data on a number on important species or species of special interest is a source of concern, the approach implemented in DTox, namely the use of SSDs, can facilitate derivation of conservative benchmark values that may protect many of the untested species. As demonstrated here and in related studies using and applying SSDs in oil research (Barron et al., 2013; Bejarano et al., 2013; de Hoop et al., 2011), the use of these SSDs can provide a mechanism by which existing toxicity data can help assess risks to untested species. Another important use of SSDs (shown here and discussed in Barron et al., 2013) is that it allows for visualization of toxicity data for many standard test species, supporting the notion that these species are appropriate surrogate for many non-standard test species and untested species. However, future toxicity testing should not only focus on standard toxicity test species, but also on other test species easily reared and maintained under laboratory conditions. Additional toxicity data of value to the oil spill community and of interest for future updates of DTox also include toxicity testing on different life stages of the same species. In addition and as discussed above, toxicity data for short exposures is lacking in the literature. In Dtox, <10% of all records are derived from exposures <8 hours, while 83% of all records came from standard exposure durations used in toxicity testing (24, 48, 72, and 96 hours combined), mostly from 96 hour exposures (50% of all records).

Despite data deficiencies and uncertainties, existing toxicity data now compiled in DTox provide useful information to end-users and oil spill practitioners, so long as this information is used within the context of what is environmentally realistic to occur under field conditions. With that caveat in mind, the existing knowledge on the toxicity of dispersants and chemically dispersed oil can be useful in informing assessments and decisions regarding dispersant use.

The effectiveness, usefulness, and transferability of DTox to oil spill response are evaluated through two oil spill drills (Section 4.3), dispersant-related workshops, and dispersant-related assessment (Section 7). These exercises show that, despite existing data limitations, DTox provides information that can be used to inform tradeoff decisions based on the current state of knowledge. The data in DTox have the potential to contributed to a better understanding of the biological effects of dispersants and oil in the aquatic environment, and can provided useful information to both, environmental assessment and decision making efforts. Future efforts will focus on maintaining and updating data in DTox, and on expanding its capabilities for use by the oil spill community.

6.0 Technology Transfer

A critical step that facilitated the success of this project was the engagement of industry, government agencies, and academia in contributing to the development of this database, as well as to their transferability to several related purposes. Data currently in DTox were used to support two NOAA efforts. The first effort involved a dispersant workshop where there were discussions on the current state of knowledge regarding the toxicity of dispersants and chemically dispersed oil. Through several examples and using data primarily from DTox, concerns regarding potential toxicological effects were addressed. The second effort involved data compilation to support an oil spill drill between Canada and the U.S. (CANUSLANT, June

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17-20, 2013). Data from Dtox were used to compare the relative sensitivity of American lobster larvae to naturally and chemically dispersed oil, relative to the sensitivity of other species for which larvae data are available in DTox. This analysis showed that American lobster larvae are relatively sensitive, compared to other species of larvae, as it falls within the lower end of the SSD curve. This information was used during internal discussions within the Unified Command during the drill. Data from DTox have also been used to support the preparation of a biological assessment on the pre-approved use of dispersants. These data, transferred in the form of data summaries and figures, provided some of the scientific bases for assessments of potential adverse effects to aquatic species, included those under the Endangered Species Act. Additional efforts were undertaken to transfer this wealth of knowledge to oil spill responders including the government, industry, and academics via web-based seminars (three in total), and presentations at national conferences (see Section 7).

As discussed above, DTox has been used to facilitate the communication of risks with the public and the scientific community concerned about the use of dispersants. DTox also has the potential to contribute to discussions taking place during consensus Ecological Risk Assessment (ERA) workshops where agency scientists and responders discuss the tradeoffs of the use of dispersant and other response options. In past ERA workshops, participants had to rely on adhoc compilations of toxicity data for oil and dispersed oil.

The results of this project and the practical application of information gathered through this effort are currently being prepared in the form of manuscripts to be published in peer-review journals. Run-time versions of DTox were distributed to end-users (in the form of a downloadable file) engaged with oil spill research and response.

7.0 Achievement and Dissemination

7.1 Workshops

Bejarano A.C. and A. Mearns. The Toxicological Effects of Dispersant Use in Oil Spill Response: Facts versus Fiction. Hawaii Dispersant Workshop. Honolulu, May 5, 2013. *Number of attendees: 20.*

7.2 Off-Site Training Seminars

Bejarano A.C. DTox for Scientific Support Coordinators (NOAA, Emergency Response Division). November 5, 2013. *Number of attendees*: 10.

Bejarano A.C. DTox for End-Users (Federal and State Agencies, Industry, Academics, International end-users). December 18, 2013. *Number of attendees*: 10.

Bejarano A.C. DTox for Scientists (NOAA, Assessment and Restoration Division). January 6, 2014. *Number of attendees*: 9.

7.3 Presentation

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Bejarano, A.C, V. Chu, J. Dahlin, J. Farr. 2013. DTox: A Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil. SETAC. Nashville, TN, USA. (Poster)

Bejarano, A.C, V. Chu, J. Dahlin, J. Farr. 2014. DTox: A Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil. 2014 International Oil Spill Conference. Savannah, GA, USA. (Oral; accepted February, 2014)

7.4 Publication

Bejarano, A.C., J. Clark, G.M. Coelho. 2014. Issues and Challenges with Oil Toxicity Data and Implications for their Use in Decision Making: a Quantitative Review (accepted in *Environmental Toxicology and Chemistry*)

Bejarano, A.C, V. Chu, J. Dahlin, J. Farr. 2014. DTox: A Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil. Proceedings of the 2014 International Oil Spill Conference. Savannah, GA, USA. (accepted February, 2014).

Bejarano, A.C and M. Barron. 2014. Development and Practical Application of Oil and Dispersant Interspecies Correlation Models for Aquatic Species (in prep).

Bejarano, A.C, A. Mearns, V. Chu, J. Farr. 2014. Use and Application of Acute Toxicity Data in Spill Response with Focus on the Use of Dispersants (in prep).

7.5 Other Forms of Dissemination

Computer Software: Bejarano, A. C. and J. Dahlin. 2013. DTox: a Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil, Version 1.1 [Computer Software]. A project for the National Oceanic and Atmospheric Administration, and the University of New Hampshire's Coastal Response Research Center (Contract No. 13-034). Research Planning, Inc. Columbia SC.

Internet information dissemination http://www.researchplanning.com/projects/dtox-worldwide-quantitative-database-toxicity-dispersants-chemically-dispersed-oil/, which includes a link to a training video.

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Appendix A- Quality Assurance Quality Control Plan (Revised)

DTox: a Worldwide Quantitative Database of the Toxicity of Dispersants and Chemically Dispersed Oil

A-1 Project Description

The ability to rapidly assess the toxicity of physically and chemically dispersed oils is a goal shared by government, industry, consultants, and academic groups involved in oil spill response. One common need of the oil spill community is the unrestricted and rapid access to available toxicity data on dispersants and chemically dispersed oils. However, there are no centralized data repositories gathering decades of existing toxicity data. The end-result of this project, the Dispersant and Chemically Dispersed Oil Toxicity Database (DTox), addresses that shared need of the oil spill community, and contributes to a better understanding of the biological effects of dispersants and dispersed oil. This quantitative data compilation provides the basis for a more thorough assessment of levels of concern for dispersants and chemically dispersed oil, and helps improve risk estimates during oil spills or drills by allowing the selection of data that most closely match the needs of the end-user. The ultimate goal of this effort is the synthesis of information in a meaningful way to improve scientific decision-making as well as to provide rapid access to centralized toxicity data. To meet the goals of this project, a Quality Assurance Plan was designed to meet the following objectives:

- Outline the procedures and data management implemented during the development of this project to ensure that data selection and data entry, storage, and management are of high quality;
- Provide a means by which the quality of information produced can be maintained throughout the project;
- Provide a sound basis for documenting, evaluating, and verifying the accuracy of data selection and entry;
- Provide guidelines for the preparation and review of project plans and reports; and
- Provide the means that would allow the end-user assess the quality of data compilation efforts.

A-2 Objectives

The main objectives of this project are to identify, evaluate, compile, and integrate all available worldwide toxicity data on dispersants and chemically dispersed oil generated under laboratory and field conditions, and to generate an interactive tool that can assist the oil spill response community in management decisions regarding the use of dispersants.

The specific objectives of this project are to:

1. Identify documents, peer-review and gray literature (e.g., field, laboratory, mesocosm, accidental oil spills), reporting the toxicological effects (acute and chronic) of dispersants and chemically dispersed oil;
2. Rigorously evaluate each data source for their quality and potential for inclusion in the DTox database;
3. Compile all quantitative information including all relevant fields (e.g., species, exposure conditions, oil type and weathering, etc.);

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4. Integrate the above information into a tool that can be used by the end-user to guide management decisions regarding the use of dispersants; and
5. Test the suitability of the compiled quantitative data for use in spill response at two pilot study areas.

This effort focuses on aquatic fauna, primarily invertebrates and fish, including all life stages, and includes all pertinent information regarding experimental methods and settings including, oil and dispersant type, oil weathering stage, dispersant to oil ratios, and exposure duration, type (continuous vs. spiked) and concentrations (e.g., oil, PAHs or TPHs). Information from each study also includes analytical chemistry methods and the reported analyte(s). Each paper is carefully evaluated to ensure inclusion of good quality research.

A-3 Quality Assurance

Data included in DTox are evaluated following a strict set of rules aimed at selecting the best available and suitable data. Data entered into the database went through Quality Assurance and Quality Control (QA/QC) procedures including periodic reviews of the database to ensure accurate data entry. Specific QA/QC procedures are described below for each of the main objectives of this project.

Papers initially considered for inclusion in the database met the following minimum criteria:

- Articles published in English; except when information in another language could be accurately translated;
- Full scientific articles, numbered government reports, and independent consultant and industry reports (abstracts are not considered);
- Data should be from original scientific publications and peer review literature (primary source) rather than from reviews or unverifiable sources; a few exceptions are made, but data source penalized via applicability (see below)
- Species' common and/or scientific name, oil source, and dispersant type should be clearly stated;
- Biological test methods should be described, or reference made to an appropriate published method;
- Effects endpoints of treatment tests should be acceptable relative to control tests; studies that do not discuss or mention the use of controls where included on a case by case basis; and
- Methods for the chemical analysis used to quantify exposure concentrations associated with toxicological effects should be described or referenced.

The implementation of these selection criteria led to the exclusion of large amounts of information. Additional data are reconsidered for inclusion by relaxing the selection criterion, but potential data inaccuracies are noted within the database (see below for details). All papers and documents evaluated for potential inclusion in DTox are classified as follows:

- A1: Meets the selection criteria. A1 papers and documents are evaluated and included in the database;

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- A2: One or more of the selection criteria are questionable. A2 papers are be kept aside for further consideration and, if included in the database, potential data inaccuracies are be clearly noted;
- Rejected: Does not meet the selection criteria or does not contain data valuable to the goals of this project.

A-3.1 Data Compilation

Data entry followed a systematic, consistent, and accurate review process of the available literature. A carefully designed database template was developed, which included all the relevant database fields (data elements) and as many standardized data entries as possible (Table A-1). Data element definitions and descriptions are summarized in Table A-2. One of the fields within this template was created to enter the applicability of each paper (e.g., high, moderate, low). Applicability is judged based on source-specific considerations including. A brief summary of the criteria used in the assessment of applicability is as follows:

High:
- Papers reporting effects concentrations based on measured analytes (particularly those involving oil exposures)
- Dispersant to oil ratios consistent with typical recommended formulations
- Exposure conditions following existing recommendations for oil spill research

Moderate:
- Papers reporting effects concentrations based on measured analytes (particularly those involving oil exposures)
- Papers reporting effects concentrations for dispersant only exposures as nominal
- Dispersant to oil ratios consistent with typical recommended formulations
- Exposure conditions following standard toxicity testing laboratory practices

Low:
- Papers only reporting effects concentrations as nominal (particularly those involving oil exposures)
- Papers not clearly stating if the reported effects concentration are nominal or measured
- Papers with missing critical information (e.g., exposure conditions, analytical methods)
- Papers reporting only No Observed Effects Concentration (NOEC) or Lowest Observed Effects Concentration (LOEC)
- Papers with toxicity data from unverifiable sources

Note: Source applicability is assigned to individual papers and not to individual records. A paper reporting toxicity data based on oil loading rates (nominal exposures) also reporting effects concentrations based on measured analytes would have the same applicability assigned to each record entered in DTox. Also it is important to note that paper applicability is based on the relevance of its data to spill response, and not on the overall scientific merit of individual papers.

When entering data into the database template, the following rules are implemented:

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- To ensure completeness and accuracy, information is entered as not reported (NR) when information is not available, or not applicable (NA) when the field does not apply (e.g., toxicity testing with dispersant only has a NA dispersant to oil ratio);
- To ensure accuracy in data entry, all numbers between zero and one are reported with a preceding zero (e.g., 0.5 not .5);
- Periods are only used to represent a decimal points;
- Effects concentrations are entered as they appear in the original document (no rounding up or down is allowed);
- Drop down menus and standardized terminology are used for unique information (e.g., COREXIT 9500);
- Non-standardized data entry fields are entered exactly as they appear in the original source. Examples include: common name, scientific name, effects concentration, water temperature and complete citation; however, current scientific names are checked and replaced are needed, noting changes in reported versus final scientific names (see below);
- Units of numeric data are entered based on a standardized values (e.g., mg/L for effects concentrations, hours for exposure duration);
- Data sources with detailed data chemistry are noted within the database, and chemistry data entered into a separate form;
- Unique citations are assigned a numeric code that matches the citation's code of the bibliographic database (EndNote®); this unique numeric code provides the link between the data entered and the bibliographic citation; and
- A "Notes" field should include only relevant data not captured within other database fields.

Upon completion of data entry, global changes are applied to "new" data fields in the database. Examples include species (global) distribution, habitat, and water depth. Consideration was given to potential changes in habitat and water depth by species-specific life stages. Species distribution databases were consulted to accurately enter this information by species. Additionally, common and species names are checked, and global changes made including standardization of common names and assignment of official species names (e.g., *Mysidopsis bahia* changed throughout to *Americamysis bahia*). Any changes made to the original data source are clearly documented.

As part of the QA/QC components of this project, periodic reviews of the database are made to ensure accurate data entry. A minimum of 15% of all data sources are reviewed for accuracy and completeness. Critical steps of the QA/QC process includes the review of currently accepted scientific species names, standardization of column content and applicability criteria, and identification of duplicate data (e.g., several papers by the same author(s) reported in several report/manuscripts).

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Table A-1. List of standardized data entry fields. In all cases, not applicable (NA), not reported (NR) can be entered in the field cell. Non-standardized data entry fields include: effects concentration and complete citation. In brackets [], descriptive information related to a particular entry field. See Table A-2 for details.

Field Type	Field Name	Examples
Effects Database		
Species	Common name	Inland silverside
	Scientific name	*Menidia beryllina*
	Taxonomic group	Crustacean, fish, coral, mollusk, other[1]
	Life stage	Adult, juvenile, larvae, egg
	Species distribution	Tropical, subtropical, temperate, frigid, pandemic
	Species habitat[2]	Benthic, water column, epibenthic
	US standard test species	Yes, No
Experimental conditions and settings	Study type	Laboratory, field, mesocosm, wave tank
	Water type	Freshwater, seawater
	Dispersant/Oil Treatment	Dispersant only, Dispersant and Oil, Oil only
	Oil name	Alaska North Slope crude oil, South Louisiana crude oil
	API gravity	[Oil specific. Most data from NOAA's ADIOS (Automated Data Inquiry for Oil Spills)]
	Oil class (based on API gravity)	Light, Medium, Heavy, Extra-heavy
	Oil stage	Fresh, weathered, biodegraded
	Dispersant name	COREXIT9500, DISPERSIT, [including mechanical dispersion]
	Dispersant to oil ratio	1:10, 1:20
	Exposure conditions	Continuous, spiked, flow through, field
	Exposure duration (h)	24 hour, 96 hour
	Temperature (°C)	6 °C, 25 °C
Endpoints	Endpoint	Mortality, growth/development, behavior [grouped by endpoint type]
	Endpoint metric- Acute[3]	Acute: LC50, EC50, LOEC; Chronic: EC50, LOEC
	Qualifier	>, <, NA [these are qualifiers associated with the reported effects concentration]
	Effects concentration (mg/L)	200
	Effects concentration range	[Minimum|Maximum or Lower|Upper confidence interval of the reported effects concentration]
	Effects concentration analyte[4]	Total PAHs, TPHs, THCs
	Reported effects concentration	Measured, nominal
	Analyte endpoint	Initial, Final
	Analytical methods	Fluorometry, GC-MS
Data Source	Complete citation	Author, Year, Title, Journal/Agency
	Endnote Reference Locator	[value assigned to each citation entry in Endnote]
Other	Paper selection criteria	A1: Meets the selection criteria A2: One or more of the selection criteria are questionable Rejected
	Paper applicability	Low, Moderate, High, Rejected

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Field Type	Field Name	Examples
	Detailed analytical chemistry	Yes, No [if yes, data extracted and entered into chemical database]
	Duplicates	[It includes individual records identified as duplicates. Duplicates are not included in SSD calculations]
	Notes	[It includes any important information not captures in preceding fields]
Chemistry Database		
Analyte	General compounds	Total Petroleum Hydrocarbons, Polycyclic Aromatic Hydrocarbons
	Analyte name	n-Pentadecane (C15), Benzo(a)anthracene
	CAS#	50-32-8
Experimental conditions and settings	Dispersant/Oil Treatment	Dispersant only, Dispersant and Oil, Oil only
	Dispersant name	COREXIT9500, DISPERSIT, [including mechanical dispersion]
	Oil name	Alaska North Slope crude oil, South Louisiana crude oil
	Oil stage	Fresh, weathered, biodegraded
	Source type	Source oil, exposure media
	Concentration qualifier	>, <, NA
Analytical endpoint	Concentration (mg/L)	200
	Analytical methods	Fluorometry, GC-MS
Data Source	Complete citation	Author, Year, Title, Journal/Agency
	Endnote Reference Locator	[value assigned to each citation entry in Endnote]
Other	Notes	[It includes any important information not captured in preceding fields]

[1] Other include: bacteria (e.g., *Vibrio*), aquatic plants (e.g., giant kelp), phytoplankton, and echinoderms.
[2] Specific to the life stage of the tested species. For example, adult oysters would be categorized as inhabiting the epibenthos, while their larvae would be more likely found in the water column; [3] LC50: median lethal concentration, EC50: median effects concentration, NOEC: No Observed Effect Concentration, LOEC: Lowest Observed Effect Concentration;
[4] PAH: polycyclic aromatic hydrocarbons; TPH: total petroleum hydrocarbons; THC: total hydrocarbons content.

Table A-2. Key data element definitions.

Element Definition	Definition
Species common and scientific name	Refers to the species used in toxicity testing within each data source. Typically reported as common name and/or scientific name. Scientific names are checked against currently accepted names. Other information associated with species includes their taxonomic group, and the life stage used in toxicity testing. Both the global distribution of the tested species, and the habitat of the tested life stage are entered manually (typically not reported within data sources) based on information reported on global databases. Species are also assigned to whether these correspond to U.S. standard test species.
Water type	Refers to the nature of the water used in toxicity testing (freshwater or seawater).
Study type	Refers to the physical location where toxicity tests were conducted. It includes exposures under laboratory, field (e.g., outdoor uncontrolled conditions), mesocosm or wave tank conditions.
Dispersant/Oil Treatment	Refers to the type of aqueous exposure media used in toxicity

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Element Definition	Definition
	testing. It includes oil only (e.g., physically dispersed oil, or water accommodated fraction), dispersant and oil (e.g., chemically dispersed oil, or chemically enhanced water accommodated fraction), dispersant (e.g., dispersant in aqueous solution).
Oil name	Refers to the oil type (typically reported) used in toxicity testing within each data source. Other information associated with each oil entered into the database includes oil class categories (light, medium, heavy, extra-heavy) assigned based on API gravity (most information from NOAA/ADIOS).
Oil condition	Refers to the nature of the oil used to derive the exposure media. It includes fresh, weathered (naturally or artificially) or biodegraded oil.
Dispersant name	Refers to the dispersant product (typically reported) used in toxicity testing within each data source. Entered as reported, typically commercial name. Other information associated with each dispersant, if used in combination with oil, includes the dispersant to oil ratio (DOR) used to prepare the aqueous exposure media.
Exposure conditions and other related exposure information	Refers to the type of experimental design used to conduct toxicity testing. Examples include: Constant static (with or without open vessels) – Refers to toxicity tests performed in the absence of low. Aqueous exposure media typically remains unchanged throughout the duration of the test. Static or semi-static renewal– Refers to the a test without continuous flow of solution, but with renewal of aqueous exposure media Flow through test– Refers to the continuous or very frequent passage of aqueous exposure media through a test chamber with no recycling. Spiked, pulsed, and spiked, flow-through (with or without open vessels) – Refers to initial spike in concentrations in the exposure media, which is allowed to decline over the duration of the exposure period. Other information associated with the exposure conditions include exposure duration and water temperature (not always reported).
Endpoints and other related endpoint information	Endpoint refers to the biological metric used to characterize toxicity. For the purpose of this database, endpoints are grouped by– Mortality (primarily LC50 data); Growth and Development (e.g., blue sac disease, embryo abnormalities) (primarily EC50 data); Reproduction (e.g., fecundity, fertilization inhibition, percent Hatch) (primarily EC50 data); Biochemical (e.g., CYP1A induction, EROD activity) (primarily EC50 data); Physiology (e.g., Heart rate, Impaired byssal activity, Impaired shell-closure) (primarily EC50 data); and Behavior (e.g., feeding rate, impaired swimming) (primarily EC50 data). Endpoints include: LC50 – Median lethal concentration that kills 50% of the exposed organisms at a specific time interval; EC50 – Median effects concentration that causes an response in 50% of the exposed organisms at a specific time interval;

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Element Definition	Definition
	LOEC (Lowest Observed Effect Concentration)– The lowest concentration that causes a response statistically different from the control; and NOEC (No Observed Effect Concentration)– The highest concentration that causes a response statistically different from the control. Whenever available information is also included on control Endpoints– How test treatments compared to controls.
Effects Concentration and other related information	Effects Concentrations (mg/L) refer to the mean reported value. Note: All concentration information is standardized to a single consistent concentration unit (mg/L). Whenever reported, the database also includes: Minimum or lower confidence interval of the effects concentrations (mg/L)– Either the minimum or the lower confidence interval of the reported value; and Maximum or upper confidence interval of the effects Concentrations (mg/L) – Either the maximum or the upper confidence interval of the reported value. Information is also included on whether or not the effects concentrations were derived from measured or nominal concentrations of the exposure media. Analytes include: total polycyclic aromatic hydrocarbons (PAHs), total hydrocarbon content (THC), among other analyte types. If available, information is also entered on the analytical method used to characterize the exposure media: Fluorometry, GC-MS
Data Source	Refers to the source from which toxicity data are obtained. It includes a complete citation (author, year, title, journal/agency)

A-3.2 Tool Development

Data were initially entered into a spreadsheet and later migrated into a database program (FileMaker® Pro 12) with expanded capabilities. The database contains multiple data formats, including graphs and relational tables that reflect the nature of the data, and is flexible enough to allow incorporation of ongoing and future studies. The format and structure of this interactive database has the characteristics of a sister database CAFÉ (Chemical Aquatic Fate and Effects Database, NOAA/ERD), allowing current CAFÉ users to query data in DTox without additional training. A similar data structure also allows for potential integration of DTox with CAFÉ.

Integration of the data template into FileMaker® Pro 12 required the following, in operational order:

- Set field requirements to identify data errors during and after data import into FileMaker® Pro 12;
- Establish data check routines to identify legitimate and illegal field combinations (e.g., oil exposures only should not have a dispersant name), check for blank cells that should have either numeric or text entries, ensure that tables (e.g., DTox and chemistry table) are properly linked based on a common numeric code link (e.g., unique EndNote® citation number);
- Verify that 100% of the data fields have converged into FileMaker® Pro 12

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- Design tools and reports that address the needs of end-users with disabilities (e.g., color blind) (Section 508 29 U.S.C. '749d) by selecting colors suggestions for color blind, as well as font size and style options;
- Run tests and other assessment procedures on the user interface tool, data queries and database products (reports, graphs) to make sure these meet the goals of the database. These test involved the selection of a variety of likely end-user scenarios (e.g., queries with few to several end-user requirement specifications);
- Additional tests aimed at improving system performance, response time, and vulnerability;
- Perform an internal review of an alpha version of the database within project team, including potential RPI end-users and members of CAFÉ's development team;
- This phase of the QA/QC plan also included detailed documentation of decisions and procedures (e.g., data entry, tracking and manipulation), as well documentation of assumptions, theory, and parameterization used in developing Species Sensitivity Distribution curves (SSDs) (see below); and
- As part of the QA plan, computer file back-up procedures were regularly undertaken.

A beta version of the interactive database was designed and tested internally and externally for input and suggestions on improvement, prior to its dissemination among selected end-users. This process allowed the project team to address and improve the tool prior to its public release.

Key attributes of this database include:

- Easy to follow layout;
- Query screens to allow for user-specific data inclusion/exclusion;
- Interactive standard navigation buttons containing the most common search attributes;
- Search results displayed in tables and graphics;
- Appearance and functionality;
- A "How To" document detailing how to perform data queries, and a copy of the most recent QA/QC Plan; and
- A copy of the EndNote® library containing the complete list of citations of all papers reviewed as part of this project.

A-3.2.1 Data Queries and Species Sensitivity Distributions

The first version of DTox contains several navigation windows allowing data selection by the end-user. Following data selection, the remaining data are plotted in separate windows in the form of Species Sensitivity Distributions (SSDs). SSDs are constructed by calculating the geometric mean of reported toxicity for each individual species (by scientific name). Data included in geometric mean calculations are:

- Data with effects concentrations qualifiers equal to NA
- Effects concentrations with qualifiers $\geq$, $\leq$, $>$ or $<$ are not included in calculations
- Data identified as duplicates are not included in calculations
- Data from Rejected papers are not included in calculations

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- SSDs are only generated for datasets with a minimum of 5 species

Additional details on SSDs include:

- SSDs are generated by fitting the empirical toxicity data to a logistic function defined by $F(x) = \frac{1}{1 + e^{-\frac{x-\mu}{\sigma}}}$, $x \in R$, with parameters μ(location) and σ (scale);
- Fitted SSDs do not include a "Goodness of Fit" test;
- Two Hazard concentrations (HC) (HC1 and HC5 equivalent to the concentrations at which 1% and 5%, respectively, of the species in the SSD may not be protected) are included for plots with a minimum of 5 species;
- Up to two SSDs are plotted per display window (Dispersant Only, Dispersant and Oil, Oil Only);
- 1 SSD per display window includes common names;
- 2 SSDs per display window omits common names;
- Data are displayed based on color coding selections; and
- All SSDs are plotted over a colored background representing a common scale of relative toxicity.

Scale
Very highly toxic (<0.1 mg/L)
Highly toxic (0.1-1 mg/L)
Moderately toxic (1-10 mg/L)
Slightly toxic (10-100 mg/L)
Not acutely toxic (>100 mg/L)

A-3.2.2 Tool Testing and Distribution

A stand-alone executable file (beta version) of the interactive database was further tested internally, and shared with external potential users and volunteers for input and suggestions on improvement, prior to its dissemination among selected end-users. This process allowed the project team to address and improve the tool prior to its public release. A stand-alone executable file of the first version of DTox was made available and shared with a selected number of end-users. End-users were asked to provide feedback and to report issues, which will be considered in future updates of the tool.

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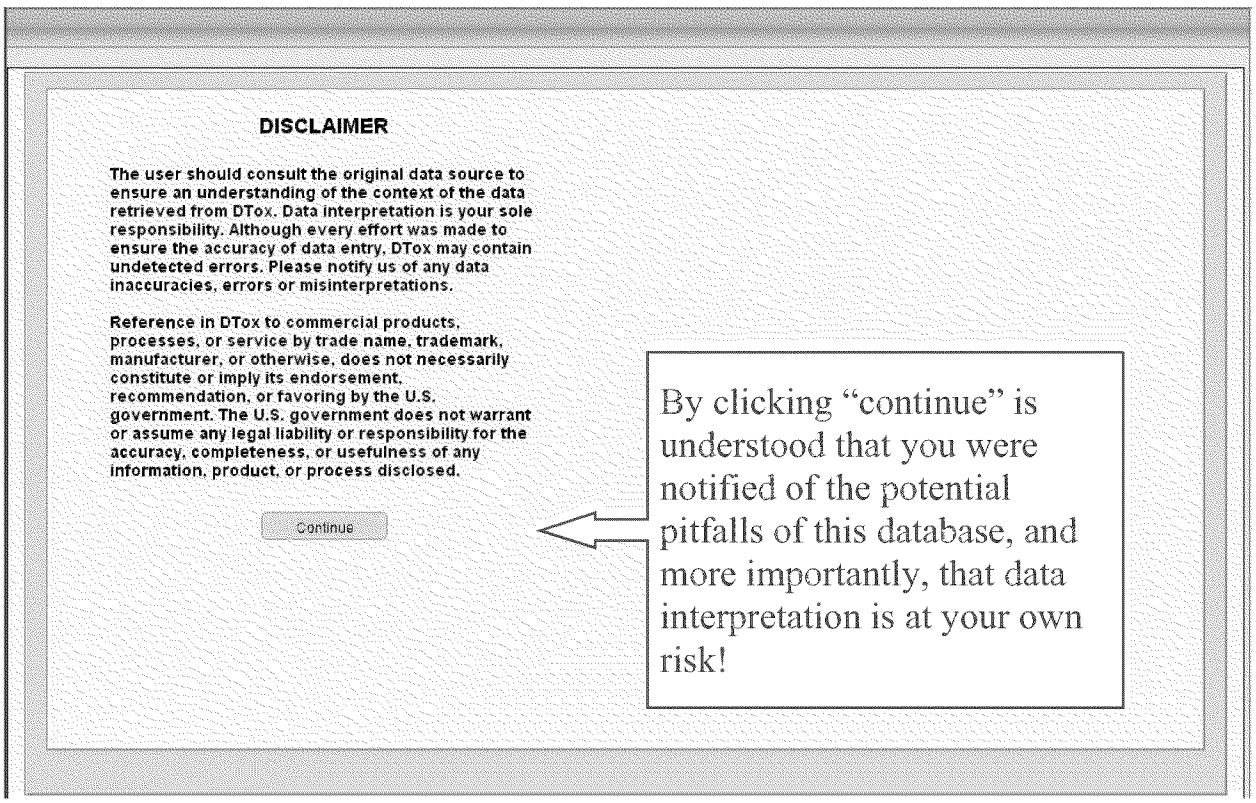
Appendix B- HOW TO "DTox" Version 1.

This document provides a brief overview on how to navigate through DTox. Before you start querying DTox, please read through the information presented here as it is intended to facilitate the use of this tool.

Performing queries in DTox-

Below you will find a series of screens shots through which you would have to navigate to perform the desired queries

1. **Disclaimer**



2. **Data selection**

There are several windows allowing the selection of the type of data you want included in your query. **Note** that if selections are not made, by default, the program will select all the available data.

   a. **Species**

Note that while only common names are listed, these correspond to "unique" scientific names.

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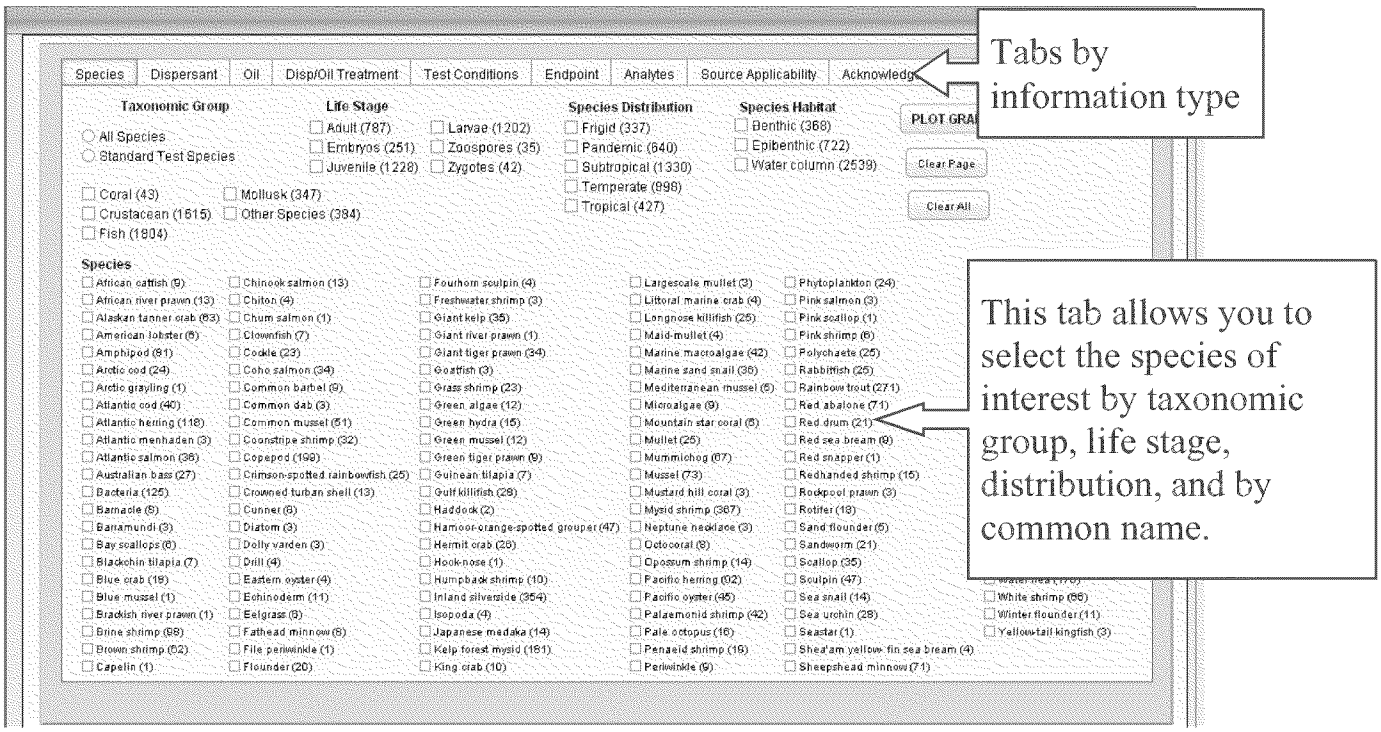
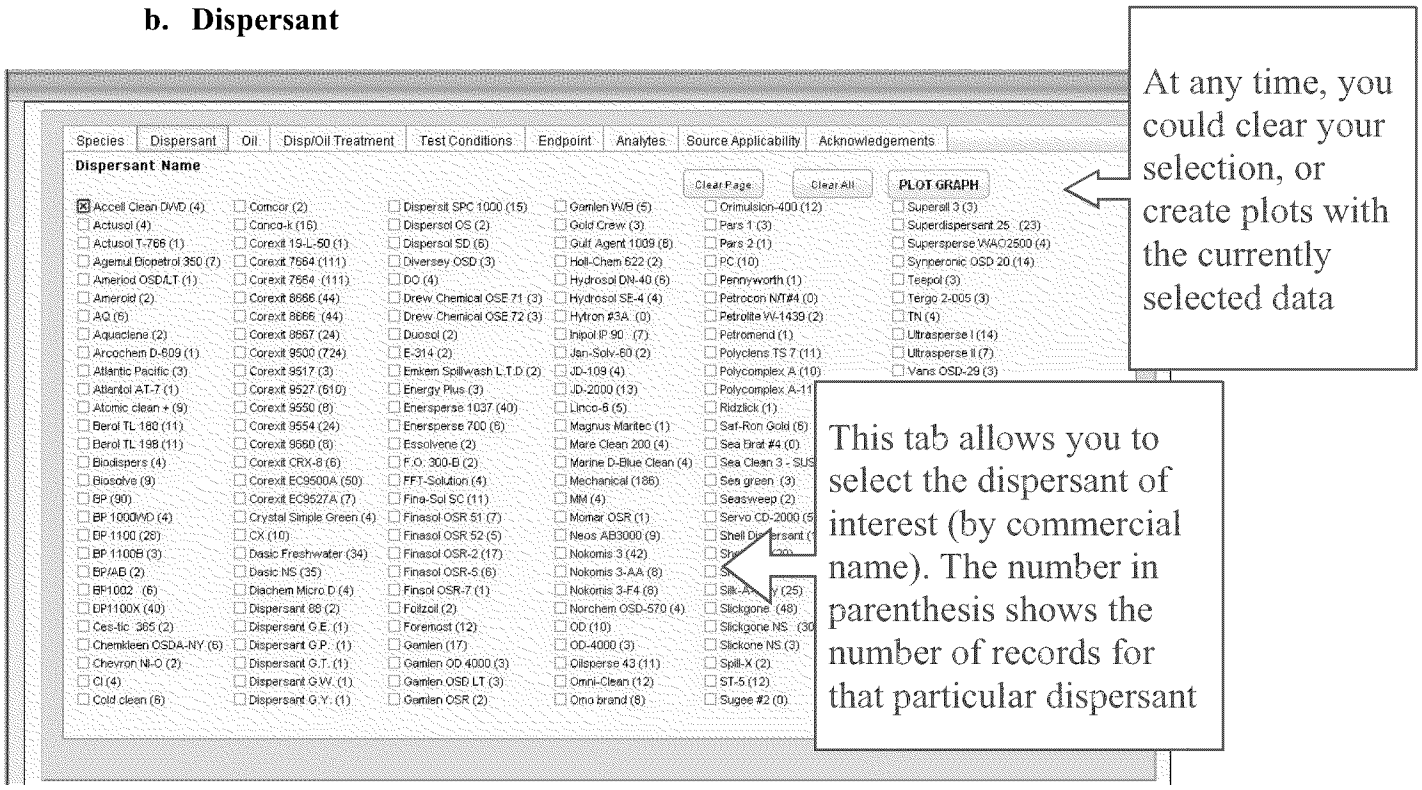
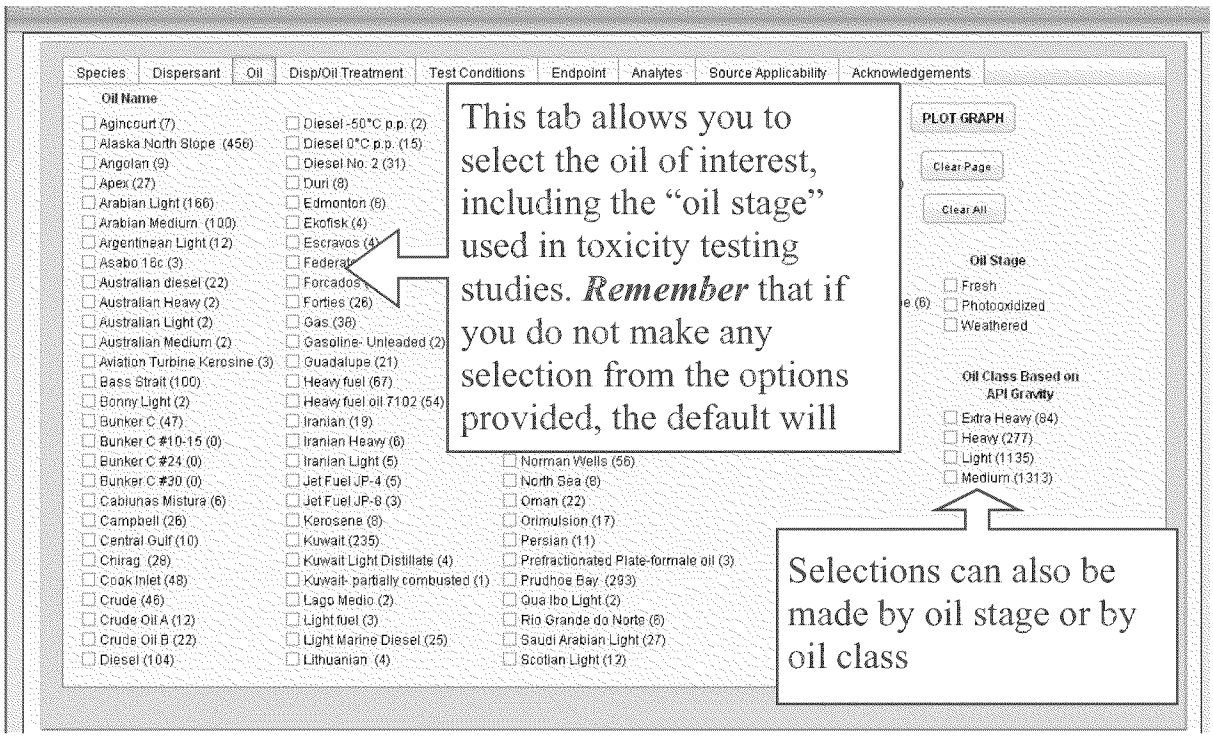


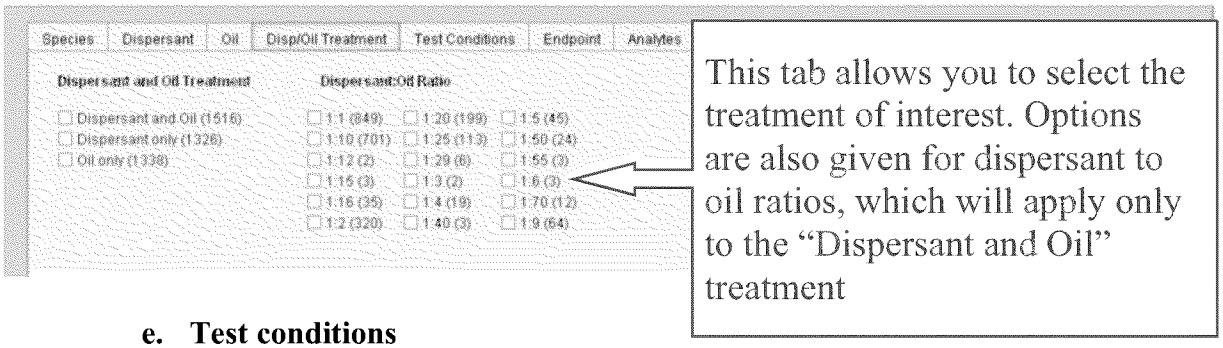
b. Dispersant



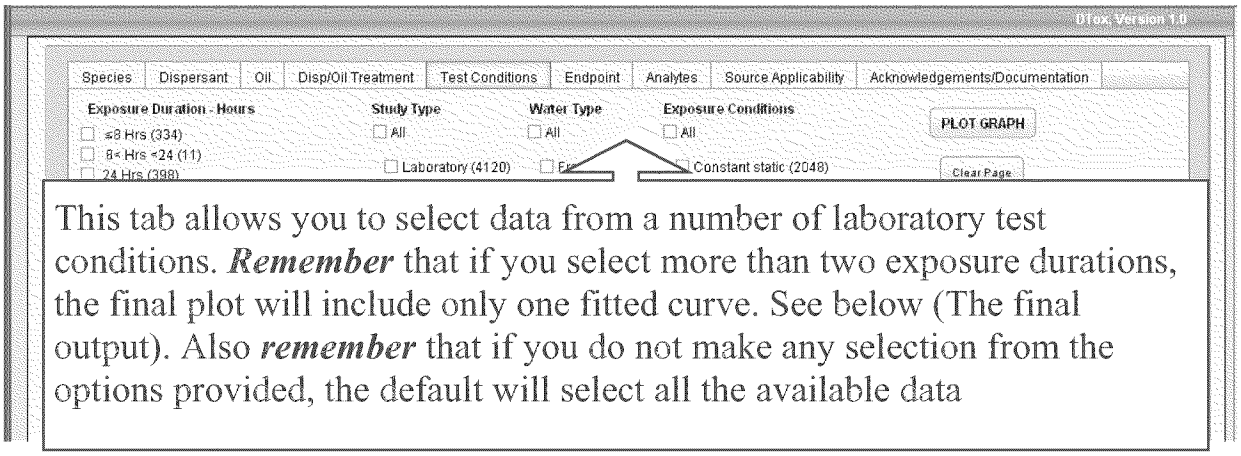
c. Oil



d. Dispersant/oil treatment

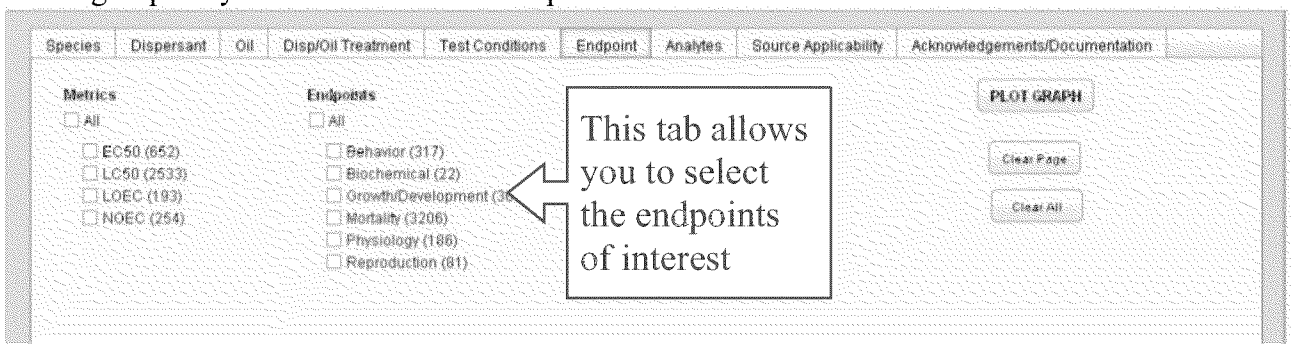


e. Test conditions

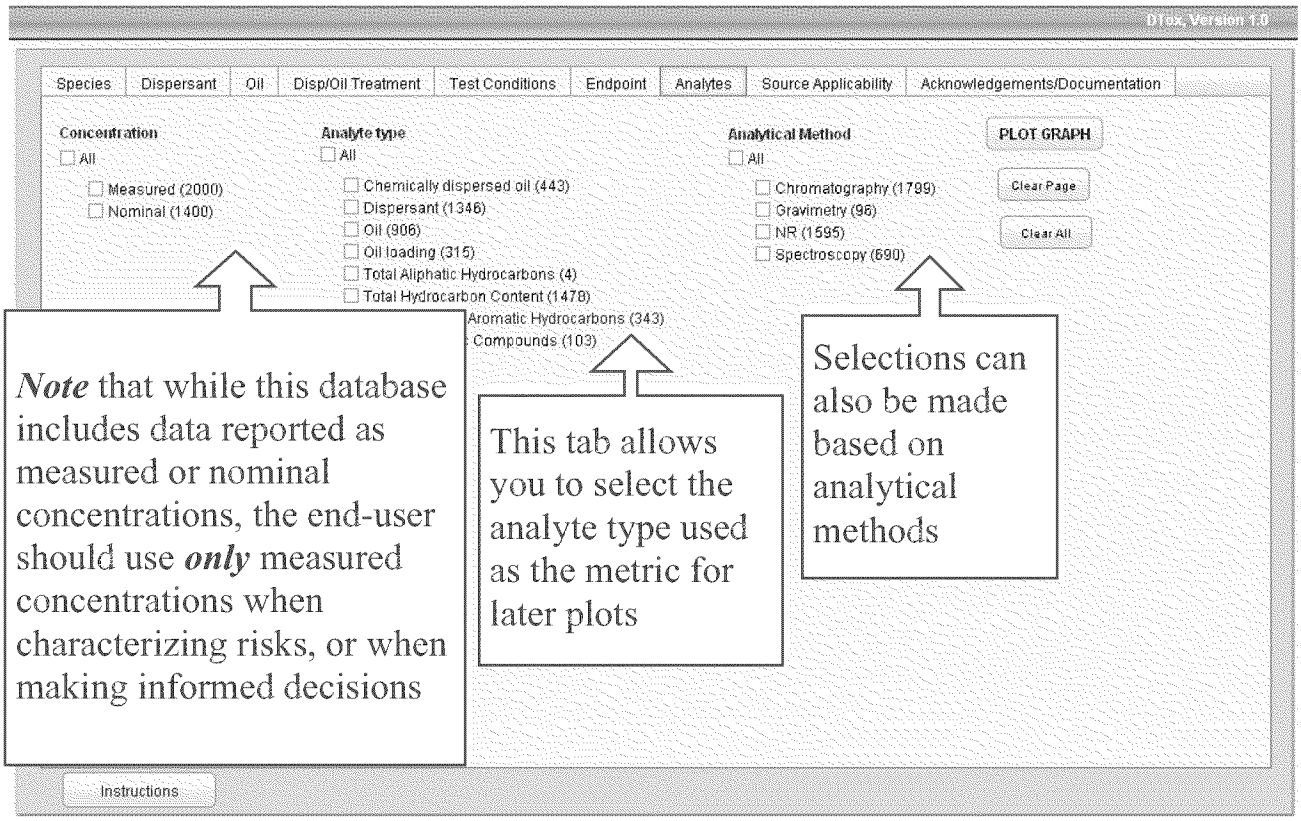


f. Endpoints

Toxicity metrics included in DTox include the most commonly reported types, grouped by lethal and sublethal endpoints.



g. Analytes



h. Source applicability

A detailed Quality Assurance/Quality Control plan was written prior to the development of this tool. A brief summary of the criteria used in the assessment of applicability[2] is shown below:

High:

[2] "Applicability" is meant to indicate the applicability or usability of these data to spill response, and to the specific goals of this project. Assigning "applicability" to each data source is not to be interpreted as a judgment of the scientific quality of each data source.

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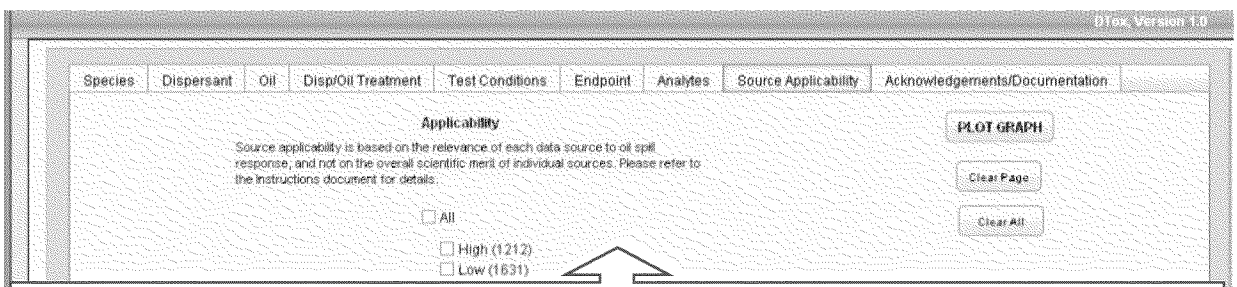
- Papers reporting effects concentrations based on measured analytes (particularly those involving oil exposures)
- Dispersant to oil ratios consistent with typical recommended formulations
- Exposure conditions following existing recommendations for oil spill research

Moderate:
- Papers reporting effects concentrations based on measured analytes (particularly those involving oil exposures)
- Papers reporting effects concentrations for dispersant only exposures as nominal
- Dispersant to oil ratios consistent with typical recommended formulations
- Exposure conditions following standard toxicity testing laboratory practices

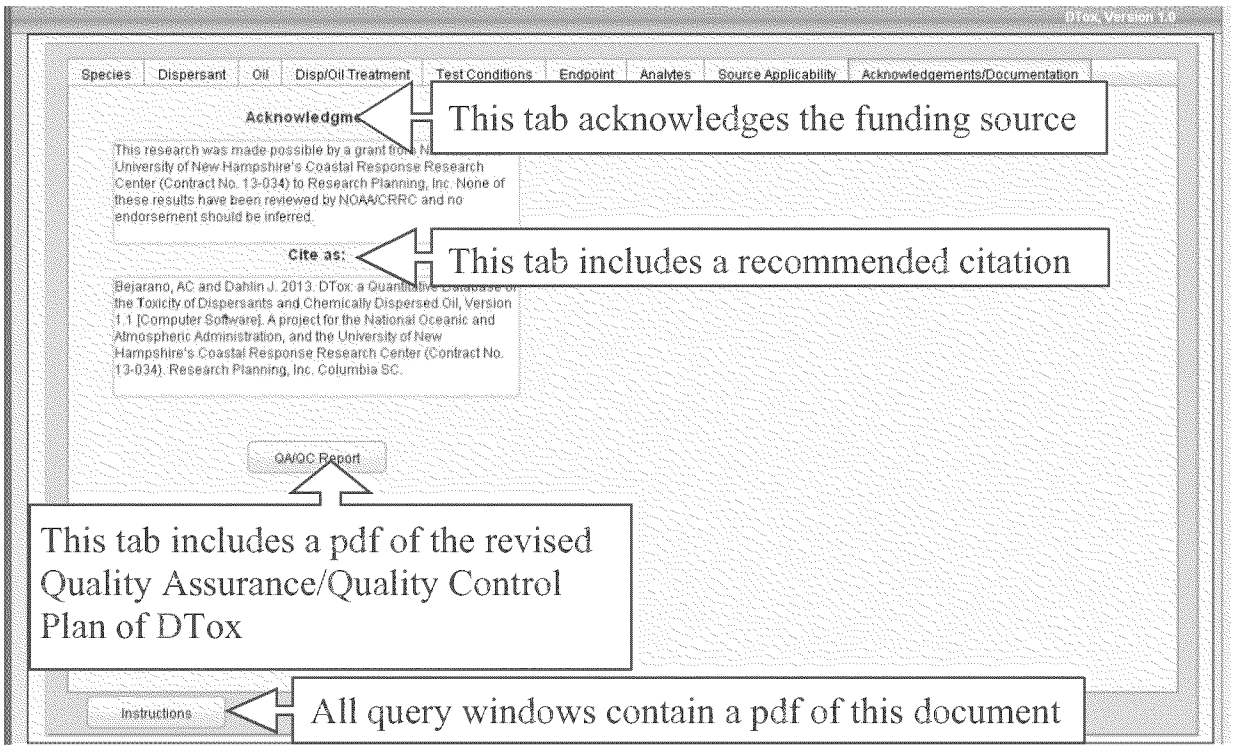
Low:
- Papers only reporting effects concentrations as nominal (particularly those involving oil exposures)
- Papers not clearly stating if the reported effects concentration were nominal or measured
- Papers with missing critical information (e.g., exposure conditions, analytical methods)
- Papers reporting only NOEC, LOEC effects concentrations
- Papers with toxicity data from unverifiable sources

Note: Source applicability is assigned to individual papers and not to individual records. A paper reporting toxicity data based on oil loading rates (nominal exposures) also reporting effects concentrations based on measured analytes would have the same reliability assigned to each record entered in DTox.



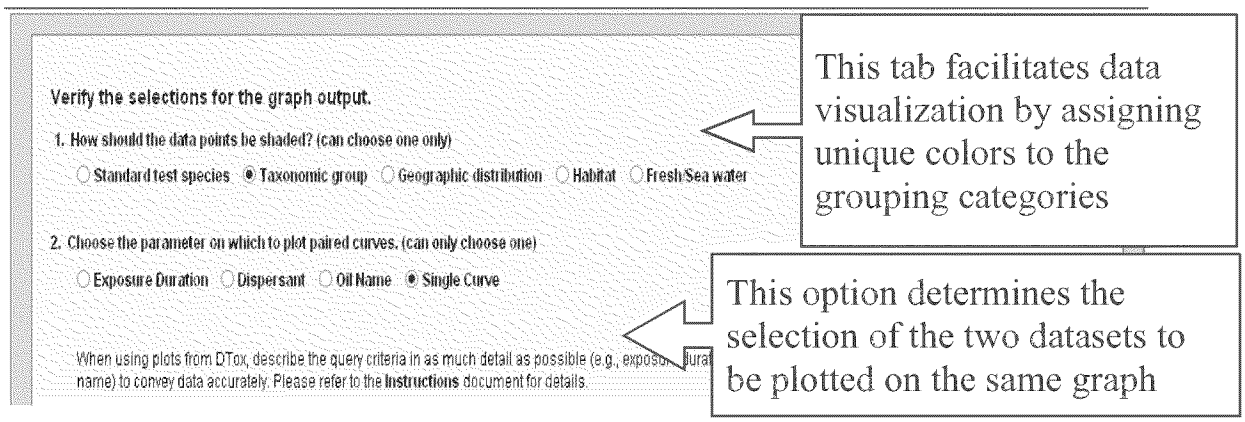
Each data source in the DTox was given an applicability score, based on the scientific value of these data to spill response. The end-user is encouraged to use the two higher applicable sources (Moderate/High) when characterizing risks or when making informed decisions

i. Acknowledgements and Documentation



3. Data plotting options

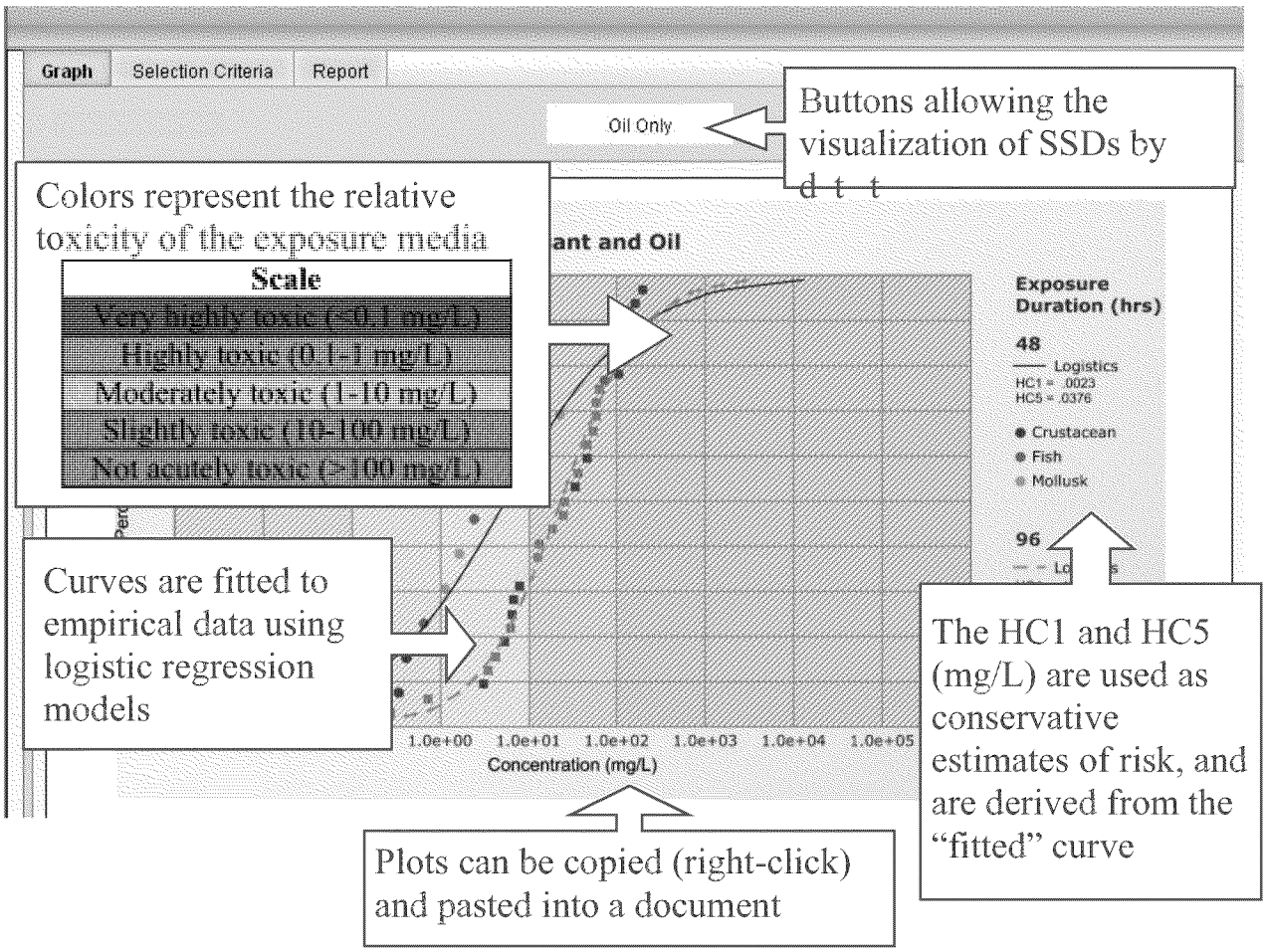
Once you have gone through the data selection tabs, your will get to chose how you want your data plotted. **Note** that only two curves can be plotted simultaneously on the same window. If more than three options are selected, only two will be plotted. For example, under exposure duration select two (e.g., 24 h and 96 h). Press "Plot Graph" to see the plotted output. This may take a few seconds… Following the step above, you will see the internal query being performed. You may need to wait a few seconds while the plots are generated.

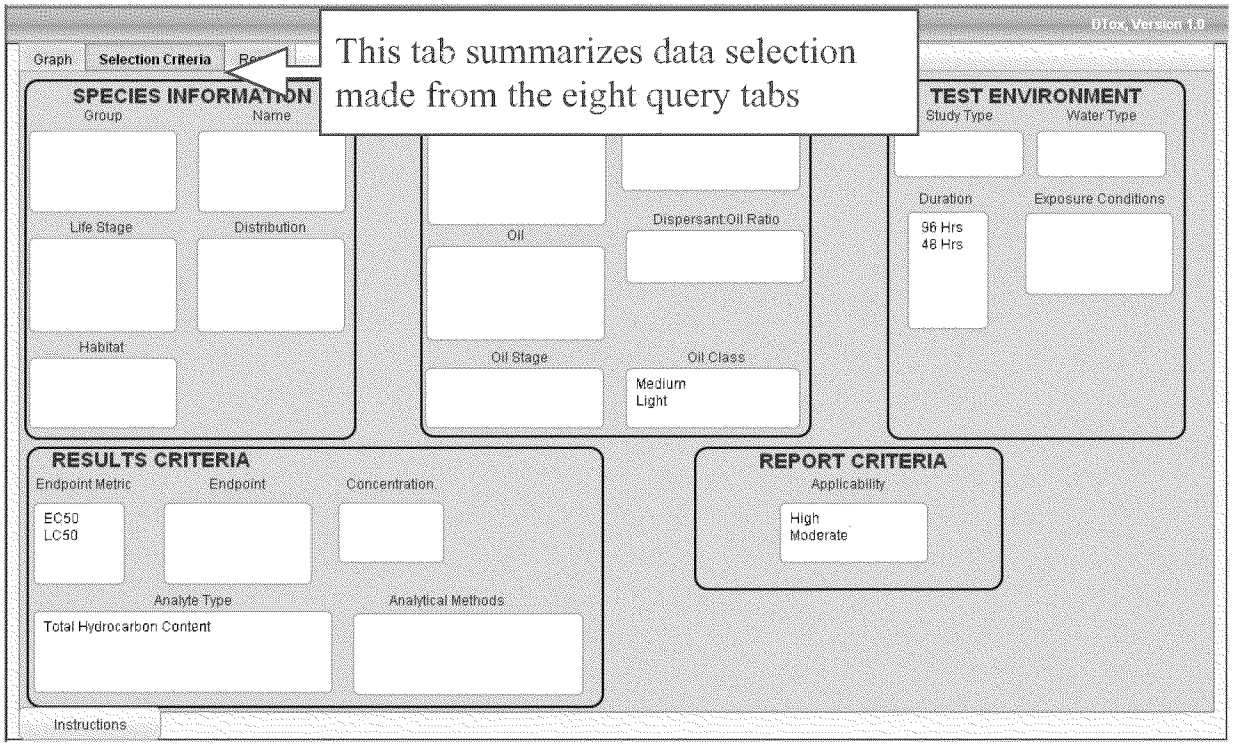


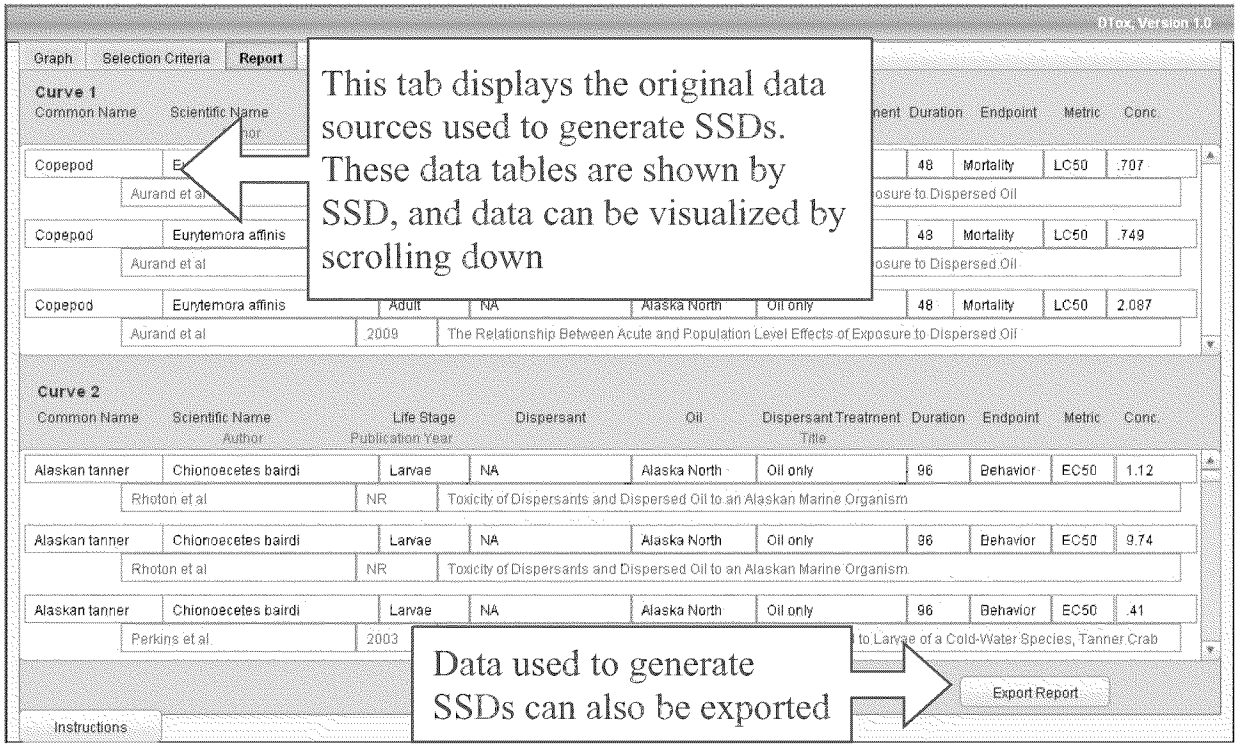
4. The final output

Queried data are combined to generate Species Sensitivity Distributions (SSDs). SSDs describe the sensitivity of aquatic species to the exposure media, where each point on the curve represents the geometric mean of all toxicity data available for a uniquely identified species (e.g.,

calculated by scientific name). SSDs are generated by ranking the relative sensitivity of individual from the least to the most sensitive, and are useful in that benchmark concentrations (hazardous concentration, HC) can be derived as a measure of risk. Here the 1st and 5th percentiles of the SSD (HC1 and HC5, respectively; in mg/L) are used as benchmark concentrations under the assumption that these would be protective of 99% and 95%, respectively, of the species on the SSD.

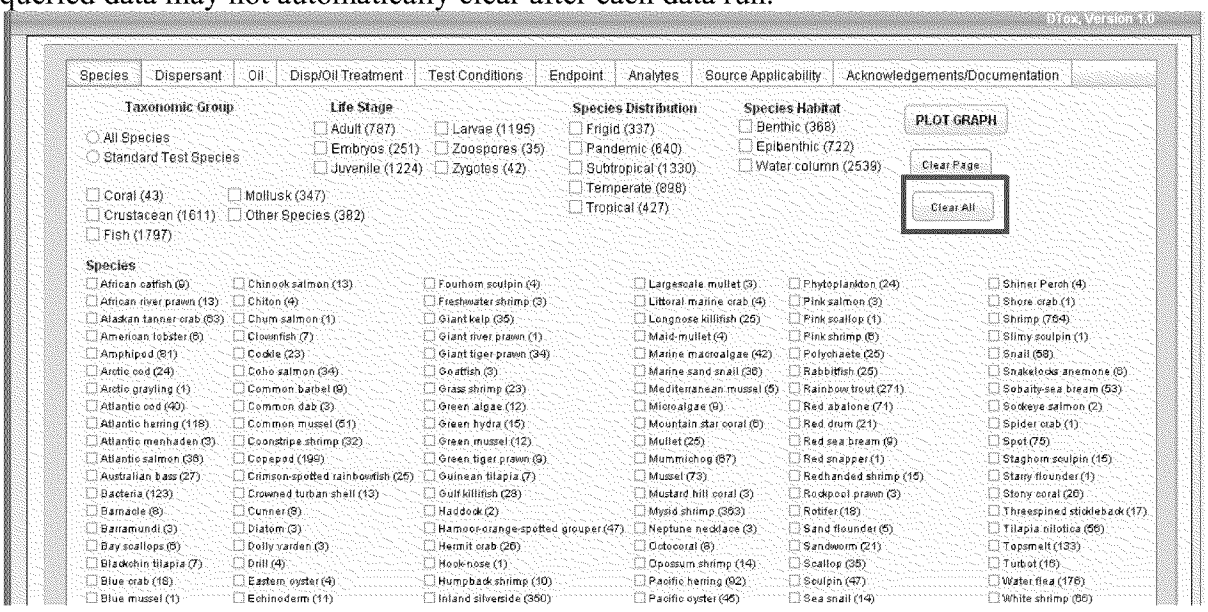



DTox Version 1.0
Graph
Selection Criteria
This tab summarizes data selection made from the eight query tabs
SPECIES INFORMATION
Group
Name
Life Stage
Distribution
Habitat
Oil
Dispersant:Oil Ratio
Oil Stage
Oil Class
Medium
Light
TEST ENVIRONMENT
Study Type
Water Type
Duration
Exposure Conditions
96 Hrs
48 Hrs
RESULTS CRITERIA
Endpoint Metric
Endpoint
Concentration
EC50
LC50
Analyte Type
Analytical Methods
Total Hydrocarbon Content
REPORT CRITERIA
Applicability
High
Moderate
Instructions


DTox Version 1.0
Graph
Selection Criteria
Report
This tab displays the original data sources used to generate SSDs. These data tables are shown by SSD, and data can be visualized by scrolling down
Curve 1
Common Name
Scientific Name
Duration
Endpoint
Metric
Conc
Copepod
Aurand et al
48
Mortality
LC50
.707
Copepod
Eurytemora affinis
48
Mortality
LC50
.749
Copepod
Eurytemora affinis
Adult
NA
Alaska North
Oil only
48
Mortality
LC50
2.087
Aurand et al
2009
The Relationship Between Acute and Population Level Effects of Exposure to Dispersed Oil
Curve 2
Common Name
Scientific Name
Author
Life Stage
Publication Year
Dispersant
Oil
Dispersant Treatment
Title
Duration
Endpoint
Metric
Conc
Alaskan tanner
Chionoecetes bairdi
Larvae
NA
Alaska North
Oil only
96
Behavior
EC50
1.12
Rhoton et al
NR
Toxicity of Dispersants and Dispersed Oil to an Alaskan Marine Organism
Alaskan tanner
Chionoecetes bairdi
Larvae
NA
Alaska North
Oil only
96
Behavior
EC50
9.74
Rhoton et al
NR
Toxicity of Dispersants and Dispersed Oil to an Alaskan Marine Organism
Alaskan tanner
Chionoecetes bairdi
Larvae
NA
Alaska North
Oil only
96
Behavior
EC50
.41
Perkins et al
2003
Data used to generate SSDs can also be exported
Export Report
Instructions

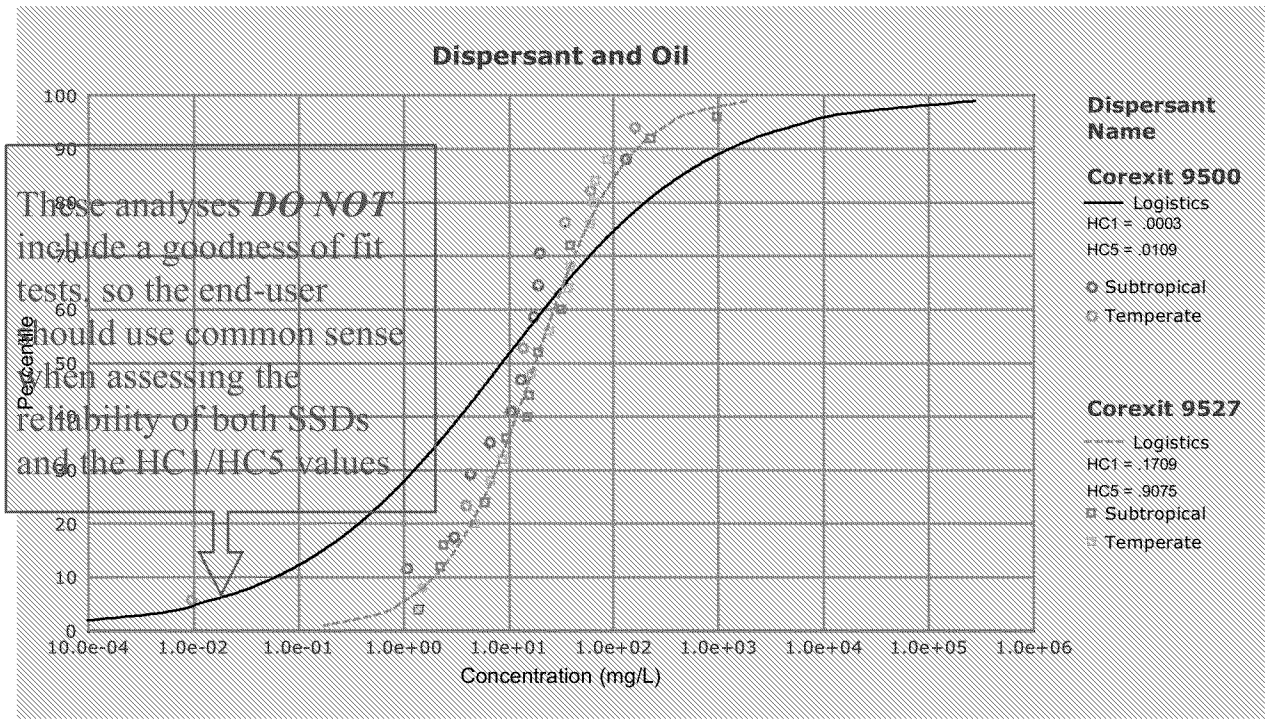
Note 1:

To ensure optimal performance and query replicability, press "clear all" after each query run. This is highly recommended step when performing multiple queries as the table containing the queried data may not automatically clear after each data run.



Note 2:

A note of caution…



Zip File Bonus!.

The zip file containing the executable file of DTox also includes the EndNote® library, with all the references evaluated during the development of this tool

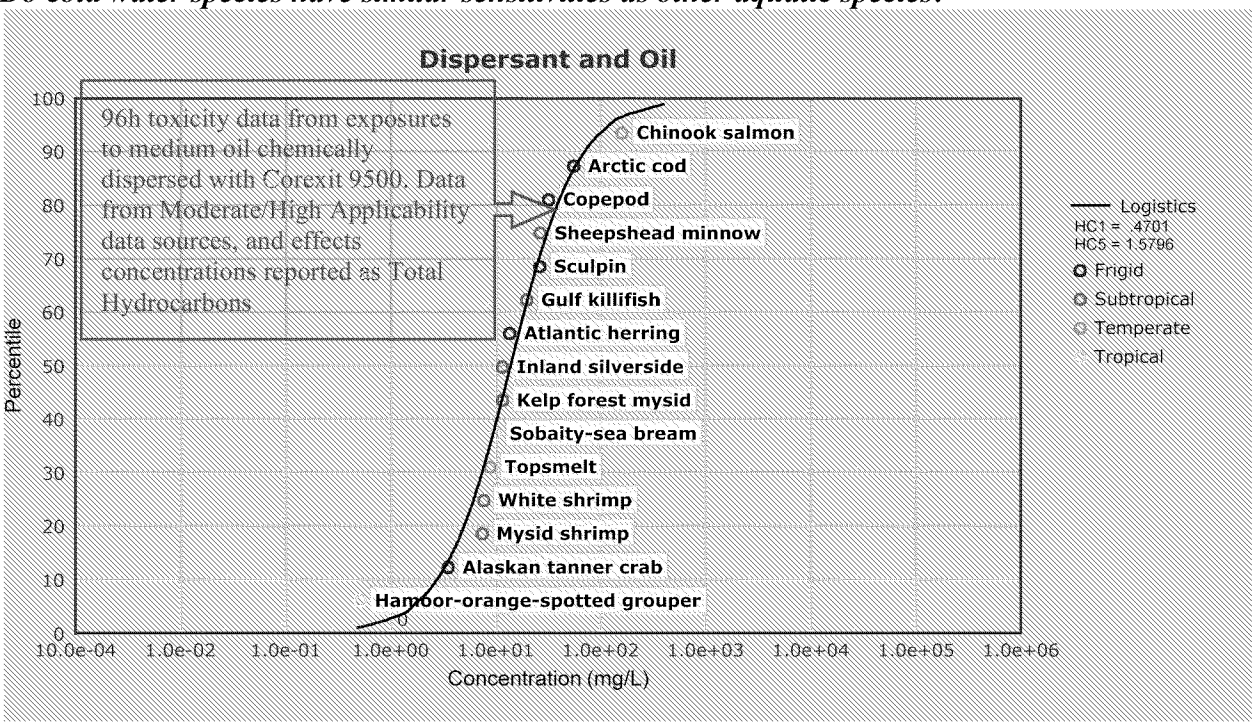
Name			
Recover.log			
DTOX.fmpur			
DTox_COMPRESSED.enl			
DTox_COMPRESSED.enlx			
zlib1.dll			
XText.dll			
XGrfx.dll			
XFC.dll			
xerces-c_3_0.dll	1,839 KB	Application Extension	3/21/2013 1:47 PM
XDraw.dll	526 KB	Application Extension	3/21/2013 1:47 PM
XCore.dll	91 KB	Application Extension	3/21/2013 1:47 PM
XalanMessages_1_11.dll	47 KB	Application Extension	3/21/2013 1:47 PM
xalan-c_1_11.dll	1,797 KB	Application Extension	3/21/2013 1:47 PM
ViewSystem.dll	745 KB	Application Extension	3/21/2013 1:47 PM
ToolkitPro1122vc90U.dll	6,254 KB	Application Extension	3/21/2013 1:47 PM
Support.dll	1,990 KB	Application Extension	3/21/2013 1:47 PM
ssleay32.dll	235 KB	Application Extension	3/21/2013 1:47 PM
SkiaDLL.dll	467 KB	Application Extension	3/21/2013 1:47 PM
ProofReader.dll	522 KB	Application Extension	3/21/2013 1:47 PM
openssl.dll	365 KB	Application Extension	3/21/2013 1:47 PM
OmniThread.dll	29 KB	Application Extension	3/21/2013 1:47 PM
OmniORB4.dll	1,203 KB	Application Extension	3/21/2013 1:47 PM
OmniDynamic4.dll	1,451 KB	Application Extension	3/21/2013 1:47 PM
NSViews.dll	51 KB	Application Extension	3/21/2013 1:47 PM
MFCX.dll	108 KB	Application Extension	3/21/2013 1:47 PM
libsasl.dll	198 KB	Application Extension	3/21/2013 1:47 PM
libetpan.dll	481 KB	Application Extension	3/21/2013 1:47 PM
libeay32.dll	1,114 KB	Application Extension	3/21/2013 1:47 PM
libcurl.dll	201 KB	Application Extension	3/21/2013 1:47 PM
FMWrapper.dll	117 KB	Application Extension	3/21/2013 1:47 PM
FMRSRC.dll	9,539 KB	Application Extension	3/21/2013 1:47 PM
FMOLE.dll	103 KB	Application Extension	3/21/2013 1:47 PM
FMEngine.dll	4,391 KB	Application Extension	3/21/2013 1:47 PM
DBEngine.dll			
DTox.exe			
HowTo_DTox.pdf			

Pdfs of this document and the QA/QC plan are also in the DTox folder

ED_001324_00006631-00063

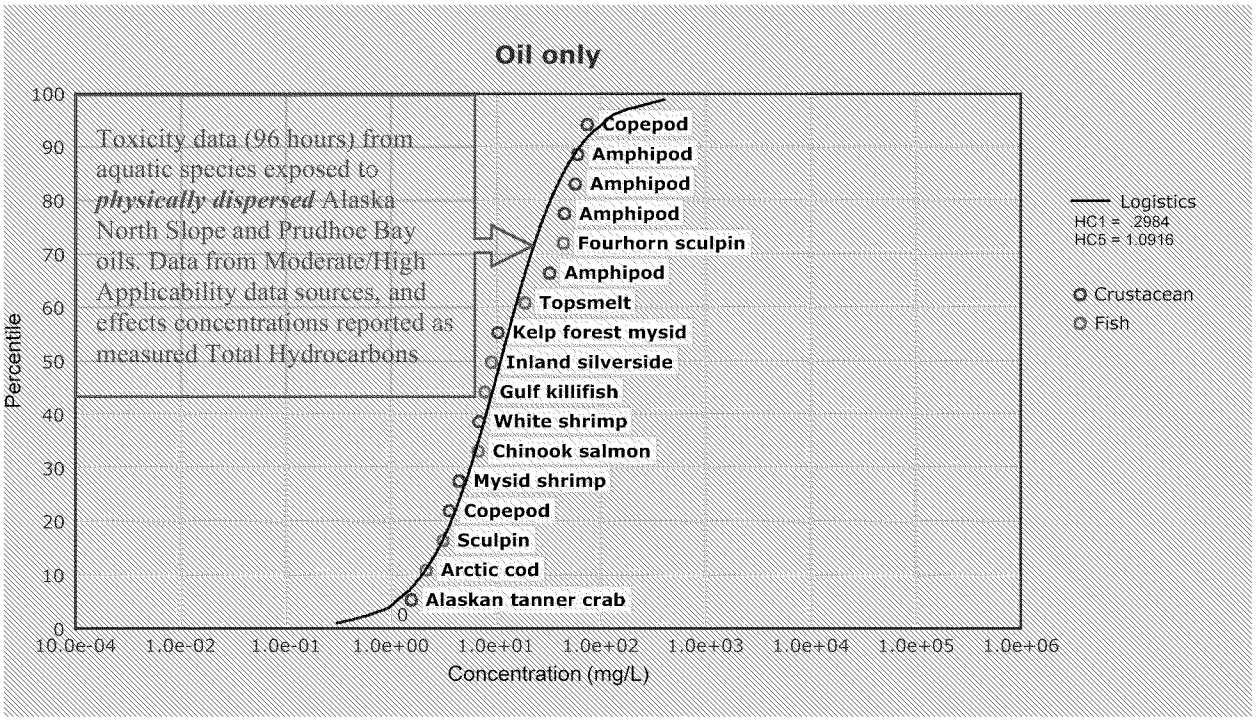
How to use outputs from DTox:
Data in DTox has several practical applications, including their use to address and answer basic questions:

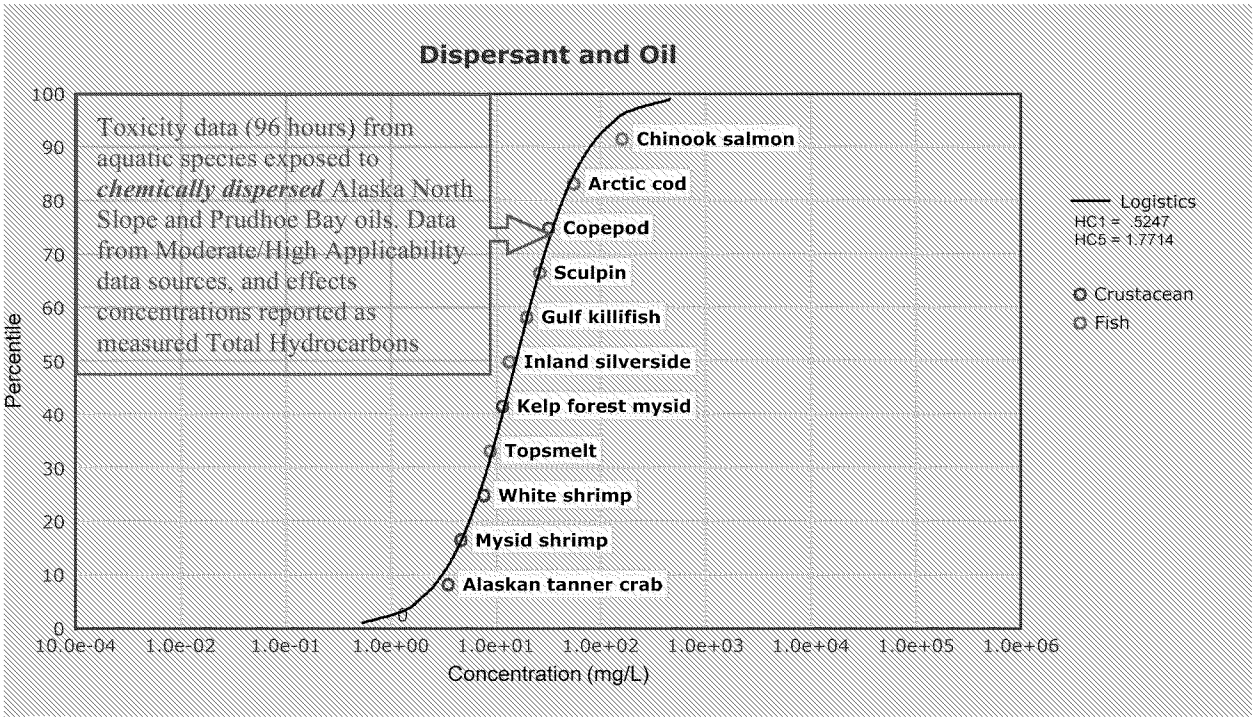
Do cold water species have similar sensitivities as other aquatic species?



Answer: Yes. Cold water species have similar sensitivities to medium oil chemically dispersed with Corexit9500 as temperate species (top plot), as well as one of the U.S. standard test species (topsmelt) (bottom plot). Therefore, both temperate and U.S. standard test species may be suitable surrogate for cold water species in toxicity testing of oil and dispersants.

Does Corexit 9500 increase the toxicity of Alaskan oils?





Answer: No. Based on the best available toxicity data available to date, there is no evidence that Corexit9500 increases the toxicity of Alaskan oils. As shown above, curves from physically and chemically dispersed oil are similar and both have comparable hazard concentrations (HCs).

To: 1145tg@listserve.api.org[1145tg@listserve.api.org]
From: Drieu, Mike
Sent: Mon 5/2/2016 1:46:29 PM
Subject: FW: Resources at Risk Document for HWCG Drill - Example for Environmental Tradeoffs (NEBA) Discussion
HCWG Drill Resources at Risk NOAA.docx

Thanks to NOAA for sending latest RAR info that could be used for NEBA section in API subsea dispersants document we are using on. It is 15 pages and shows extensive detail and good references.

If this is accepted as baseline for future concurrence packages for subsea dispersant use, we may consider using this entirely and incorporate as another Annex.

Thanks,

Mike Drieu

Anadarko Petroleum Corporation

"Enhance Preparedness; Reduce Risk"

EHS Advisor

(O) 832.636.8493

(F) 832.636.0435

(M)281.844.0813

From: Paige Doelling - NOAA Federal [mailto:paige.doelling@noaa.gov]
Sent: Friday, April 29, 2016 2:58 PM
To: Drieu, Mike; Robert Simmons; Braddock, Mary; aahnell@exponent.com; John Temperilli; Bess, Amanda S; Brandon Klopfenstein; Horace Bussey; Jon Unwin; Nedwed, Tim J; Cramer, Marty:; Roland Goodman; Condon, Michael W; Walker, Samuel; Steve Buschang
Subject: Resources at Risk Document for HWCG Drill - Example for Environmental Tradeoffs (NEBA) Discussion

Hi Mike,

In support of the upcoming HWCG drill, I had NOAA's resources at risk contractor, Research Planning, Inc, develop the attached resources at risk document.

In my opinion, it contains the appropriate level of detail for an incident-specific evaluation of dispersant use. I am forwarding it along to the work group to inform the planned discussions on the NEBA part of the guidance document.

I used the circulation list from the last invitation, so if I've left anybody out, please forward along.

Also, because all SSCs don't think exactly alike, I've asked my fellow SSCs to take a look at it as well.

I plan on attending the work group meeting in May, and hoepfully will be able to attend some of the later ones as well.

See you in May,

Paige

--

Paige Doelling, PhD

NOAA Scientific Support Coordinator

for USCG District 8

Houston, TX

Mobile: 206-549-7819

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DRILL- DRILL- DRILL Resources at Risk for the northern Gulf of Mexico (GOM)

I. Spill Source Information

This report was prepared on 27 April 2016. Information in this report is meant to cover a release of approximately 6,500 barrels per day of Louisiana crude originating on May 10th at 28°40'59.913" N and 88°10'34.391" W. The spilled product is moving north and east, and will impact the shoreline primarily in Mississippi, Alabama, and Florida if it makes landfall.

II. Geographic Region Covered

The resources covered in this report are those expected to be found in the offshore area corresponding to block MC-300, the adjacent continental shelf, and coastal zone extending from lease block MC-300 to the shore from the Chandeleur Islands, LA to Destin, FL.

III. Oil type, behavior and effects to impacted species

Louisiana crude is a light crude that has an API of 37. It has moderate concentrations of toxic compounds and is moderately volatile. Observations during aerial surveys indicate that the crude oil readily emulsifies (both during its 5,000 ft rise to the water surface and by wave action on the sea surface). Thick emulsified oil occurs as large patches (tens of meters in diameter), long streamers, and smaller tarballs. Large areas of sheens are associated with the emulsified oil. The oil could concentrate in convergence zones, in patches of Sargassum (where sea turtles and birds may also concentrate).

Oil that reaches nearshore and coastal areas will mostly be weathered crude oil from the well. These relatively large accumulations of emulsified oil can heavily coat intertidal areas. The emulsified oil could also become mixed with sand, either in the surf zone or after stranding onshore. These oil:sand mixtures are heavier than water and could accumulate as submerged oil mats in nearshore areas off Gulf sand beaches. They can become buried by the movement of offshore bars, be buried within the beaches, and persist for years. The oil can become trapped in and form thick deposits along fringing marsh shorelines. The stability of the emulsions, once stranded on the shoreline and sheltered from wave action, is uncertain. One possibility is that the emulsion could break, releasing liquid oil that could be only moderately weathered (emulsification slows weathering processes such as evaporation and dissolution). The release of liquid oil inside the marsh fringe or on beaches could cause significant additional impacts to benthic, water-column, and water-surface resources in these shallow water habitats. Animals may not avoid the weathered emulsified oil, particularly if it does not provide any indication of hazards (e.g., it might not smell oily, could look like natural debris), and animals could still attempt to feed in the open areas between the patches that would still have some sheen. Further away from the source, tarballs (oil <10 cm in diameter), tar patties (oil >10 cm), and occasional tarmats may strand along the shoreline. These oil deposits could range in texture from soft, emulsified oil to semi-hardened outer layers. The oil may adhere to aquatic vegetation, birds, fur-bearing mammals, and reptiles. Oil coming ashore will be weathered so oil effects are likely to

be a result of coating and smothering of shoreline resources, ingestion of tarballs by sea turtles, and the persistence of oil in sediments.

Background on Potential Effects

The impacts arising from oil spills on aquatic species in open waters likely varies by species and with the rate at which oil partitions and dilutes in the water column, and with the co-occurrence of sensitive life stages and both physically and chemically dispersed oil. Species that may be at increased risk of exposure to chemically dispersed oil are those entrained within and traveling with the water mass containing the chemically dispersed oil (e.g., small species, embryos, larvae, zooplankton), followed by slow-moving species and life stages. Highly mobile species (e.g., adult shrimp, pelagic fish) may be less likely to be exposed to high concentrations of chemically dispersed oil due to dilution and avoidance.

Toxicity Studies

Exposure of aquatic species, and in particular early life stages, to physically and chemically dispersed oil can lead to lethal and non-lethal but ecologically important impacts (Teal and Howarth, 1984; Albers, 1995; NRC, 2005), but the onset of these impacts depends on several factors including oil concentrations and exposure duration. A growing body of literature (e.g., Carls *et al.*, 1999; Heintz *et al.*, 1999; Heintz *et al.*, 2000; Incardona *et al.*, 2004; Incardona *et al.*, 2005; Incardona *et al.*, 2011; Incardona *et al.*, 2013; Mager *et al.*, 2014; Esbaugh *et al.*, 2016) has shown that under controlled laboratory conditions fish embryos exposed for several hours post hatch to low oil concentrations (>1 mg/L oil, dissolved polycyclic aromatic hydrocarbons [PAHs] in the low µg/L range) develop gross abnormalities, with permanent impacts potentially causing reduced survival later in life (Incardona *et al.*, 2013). These impacts have been documented under laboratory conditions on embryos of pelagic species (i.e., yellowfin tuna [*Thunnus albacares*], Southern bluefin tuna [*T. maccoyii*], yellowtail amberjack [*Seriola lalandi*], and mahi mahi [*Coryphaena hippurus*]), some of which occur in the Gulf of Mexico (Incardona *et al.*, 2014; Mager *et al.*, 2014; Esbaugh *et al.*, 2016). However, the impacts arising from oil spills on fish embryos in open waters and their recruitment to the larval stages likely varies with the rate at which oil partitions and dilutes in the water column, as well as with the co-occurrence of fish embryos and the chemically dispersed oil. As a point of reference, a large proportion of water samples (75%) collected during the *Deepwater Horizon* oil had total PAH concentrations <1 µg/L, though water samples in the immediate vicinity of the wellhead had concentrations >1,000 µg/L (Boehm *et al.*, 2016). In contrast to these sensitive life stages, juveniles and adults are generally highly mobile and may only be temporarily exposed to chemically dispersed oil given their ability to move in and out of the water masses containing the entrained oil.

One of the greatest limitations in understanding the potential impacts related to dispersant use in open waters is the lack of data derived using relatively realistic exposure conditions. Even greater uncertainties and data limitations exist on the potential impacts of subsea dispersants.

Despite these limitations, toxicity data from controlled laboratory studies could provide conservative estimates of potential impacts. Toxicity data are commonly reported as lethal or effects median concentrations (LC50 and EC50, respectively[1]). With regards to dispersants alone, data based on spiked exposures[2] show that most data fall within the slightly to practically nontoxic range[3], with most data falling within the practically nontoxic range. Even for sensitive species, most toxicity values for COREXIT 9527 and COREXIT 9500, regardless of exposure conditions, are >20 mg/L, falling within the range of what is considered slightly toxic. Similarly, the reported toxicity of South Louisiana crude oil chemically dispersed with COREXIT 9500 from 96-h (LC50s and EC50s combined) constant static exposure[4] ranges from 4.84 to 18 mg THC/L (n=8 records) (NOAA/ERD, 2015), falling within the moderately to slightly toxic range.

Potential Levels of Concern

Derivation of potential thresholds of concern could be achieved by the use of Species Sensitivity Distributions (SSDs). SSDs are cumulative distributions of toxicity data that allow for comparisons of the relative sensitivities of aquatic species dispersed oil, and they are useful in that they could be used to calculate the 5th percentile Hazard Concentration (HC5), or concentrations assumed to be protective of 95% of all species in the SSD. While HC5 values may not be necessarily protective of all aquatic organisms, and particularly of those known to be most sensitive to oil, their derivation is often conservative enough to a large range of sensitivities. Conservative estimates HC5s for COREXIT 9527 and COREXIT 9500 are 8.38 mg/L and 4.04 mg/L, respectively, falling within the moderately toxic range. However, these concentrations are assumed to be worst case, as exposure concentrations under standard dispersant applications (ASTM, 2010a; ASTM, 2010b) are not expected to remain constant in the water column, and at any given moment are likely below these concentrations. Based on modeled information of toxicity data (96-hr exposures) for South Louisiana crude oil, the conservative HC5 estimate is 0.97 mg THC/L with a 95% confidence interval of 0.63-1.49 mg THC/L (Bejarano and Barron, 2014). These values fall within the upper and lower ends of the highly toxic and the moderately toxic range, respectively. As a point of reference the range of oil concentrations in the chemically dispersed underwater plume range from non-detectable levels to 6,130 mg/L, with a geometric mean of 1.09 µg/L (Boehm *et al.*, 2011). Given that this oil release is smaller in volume (6,500 bbl/d) than the estimated release rate of the *Deepwater Horizon* oil spill (ca. 50,000-60,000 bbl/d[5]), the THC concentrations would be expected to be lower.

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[1] The LC50 is the concentration lethal to 50% of the exposed test population, while the EC50 is the concentration that causes an adverse non-lethal effect to 50% of the exposed test population. As a general rule, the smaller the LC50 or EC50 values, the greater the toxicity.

[2] Spiked or spiked flow-through tests are tests that address the dilution that occurs in open waters by reproducing under laboratory conditions rapid changes in concentrations within the water column.

[3] Toxicity LC50 and EC50 categories for aquatic organisms are as follows: Very highly toxic <0.1 mg/L, Highly toxic 0.1-1 mg/L, Moderately toxic >1-10 mg/L, Slightly toxic >10-100 mg/L and Practically nontoxic >100 mg/L Source: http://www2.epa.gov/pesticide-science-and-assessing-pesticide-risks/technical-overview-ecological-risk-assessment-0

[4] Exposures that do not account for the natural dilution that occurs in open waters.

[5] Source: Oil Budget Calculator Deepwater Horizon

Potential Impacts

As describe above, HC5 values could be used as surrogate for threshold concentration, with the lower confidence value for South Louisiana crude oil (0.63 mg/L; 96-hr exposures) serving as a conservative threshold to assess potential impacts to the most sensitive life stages. While these concentrations may be possible, it is unlikely that these concentrations would remained elevated for a long period given the dilution that may occur within the water column. Although short exposures have the potential to negatively impact embryos, natural mortality of larvae is high, and the projected plume is limited in geography compared to most larval distributions. Therefore, impacts on entire populations are unlikely. However, given that early life stages of several species (**Table 1**) may be present in the area and their spatial distribution overlap with the water mass containing chemically dispersed oil, it is expected that a portion of each species' cohort would be exposed. Because most other aquatic groups (i.e., sea turtles, marine mammals) are able to swim through water mass containing chemically dispersed oil, potential impacts are likely minimal. A greater risk of exposure may result from inhalation of volatile compounds and smothering at the water surface.

(http://www.restorethegulf.gov/sites/default/files/documents/pdf/OilBudgetCalc_Full_HQ-Print_111110.pdf)

Table 1. List of representative species in the offshore area of interest with early life stages at risk of potential exposure to the water mass containing chemically dispersed oil.

Species	Spatial Overlap with Early Life Stages	Potential Impacts
White and brown shrimp	Spawning inshore of the area of interest; eggs and larvae may be present	Early life stages in shelf waters may be exposed and experience mortality. It is not likely that a large proportion of the population is exposed to oil, given the timing and location of the spill relative to these species' habitats.
Blue crab	Spawning inshore of the area of interest; eggs and larvae may be present	
Bluefin tuna, yellowfin tuna	Spawning in the area; eggs and larvae are present	Early life stages may be exposed and larval mortality can occur. Given that natural mortality rates are high, population level impacts are unlikely.
Swordfish	Larvae may be present year-round in the area	Early life stages may be exposed. It is not likely that a large proportion of the population is exposed to oil, given the timing and location of the spill relative to these species' habitats.
Other pelagic species (e.g., dolphinfish, blackfin tuna, blue marlin, dolphinfish, wahoo, whale shark, white marlin, amberjack, mackerel)	Early life stages may be present in the area; spawning mostly in a different geography.	
Red grouper, scamp, and red, lane, gray and vermilion snapper	Spawning in the area; eggs and larvae may be present	

IV. Shoreline Resources at Risk

Shorelines in the area of impact consist of barrier islands (including Breton, Cat, Ship, Horn, Petit Bois, Dauphin, Santa Rosa, Okaloosa Islands) with mainly fine-medium grained sandy beaches. Mainland shorelines are primarily salt marshes with interspersed pockets of fine- to medium-grained sand beaches. Fresh- and brackish-water marshes may be present in some areas depending on localized freshwater input. Manmade shorelines (riprap, seawalls) are also present in developed areas. Some sheltered flats are present and may be exposed dependent on wind conditions. Riprap jetties are present at the mouth of Destin inlet (East pass) and Perdido Pass.

Because of the broken nature of the interior shoreline, the thick emulsified oil patches and tarballs could penetrate deeply beyond the outer "shoreline" depending on wind conditions, into areas that are very shallow, muddy, and difficult to access. The emulsified oil will readily adhere to marsh vegetation and could form thick bands on the vegetation as water levels vary. There is

also the possibility that the emulsions could break after stranding on the marsh and release liquid oil, which could spread over a much larger area than the footprint of the emulsified oil patches.

Emulsified oil deposited on fine-medium grained beaches is unlikely to penetrate deep into the sediment (<4 mm); however, depending on local conditions, accumulation of sand may result in rapid burial of stranded oil. Some of the barrier islands have a low elevation and could be overwashed during high wind conditions. If oil was present at that time, it could be transported across the islands and either buried in the washover fan or deposited in the marshes on the leeward side of the island. On outer sand beaches, the tarballs and tar patties will collect in debris lines near the high tide mark. Depending on the tides and the concentration of tarballs in the water, the collection zone may be from less than a meter to several meters wide. There may also be scattered tarballs across the rest of the beach face, but in much lower concentrations. The outer shell of the tarball may be heavily weathered by the time it reaches these beaches, making it less sticky with less of a tendency to pick up sediments. However, the inside of the tarball may still be relatively fresh, so if pressure is applied, the outer skin will rupture and the tarball may adhere to whatever it is in contact with. Also when stranded out of the water, the daytime heating may melt the tarballs causing them to adhere to whatever surface they are on at the time. Depending on the beach cycle, the tarballs and patties can become buried during depositional cycles. Therefore, rapid removal is important.

Oil may adhere to rough surfaces, such as riprap and seawalls, leaving a band at the high-water line. In the riprap areas, emulsified oil and tarballs may collect in the crevices between the rocks; there is often debris in these crevices, which can also become oiled, which can be a source for chronic reoiling.

V. Biological Resources at Risk

Threatened, Endangered, and Special Concern (T/E) Species

Birds

Louisiana - Brown pelican (LA SE, over 8,500 pairs) are present and nesting on and around the Chandeleur Islands. Red knot (FT) are present on the shores of the Chandeleur Islands.

Mississippi - Brown pelican (MS SE) and snowy plover (MS SE, nesting) are present on Mississippi barrier islands and Mississippi mainland shorelines. Brown pelican are also present on Mississippi nearshore waters.

Alabama - Least bittern (AL State Protected (SP)), white ibis (AL SP, nesting in locations east of Mobile Bay), mottled duck (AL SP, nesting), northern harrier (AL SP) are present on the back sides of AL barrier islands. Reddish egret (AL SP) are present on and around AL barrier islands and in nearshore waters west of Mobile Bay. Snowy plover (AL SP) is present on islands surrounding Dauphin Island Bay, and it is nesting on Pelican Island, a large sandbar south of Dauphin Island. Wilson's plover (AL SP) is present and nesting on islands surrounding Dauphin

Island Bay and Pelican Island. American oystercatcher (AL SP) is present and nesting on Pelican Island and ocean beaches east of the mouth of Mobile Bay. Willet (AL SP) is present and nesting on the west end of the Mobile Point peninsula and is present on islands surrounding Dauphin Island Bay and ocean beaches east of the mouth of Mobile Bay. Black skimmer (AL SP), common tern (AL SP) and gull-billed tern (AL SP) are present and nesting on Pelican Island. Caspian tern (AL SP) are present on the back sides of AL barrier islands, islands surrounds Dauphin Bay, and beaches at the west end of the Mobile Point peninsula. Royal tern (AL SP) is present in nearshore waters west of Mobile Bay and in waters on the back side of barrier islands east of Mobile Bay. Sandwich tern (AL SP) is present on ocean beaches east of the mouth of Mobile Bay. Seaside sparrow (AL SP) is present and nesting on the islands north of Dauphin Island Bay.

Florida - Black skimmer (FL Species of Special Concern (SSC)), brown pelican (FL SSC), and least tern (FL ST) are present throughout the Florida potential impact area. Piping plover (FT, FL ST) are present on ocean beaches and the back sides of barrier islands throughout the Florida potential impact area. Reddish egret (FL SSC, occasional) and snowy egret (FL SSC, occasional) are present in lagoons/ponds? behind the beach east of Destin. Snowy plover (FL ST) are present and nesting on beaches of barrier islands from the FL/AL border to the east end of Santa Rosa Island.

Reptiles

Five species of endangered or threatened sea turtles inhabit the Gulf of Mexico. Of those, Kemp's ridley (FE, LA E, MS E, AL SP) , leatherback (FE, LA E, MS E, AL SP) and loggerhead (FT, LA T, MS E, AL SP) are most likely to be present in offshore waters near the source of the spill. Turtles are most likely to be encountered in offshore waters (> 5.6 km from shore), and less than 100 m in depth, and are more frequently sighted from spring to fall. Loggerhead turtles are known to frequent oil production platforms. Juvenile turtles are often found associated with *Sargassum* mats, where oil can also accumulate. Nearshore, Kemp's ridley are abundant, loggerheads are common, Green (FE in Florida, FT elsewhere; LA T, MS E, AL SP) are occasional visitors, leatherbacks are rare, and hawksbill (FE, LA E, MS E, AL SP) are very rare or rare.

Sea turtle nesting season is in progress. Nesting occurs in the area of impact, and is summarized below:

- Loggerheads nest on beaches east of Ship Island, MS in low-medium concentrations
- Greens nest in low concentrations on beaches in Alabama and Florida
- Kemp's ridley nest in Alabama in low concentrations
- Leatherback nesting has occurred in the Panhandle of Florida but is rare

Diamondback terrapins (AL SP) can be found along the gulf shoreline in the area of impact.

Direct contact with oil may irritate the eyes, mouth, and nostrils of turtles. Turtles may also ingest tarballs while foraging.

Fish

Gulf sturgeon (FT, LA E, MS E, AL SP) and smalltooth sawfish (FE) may be present in the GOM in the area of impact. Most sturgeon are migrating upstream at this time of year; however, some may remain in coastal areas. Juvenile and adult sawfish may be present in coastal areas and on the continental shelf off of the Florida coast. Both species are demersal and are not common around the spill site, so impacts are likely to be limited. Populations of Alabama shad (AL SP) occur in coastal waters likely to be impacted. Adults return to saltwater habitats in Apr-May after spawning upstream.

Marine mammals

Of the 29 species of marine mammals known to occur in the Gulf of Mexico, all are protected and six (sperm, sei, fin, blue, humpback and North Atlantic right whales) are listed as endangered under the ESA. Of these, only the sperm whale is considered to commonly occur, in the northern Gulf of Mexico. Areas beyond the 100 m isobath are important habitat for endangered Sperm whale (FE, LA E). West Indian manatee (FE, LA E, MS E, AL SP), occurs primarily in Florida bays, estuaries and coastal waters but their range appears to be expanding, and could also be present in sheltered waters in Alabama, Mississippi, and Louisiana. The primary risk of oil spills to marine mammals is inhalation of volatile compounds from fresh oil and ingestion of oiled prey.

Terrestrial mammals

The Perdido Key Beach Mouse (FE, AL SP) is present on beaches and in dune habitats on Perdido Key. Alabama Beach Mouse (FE, AL SP) can be found on beaches from Fort Morgan to Gulf State Park in Alabama. Mice can ingest tarballs and encounter subsurface oil while burrowing, exposing them to the toxic components of oil.

<u>Other Birds</u>

Offshore birds

High concentrations of common tern occur offshore in the impact area. Other offshore bird species present in the area include: Audubon's shearwater, band-rumped storm-petrel, black-capped petrel, brown booby, herring gull, laughing gull, Leach's storm-petrel, long-tailed jaeger, magnificent frigatebird, masked booby, pomarine skua, red-billed tropicbird, sooty tern, Wilson's storm-petrel.

Nearshore and shoreline birds

Louisiana - American oystercatcher (26 pairs), least tern (123 pairs), and Wilson's plover (164 pairs) are present and nesting on the Chandeleur Islands. Over 5,000 pairs of terns are present and nesting on the southern Chandeleur Islands. Scaup (100,000s) occur nearshore just east of the Chandeleurs Islands. American white pelican (10s) may be present immediately around the

Chandeleur Islands. "Nearshore" birds present in waters off Louisiana extend to the edge of the continental shelf and include: gulls, magnificent frigatebird, parasitic jaegar, pomarine skua, royal tern, and sandwich tern.

Mississippi - Birds present on and immediately surrounding Mississippi barrier islands include nesting marsh birds (clapper rail, king rail, least bittern), shorebirds (American oystercatcher [nesting], killdeer, sanderling, semipalmated plover [nesting], willet [nesting], Wilson's plover [nesting]), terns (black skimmer, gull-billed tern [nesting], least tern, royal tern, sandwich tern), raptors (bald eagle [nesting], osprey [nesting]), gulls, wading birds (black-crowned night-heron [nesting], cattle egret, great blue heron, great egret, green heron, little blue heron, reddish egret, snowy egret, tricolored heron, yellow-crowned night-heron [nesting]), dabbling ducks, and migratory songbirds. Many of the same species are found along the mainland shoreline of Mississippi, including several species of shorebirds, raptors, and several species of gulls and terns. Birds present in Mississippi salt marshes include the aforementioned wading bird and marsh bird species, marsh-obligate passerines, rails, and several species of waterfowl (including blue-winged teal, Canada goose [nesting], hooded merganser [nesting], mottled duck [nesting], and wood duck [nesting]). Nearshore birds in Mississippi include gulls, terns, waterfowl and sea ducks, common loon, and pied-billed grebe.

Alabama - Birds present on and immediately surrounding Alabama barrier islands include brown pelican, nesting marsh birds (clapper rail, king rail, sora), shorebirds (black-bellied plover, black-necked stilt, killdeer [nesting], least sandpiper, lesser yellowlegs, sanderling, semipalmated plover, solitary sandpiper, stilt sandpiper, western sandpiper), gulls (Bonaparte's gull, herring gull, laughing gull, ring-billed gull), raptors (bald eagle, osprey), wading birds (great blue heron [nesting], great egret [nesting], green-backed heron [nesting], green heron [nesting], snowy egret [nesting], tricolored heron), and waterfowl (mallard, Canada goose [nesting]). Many of the same species are found along the mainland shoreline of Alabama, including raptors, gulls, terns, and marsh birds. Birds present in Alabama salt marshes include the aforementioned wading bird and marsh bird species, rails, and waterfowl. Nearshore birds in Alabama include gulls, terns, raptors, brown pelican, magnificent frigatebird, northern gannet (common), common loon, horned grebe, and pied-billed grebe.

Florida - Birds present on and immediately surrounding Florida barrier islands include shorebirds (black-bellied plover, dunlin, sanderling, semipalmated plover, short-billed dowitcher, willet [nesting], Wilson's plover), terns (Forster's tern, common tern, royal tern), gulls (laughing gull, ring-billed gull), double-crested cormorant, osprey. Many of the same species are found along the mainland shoreline of Florida, including osprey and several species of gulls and terns. Birds present in lagoons behind beaches east of Destin include bald eagle, gull-billed tern, shorebirds (least sandpiper, lesser yellowlegs), and wading birds (great blue heron, great egret, green heron, yellow-crowned night-heron). Nearshore birds in Florida include gulls (laughing gull, ring-billed gull), terns (common tern, royal tern), and osprey.

Oil can adhere to the feathers reducing insulation, water buoyancy, and water repellency, leading

to sickness or death from hypothermia and/or drowning. Diving birds, such as cormorants and loons, are usually at high risk during oil spills because they spend nearly all their time on the water surface. Wading birds, shorebirds, dabbling ducks, gulls, and terns, can also be severely impacted by oil in some cases. Wading birds and some shorebirds may be directly oiled and can become oiled on the upper body and feathers by coming in contact with oiled vegetation or wrack. Direct oiling of birds reduces the buoyancy, water repellency, and insulation provided by feathers, and may result in death by drowning or hypothermia. Preening of oiled feathers may also result in ingestion of oil resulting in irritation, sickness, or death. Bird oiling may continue even after the floating oil slicks have been removed, depending on the extent of oiled habitat. Oil brought back to the nests by adult birds may kill or injure eggs and young birds. All species can potentially ingest oil while feeding. Wading birds and marsh birds (i.e. American bittern) eat small fish, insects, and crustaceans and may be at risk of coming in contact with oil on the water or oiled marsh vegetation while feeding.

Other Marine Mammals

Offshore - A small population of Bryde's whale, the only baleen whale to commonly occur in the Gulf, inhabits the shelf break region in the northeastern Gulf. Pods of transient Killer whales have been sighted with increasing frequency over the past several decades in the Gulf of Mexico, including off the Mississippi Delta. Other species that may be found in the vicinity of the spill site include: Blainville's beaked whale (common), Clymene dolphin (low), Cuvier's beaked whale (common), Dwarf sperm whale (common), False killer whale (rare), Fraser's dolphin (Rare), Gervais' beaked whale (common), Killer whale (low), Melon-headed whale (common), pantropical spotted dolphin (abundant), pygmy killer whale (low), pygmy sperm whale (common), Risso's dolphin (common), Rough-toothed dolphin (low), Short-finned pilot whale (common), spinner dolphin (low), striped dolphin (common). Little information is available on the reproduction and calving of offshore whales and dolphins in the Gulf. However, a number of species do breed and calve in winter through early summer.

Nearshore and inshore - Atlantic spotted dolphins may be present on the shelf. Bottlenose dolphin are abundant and common in bays, estuaries and inter-bay passes in the northern Gulf of Mexico, and have less opportunity to avoid oil than do offshore whales and dolphins. Bottlenose dolphin may breed and calve throughout the year.

The primary risk of oil spills to toothed whales and dolphins is inhalation of volatile compounds from fresh oil. Bottlenose dolphins exposed to oil during the Deepwater Horizon Oil Spill have shown hormonal abnormalities and high incidences of lung disease from inhaling the toxic components of oil. Oil may foul the baleens of baleen whales if they encounter oil while feeding.

Terrestrial mammals

Muskrats, nutria and other small mammals can be found in brackish-freshwater marshes. The Santa Rosa Beach mouse is present on Santa Rosa Island. Unless exposed to the oil for prolonged periods, mortality is not expected. Terrestrial mammals are at risk of oiling of fur and ingestion during attempts to clean themselves.

Habitats

Offshore - The spill source is in an area of high habitat suitability for deepwater coral species. Known deepwater coral ecosystems are in the impact area, including Viosca Knolls. DeSoto Canyon is a large geologic feature in the impact area that harbors many deepwater reefs and other benthic communities. Due to the high habitat suitability, other deepwater coral reef systems that have not yet been discovered may be in the impact area as well. Sargassum is found on the top of the water column, and has higher concentrations in summer months in the GOM.

Inshore - Seagrass is present on the sound side of the Chandeleur Islands, the Mississippi barrier islands and Dauphin Island, and in the lower portion of Perdido Bay. Seagrass may be present at other locations in addition to these.

Deepwater corals exposed to oil suffer mortality of the portions of colonies exposed, and the fauna dependent on the corals are likely impacted as well, though less is known of these impacts. Care should be taken to leave seagrass beds undisturbed during cleanup, so that the grasses can grow back during the summer growing season. It is doubtful that the oil will be mixed into the substrate, unless there is a lot of disturbance during clean up. It is possible that fauna hiding or living in the grass will be exposed to and impacted by the oil.

Invertebrates

Offshore - Deep benthic environments support unique invertebrate communities, including brittle stars, red crab, hermit crabs, red shrimp, squat lobsters, isopods, sea pends, sea cucumbers, anemones and sponges.

Shelf - Commercially valuable invertebrates likely to be impacted by the spill include white shrimp and brown shrimp. Brown shrimp spawning may be occurring in waters between 46-90m deep, Brown shrimp spawn from Sep-May, and the peak months are Sep-Nov and Apr-May. White shrimp are abundant and spawning from May-Nov, and are generally found in waters less than 30m deep. Blue crab spawning is ongoing throughout the summer and larvae may be present. Females are found in high abundance in shallow areas of the Gulf of Mexico during the spawning season as they release their eggs. Squid may be spawning in the water column Mar-Nov. Pink shrimp may be present.

Inshore - Extensive oyster beds occur on the sound side of the barrier islands in the area of impact, particularly in Mississippi Sound. Oyster spawning is triggered by rising temperatures

and salinities, and typically begins in May and runs through Nov. Brown shrimp are abundant in estuarine waters late summer through fall. Larval white shrimp and blue crab will begin moving inshore in May-Jun to estuarine nursery areas. Blue crabs may be present in nearshore and inshore waters.

Early life stages (eggs, larvae) of invertebrates are sensitive to exposure to the toxic components of oil, which could have both immediate and delayed impacts to the populations. Shrimp eggs are pelagic and buoyant; however, later larval stages have the ability to regulate their position vertically throughout the water column.

Fish

Offshore - Bluefin tuna are abundant and spawning in the vicinity of the spill source through May; eggs and larvae may be present in the area of impact. Yellowfin tuna are also spawning in the area from May-November and swordfish larvae may be present year-round, however neither have been observed in high densities in the spring. Dolphinfish may be spawning year round. Pelagic species such as blackfin tuna, blue marlin, bluefin tuna, dolphinfish, swordfish, wahoo, whale shark, white marlin, yellowfin tuna are present in offshore waters. Early life history stages of these species may be present.

Demersal fish species likely present in the vicinity of the release site are likely to include sixgill shark, eels and cusk-eels.

Shelf - Many species of reef fish are present on the continental shelf in the area of impact, including commercially important snapper and grouper species. Larval duration for most of these species is approximately a month, and larvae are pelagic. Grouper species that may be spawning in the area of impact include (spawning months in parentheses): red grouper (May-Jul) and scamp (Mar-May). Snapper species spawning in area of impact include: Red snapper (Mar-Nov), lane snapper (Mar-Aug), gray snapper (Jun-Nov), and vermilion snapper (Apr-Nov). A summary of 17 years of SEAMAP data indicates that higher larval abundances have been observed in fall samples compared to spring (Mar-May) surveys for most snapper species, whereas groupers have only been observed in the spring in low densities.

Several species of coastal sharks can be found in the nearshore and shelf waters of the northern Gulf of Mexico, arriving in May and remaining until the fall. Shallow coastal waters are important pupping grounds for some of these species, including Atlantic sharpnose shark, Blacktip shark, finetooth shark, scalloped hammerhead, and possibly lemon sharks. Other shark species present include whale, bull, great hammerhead, shortfin mako, and spinner sharks.

Many forage species begin spawning in coastal waters in the spring and continue through the fall, including anchovies, sardines, mullet, and herrings.

Other species that may be spawning (and therefore have eggs or larvae present) in nearshore waters include: Atlantic tripletail (May-Sep), White trout (Mar-Oct), Squid (Mar-Nov), Ballyhoo

(Mar-Jul), Atlantic spadefish (Apr-Sep), Great barracuda (Apr-Oct), Kingfishes (Apr-Aug), Florida pompano (larvae present through May), Great barracuda (Apr-Oct), amberjack and Spanish mackerel (Apr-Oct), spotted seatrout (Apr-Sep).

Inshore - Marsh habitats are extremely productive and support high biodiversity and abundance of resident estuarine fish. Estuarine areas are important nursery grounds for many commercial species, including snappers, groupers. Inlets and passes are often sites of fish spawning.

Larval and juvenile stages of fish are at a greater risk from the toxic components of oil. Embryonic and larval exposure to PAHs from crude oils has been linked to cardiac defects in pelagic fish species, such as yellowfin tuna. Oil mixed into the water column can adhere to the gills of a fish, causing lethal or sublethal effects.

VI. Human-Use Resources

Lease block MC-300 is within the bluefin tuna Habitat Area of Particular Concern (HAPC) for spawning bluefin tuna.

Species with Essential Fish Habitat in shelf and offshore near the waters of spill include whale shark, bigeye thresher shark, bluefin tuna, skipjack tuna, longbill spearfish, swordfish, white marlin, roundscale spearfish, yellowfin tuna, silky shark, angel shark, blue marlin, longfin mako shark, oceanic whitetip shark,scalloped hammerhead shark, finetooth shark, bignose shark, bull shark, shortfin mako shark, bluefin tuna, longbill spearfish, sailfish, spinner shark, blacknose shark, smooth dogfish, Atlantic sharpnose shark, sandbar shark, and tiger shark.

Federally designated Essential Fish Habitat (EFH) is present in coastal and inshore waters for stone crab, shrimp, reef fish, red drum, coral, and coastal migratory pelagic species.

The area of impact is a productive commercial fishing area and a popular recreational fishing destination. Should the oil make landfall, it has the potential to impact economically important amenity beaches in Mississippi, Alabama, and Florida.

Management Areas present in the area of impact include Gulf Islands National Seashore, Bon Secour NWR, Breton NWR, and numerous state-protected areas. Critical habitat occurs in the area and is summarized by species below:

- Loggerhead sea turtle - Beaches on Horn and Petit Bois Islands, the Alabama shoreline east of Mobile Bay, and Perdido Key. Marine critical habitat occurs in the GOM offshore of the spill site.
- Perdido Key Beach Mouse - Perdido Key
- Alabama Beach Mouse - sites present in Bon Secour NWR and Gulf State Park
- Piping Plover - many of the barrier islands west of Mobile Bay and along Mississippi Sound, Fort Morgan, some sites on Santa Rosa Island
- Gulf sturgeon - Mississippi Sound, Pascagoula Bay, Pensacola Bay and tributary rivers.

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To: Matthiessen, Craig[Matthiessen.Craig@epa.gov]
Cc: Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Principe, Vanessa
Sent: Mon 7/27/2015 6:33:42 PM
Subject: IPIECA Dispersants: Subsea Use Draft Guidance / in Preparation for IMO Subsea Guidance Meeting
IPIECA_Dispersants_Subsea Use _OEM_7_27_15.docx

FYI – Attached are our comments on the IPIECA draft guidance that the workgroup wanted to consider adopting as IMO Subsea Guidance.

We have overarching concerns with the guidance's approach to NEBA, and with some very general statements and scientific "conclusions" that we should be very careful agreeing to as part of a government product. We will be recommending that we do not adopt this document.

V

To: Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Stroud, Fred
Sent: Wed 7/22/2015 2:44:39 PM
Subject: FW: SMART - TTP - IPT Stage 3 Coord Draft Meeting @ 1400/2:00pm EST / 1100-PST
CGTTP_3-75_1_SMART_20150720.doc

-----Original Message-----
From: Bowlin, Mathew T LT [mailto:Mathew.T.Bowlin2@uscg.mil]
Sent: Tuesday, July 21, 2015 9:22 AM
To: Alfonso, Arian MST1; Balsley, Alexander CIV; Bannan, Agustus J CDR; Blount, Trevor A LT; Bock, Edward L CIV; Bond, Kenneth W DC1; Brian Parscal - PP-LLC; Clark, Heather L MST2; Coburn, Craig H BOSN3; Cooper, Jonathan A LT; ed.levine@NOAA.gov; Fong, Donna M CTR; Stroud, Fred; Harms, Jesse B LT; Isom, Donald K LCDR; Kulesa, Frank R LCDR; Levine, Edwin A CIV; Mauch, Edward R MAT4; Murray, Dawn W CDR; Scott, Jason R LT; david.a.studer@uscg.mil
Subject: SMART - TTP - IPT Stage 3 Coord Draft Meeting @ 1400/2:00pm EST / 1100-PST

Greetings,

SMART ? TTP/IPT Project Develop Author뭘 Coordinated Draft Meeting schedule for Tuesday at 1400/2:00pm ? EST/1100-PST on July 21, 2015. IPT members who aren't able to access the CG SharePoint Website use the enclosed doc. Make your comments and save, and email back to Ms. Donna Fong?

Participants Telcon Num:
Telecon-Num: 712-432-0800
Pin: 1021220

v/r,

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From: Vocke, William CIV
Sent: Wed 5/13/2015 5:16:26 PM
Subject: ICCOPR R&T Plan Chapters 7 , 8, and 9 for review
Ch 7&8 Member Draft 2015-05-13.docx
Ch 9 - Member Early review 2015MAY13.docx

All,

Thank you for comments on chapters 2 through 6. Attached for your early review are chapters 7 (Noteworthy Oil Spills), 8 (Current State of Oil Pollution Knowledge), and 9 (Priorities). Please review these chapters and provide me with comments or edits by COB May 27, 2015.

I expect to send out the remaining chapter (1-Need for Oil Pollution Research) sometime next week. At that point, all chapters of the R&T Plan will be drafted and under review. I appreciate any input you have so I can address issues before we undergo formal review.

Bill Vocke
ICCOPR Executive Director
(202) 372-2019

To: Principe, Vanessa[Principe.Vanessa@epa.gov]
Cc: Debbie Payton - NOAA Federal[debbie.payton@noaa.gov]; James Rosenberg - NOAA Federal[James.E.Rosenberg@noaa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]; Matthiessen, Craig[Matthiessen.Craig@epa.gov]
From: Jennifer Barre - NOAA Federal
Sent: Fri 7/17/2015 2:35:59 PM
Subject: NOAA Subpart J Comments
Subpart J - NOAA Final Comments.doc

Ms. Principe~

At the request of Ms. Payton, I am forwarding NOAA's comments on the proposed modifications to 40 CFR Part 300 Subpart J - use of Dispersants and Other Chemicals. Please let me know if there are any questions, comments or concerns.

Very Respectfully,

LTJG Jennifer L Barre
Emergency Response Program Coordinator
Emergency Response Division, Office of Response and Restoration
NOAA's Ocean Service
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Stay up to date with our Blog

Docket ID No. EPA–HQ– OPA–2006–0090

As the nation's experts on oceanic and atmospheric science and the lead science agency for coastal oil spills, The National Oceanic and Atmospheric Administration, Office of Response and Restoration (OR&R) has conducted a thorough scientific review of the proposed modifications to 40 CFR Part 300 *Subpart J - use of Dispersants and Other Chemicals*. This rule provides a National level standard for oil spill response operations and a framework for the scientific support provided by OR&R, and we will rely on its guidance as we provide our expertise in response.

EPA's proposed modifications are a much needed and welcomed change. When oil and chemical spills threaten our coasts, this proposed rule will provide valuable information to contingency planning stakeholders, first responders, and industrial partners to protect our environment, communities and economies. The proposed requirements will provide data to guide response decisions, building resilience by reducing impacts to ocean ecosystems, limiting human exposure, and expediting remediation. At the same time, this rule preserves the use of dispersants and other chemicals as invaluable tools while establishing modern national standards to ensure they are used in a safe and scientifically-informed manner.

However, EPA could provide even stronger support for response by revising this proposed rule to adjust the testing and monitoring requirements to allow for more representative data collection and technology growth. To further strengthen spill planning and response operations, OR&R offers the following comments on the proposed rule:

***§300.910(a)(1)*: Logistical factors, as a requirement for authorization for agent use should be removed.** Logistical factors will systematically be assessed when an agent's use is proposed. Logistical factors frequently change for reasons which are not controllable by the plan developers and maintenance of this portion of the plan would be an unnecessary burden.

Additionally, it is more specifically requested that the logistical factor "manufacturing capabilities of available agents" be removed, as this parameter is at the discretion of Industry entities. Industry has no obligation to provide their capabilities to the plan developers and their ability to manufacture may drastically change pending economic influences.

***§300.910(a)(2)*: Modify the language to read, "Withdraw of [Approval] means the …"**. The word concurrence is inconsistent with the "approve, disapprove" or "approve with modifications" language earlier in the paragraph. The term concurrence is used for consultation roles.

***§300.910(a)(2)*: The requirement for a 30 day notification to the NRT should be removed from of this rule.** Since, there is no requirement proposed for a 30 day notification to the NRT for initial concurrence, the need for a NRT notification following a withdrawal of concurrence is unclear.

***§300.910(a)(3)*: Either add an extension clause or remove the a 5 year review.** This timeline places a burden on RRT members and may make plans legally invalid. The need for reviews and updates is undebatable, however allocation of resources may not always allow for compliance with this timeline. It is vital that the OSC have all tools available for response operations.

***§300.913(b)*: Revise the language to clarify the intent of the requirement.** This section can be interpreted that every sample within the plume must be analyzed for all eleven items listed under this part; this would be arduous and restrictive. It may also been interpreted that a minimum of one sample must meet all of those requirements. This section should require that sampling be conducted within the dispersed oil plume to provide representative data. Suggested language: "In the dispersed oil plume, collect daily water column samples following guidelines agreed to by the FOSC for the incident. Plume sampling shall be representative and may include analyses for: …"

***§300.913(b)*: It is requested that the OSC be authorized to waive collection requirements due to safety, environmental, and operational considerations.** We are in support of the monitoring efforts proposed and all of the information requested is important. However, there may be conditions that prevent collecting all of the proposed data.

***§300.913(b)(2)*: The language should be changed to "in-situ monitoring for the presence of hydrocarbons targeted to the type of oil discharged and referenced against the source oil;"** The requirement for in-situ fluorometry and fluorescence signatures is a specific and therefore limiting requirement. Monitoring technologies are developing and the rule should allow for inclusion of any emerging technologies that can perform the same function.

***§300.913(c)*: Modify the language to, "In consultation with the OSC, and using [Special Monitoring of Applied Response Technologies guidance], characterize".** The best available technologies may be excessive monitoring, pending the scenario. The SMART protocol provides guidance to responders and allows for the OSC and the EU to determine what is necessary for the specific incident.

***§300.915*: In addition to the proposed submission requirements of the rule, manufacturers should be requested to provide supplemental data if available.** This additional data may provide decision makers with necessary information to make trade-off decisions.

***§300.915(a)(15)*: The National Water Quality Standards lowest acute value for aquatic life may not be appropriate for this use.** Concentrations in products may exceed the standard; however dilution to use ratios and then addition to the receiving waters will reduce the concentration by orders of magnitude. A calculated concentration in the receiving water following application would be a protective limitation. If a safety factor is necessary, the values

in the application concentration would be less limiting than the product concentrate. As the rule is written it may be beneficial for companies to dilute their product to application concentrations to comply with this rule. This would require more storage capacity and limit smaller companies from competing.

***§300.915(b)(1)(i-iv) and Appendix C*: A Gulf of Mexico oil should be a reference oil required in testing protocols.** It is recognized that the oils selected provide a broad range of data, however the GOM has been the location for the majority of historic use and is the most likely region for future applications. By including a Gulf of Mexico oil in this requirement, responders will have pertinent information for a common oil type most likely to be involved in an incident.

***§300.915(b)(1)(i-iv)*: The 5°C testing temperature should be replaced with 0°C.**
V.C.4.a.14.b.1. discusses that monitoring temperatures were selected to prepare for response operations from Arctic to tropical conditions. While 5°C is the winter temperature along most of the mid-Atlantic, New England, and Southern Alaska, Arctic temperatures are closer to 0°C. To prepare for response in the Arctic, these testing temperatures should include a temperature that is more representative of Arctic conditions.

***§300.915(b)(2)*: Oil-only tests with *Menidia beryllina* and *Americamysis bahia* should be monitoring requirements.** These tests demonstrate if a dispersant adds toxicity to the oil, by comparing the oil only LC50s to the dispersed oil mixture LC50s. This information assures that any product used in a response is not increasing the toxicity. This information can also be used as a data control measure for the results of dispersant/oil toxicity testing.
With heavier oils there may be considerable variability in the production of non-chemically dispersed oil water accommodated fractions (WAF). In the absence of a dispersant, these oils may or may not result in concentrations that are within a range for calculating LC50s and thus obfuscating the calculation of LC50 ratios.
An evaluation of existing NPS dispersant toxicity data found considerable variability among the vendor LC50 data in terms of both No.2 fuel oil and reference toxicant (DDS) data. For example, *Menidia beryllina* LC50s for No.2 fuel ranged from 6 to 200 ppm and the reference toxicant (DDS) ranged from 1 to 160 ppm. This amplifies the need for certification and QA/QC reviews of laboratories. The laboratories results of oil toxicity tests should be compared to oil only tests. This would then allow the EPA, industry, and stakeholders to place confidence in the dispersant/oil tests.

***§300.915(b)(2) and Appendix C to Part 300 3.0*: A moderately sensitive species should be selected for the Developmental Assay testing requirements.** The majority of literature on early life stages exposed to oil/dispersant mixtures indicate that the urchin is not a very sensitive species. As possible adverse effects of dispersants on the developmental processes of fish and invertebrate species is an issue of concern, a species that can provide representative toxicity information should be used.

***§300.915(d)*: Bioremediation agents that contain surfactants should be required to conduct the Baffled Flask Efficacy Test to determine if the agents have dispersing effects.** If it is determined that an agent passes the dispersant efficacy test, then the agent should be required to conduct the Dispersant Toxicity Test and to also be listed as a dispersant on the product schedule.

***§300.915(d)(1)*: Bioremediation agents should be required to degrade alkanes "or" aromatics.** Oil degrading organisms are highly specialized and each break down different components of oils. The requirement for agents to degrade both alkanes and aromatics limits the use of products that are specialized to focus on particular components; this may be particularly important as products are developed to degrade weathered oils. The paragraph should read "To be listed on the Schedule, a bioremediation agent must successfully degrade alkanes [or] aromatics …"

***§300.915(d)(4)*:** Most fertilizers include more than 50% inactive ingredients as binders and fillers. Is it the intent of this rule to require list of fertilizers that are complexed in inert materials?

***Appendix C to Part 300 2.6.1*: Untreated oil controls are needed for reference oils to demonstrate the effectiveness of oil dispersion in the Baffled Flask Test, in the absence of product addition.** Information derived from reference oils would be valuable to the OSC as a measure of how product application may enhance natural dispersion. This may be done by adding the monitoring requirement to the rule or EPA could conduct these studies on the reference oils at the prescribed temperatures and use this standard data for product effectiveness comparisons.

***Appendix C to Part 300 2.2*: The dispersant to oil ratio for the Baffled Flask Test should be changed to the 1:20 field application ratio or the 1:10 conservative ratio for consistency.** The dispersant to oil ratio proposed in the Baffled Flask Test is 1:25. This ratio is inconsistent with the typical field application ratio of 1:20 and the 1:10 conservative ratio used for toxicity testing.

***Appendix C to Part 300 2.11*:** We request that Subpart J cite Kaku, V., Boufadel, M., and Venosa, A. (2006) "Evaluation of Mixing Energy in Laboratory Flasks Used for Dispersant Effectiveness Testing." J.Environ.Eng., 132(1),93-101.

***Appendix C to Part 300 5.1*: This should read, "The manufacturer may test either one or both freshwater [and] saltwater, depending on the product's intended use."**

To: Wilson, Gregory[Wilson.Gregory@epa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Matthiessen, Craig[Matthiessen.Craig@epa.gov]
From: Ruhl, Christopher
Sent: Mon 6/1/2015 7:56:42 PM
Subject: FW: Sea Grant publications dispersants
Dispersant background v4.docx
Dispersant Effectiveness and Fate v4.docx
Top 5 Oil Spill Questions v4.docx
Aq Animals Dispersant v4.docx

I don't know what these are about but thought it might be something you should be looped in on.

Chris Ruhl

Preparedness and Response Operations Division (PROD)

Office of Emergency Management

US Environmental Protection Agency

(202) 564-0743

(214) 789-9587 (cell)

From: Mason, Steve
Sent: Monday, June 01, 2015 3:43 PM
To: Rhotenberry, William; Ruhl, Christopher
Subject: FW: Sea Grant publications dispersants

No idea while I am getting these, but I do not think I should be making comments… any ideas…

With Regards, Steve

Stephen Mason
EPA Region 6 (6SF-PE)
1445 Ross Avenue, Dallas, TX 75202
214-665-2276
mason.steve@epa.gov

"Frequently, my thoughts get bored and walk down to my mouth. Often, this is a bad thing."

From: Jacobson, Doug
Sent: Monday, June 01, 2015 2:19 PM
To: Mason, Steve
Subject: Sea Grant publications dispersants

I just received these last week while I was out of the office. Would you give them a quick review and send any comments to the Sea Grant folks, please.

From: Larissa Graham [mailto:ljg0008@auburn.edu]
Sent: Wednesday, May 27, 2015 10:40 AM
To: Jacobson, Doug
Subject: Reminder - due Fri: Technical review for oil spill science publications

Hi Doug,

I just wanted to send you a quick email to remind you that we're hoping to get all of the edits for the attached publications in by this Friday. I know you were forwarding the documents along so if you or your EPA colleagues need more time, that's fine by us--just let me know. We really appreciate your help!
Thanks,

Larissa

Larissa Graham

Oil Spill Science Extension Specialist

Mississippi-Alabama Sea Grant Consortium

Office: (251) 438-5690

Cell: (251) 348-5436

Larissa.Graham@auburn.edu

From: Larissa Graham
Sent: Thursday, May 14, 2015 4:07 PM
To: 'jacobson.doug@epa.gov'
Cc: Wilson,Monica; Emily S Maung-Douglass
Subject: Technical review for oil spill science publications

Hi Doug,

Attached are the three dispersant publications that I called you about earlier today. Our Sea Grant Oil Spill Science Outreach Team has pulled these documents together to summarize oil spill science that can answer some of the lingering questions that our coastal audiences have about the Deepwater Horizon oil spill.

EPA's dispersant testing and monitoring are highlighted in these documents and we want to make sure that everything we are saying is accurate so we are asking that someone within EPA provide a technical review. Please send any comments or edits back to me within the next two weeks (by May 29th) so we can meet our deadline. If you do need more time for review, just let me know. We appreciate your time and are happy to accommodate in any way that we can.

I have also attached a Frequently Asked Questions publication that is targeted for the tourism industry. It is short and sweet but if your EPA contact could also look that one over, too, we would appreciate it.

Please do not distribute any of the attached draft documents outside of EPA because they are still in the review process.

Thank you for all of your help so far—it was great talking with you today!

Thanks again,

Larissa

Larissa Graham

Oil Spill Science Extension Specialist

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Responses of Aquatic Animals in the Gulf of Mexico to Oil and Dispersants

Emily S. Maung-Douglass
Larissa J. Graham, Christine Hale, Stephen Sempier, LaDon Swann, and Monica Wilson

In April 2010, the Deepwater Horizon oil rig caught fire and sank off the coast of Louisiana. Over the next 87 days the Deepwater Horizon oil spill (DWH) released an estimated 200 million gallons of oil from the Macondo well into the Gulf of Mexico.

Chemical dispersants were one of several cleanup methods used by emergency responders in an effort to reduce the number of oiled animals and the amount of oil reaching the coastline. The Gulf of Mexico Research Initiative (GoMRI) has sponsored a great deal of research to better understand the responses of marine and coastal animals to oil-dispersant mixtures. This outreach publication summarizes research thus far on the effects of oil and dispersants on aquatic life.

Polycyclic Aromatic Hydrocarbons (PAHs)

Dispersants break up oil slicks into relatively small oil droplets that can be more readily degraded by bacteria than an oil slick. Oil, tar, burned wood, charred animal fat, and coal all contain compounds known as **polycyclic aromatic hydrocarbons** (**PAHs**). Dispersant use increases the concentration of PAHs in the water and thus, the possibility of PAHs entering the bodies of animals.[1,2] PAHs have been a major concern since the DWH oil spill because some PAHs cause mutations, developmental problems[3], and/or cancer in wildlife and humans.[4]

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Physiological Responses

Wildlife can have several responses when exposed to foreign chemicals, like oil or dispersants (Figure 1). For example, chemicals that are not easily broken down are often stored (**bioaccumulated**) in the body's tissues. Chemicals that bioaccumulate in the body have the potential to be passed on to predators higher in the food chain.

To adapt to environmental stress, animals can also respond with changes in **gene expression** (i.e., which genes are turned on or off). Scientists can analyze these changes in gene expression to determine if aquatic life has encountered oil in the environment. For example, if a fish encounters oil in the environment, it 'turns on' genes like **CYP1A**. This gene also exists in humans and other organisms, and helps the body breakdown and excrete foreign chemicals (i.e., **metabolism)**. This prevents foreign chemicals from being stored in the tissues of the animal. This gene can be triggered by several compounds[5,6,7,8,9], including PAHs. Scientists examine CYP1A levels to determine if aquatic life has encountered oil. Scientists are able to confidently estimate the effects of oil by using the results of experiments done in a controlled laboratory environment and compare those results with field sampled experiments which represent 'real life' conditions.

Key findings
When reviewing the findings that have come out of study of the Deepwater Horizon oil spill, a few key points emerge.

1. **Some species accumulate PAHs**
Fish are able to metabolize and eliminate PAHs from their bodies. However, many other aquatic species cannot, which causes them to accumulate such compounds in their tissues.[10] Laboratory studies demonstrate this principle in both copepods (Figure 2) and jellyfish exposed to oil.[11,12] In the case of the copepods, tiny crustaceans only about the size of a pinhead, PAHs accumulated in their body and were also present in their bodily waste. Levels of PAHs in jellyfish exposed to oil were between 1.4-3.1 times higher than in jellyfish not exposed to oil, with PAH levels in the tissues increasing with level of oil exposure. These results imply that jellyfish and copepods and their bodily waste could be a vehicle to transport PAHs in the food web.

Scientists monitoring wild Gulf coast coquina clams (Figure 3) found that levels of PAHs in the clams were variable the year after DWH, possibly due to the patchy distribution of the oil that made it to shore.[13] PAH levels in the clams were higher than those detected in the surrounding sands. This indicates that these bivalves were accumulating PAHs in their tissues, making them a living monitor for the long-term presence of PAHs in the environment.

Such results are not unique to this species. Clams and their relatives (e.g. oysters, mussels, scallops) are stationary. Thus, they are more likely to encounter oil in the wild because they cannot escape it. Their bodies are also slow to breakdown and excrete certain types of PAHs, causing them to bioaccumulate in their tissues.[14] NOAA's Mussel Watch program tests the tissues of oysters and mussels to monitor the presence of foreign chemicals (e.g., PAHs, PCBs, metals) in the environment.[16] Similarly, GoMRI funded scientists tested oysters from Mississippi and Alabama, during and after the DWH oil spill to determine if oysters had accumulated oil in their tissues or shell.[17] They found no chemical traces of oil-based compounds in the oysters.

2. **Some species break down oil-based compounds in their bodies**
Gulf killifish have been the focus of many studies since DWH because they tend to stay near their homes (Figure 4).[17,18] Collecting wild killifish and assessing their oil metabolizing gene (CYP1A) can help determine if PAH/oil exposure has occurred at a location. Fish sampled after the oil made landfall in Grand Terre, LA had higher levels of the gene than those sampled in the time period just prior to oil landfall.[18] Fish sampled from Grand Terre also had higher levels of this gene than those collected in places that did not have oil exposure. More than a year after the well was capped (August 2011), scientists found higher levels of this gene in gills, livers, head kidneys, and intestines of adult killifish sampled from Grand Terre than those fish sampled from locations not oiled.[17] The elevated levels of this gene suggest that high levels of oil and/or oil components remained in Grand Terre for at least one year proceeding the DWH oil spill.

3. **Effects differ based on stage of life and environmental conditions**

An animal's response to oil and dispersant may vary with age. Exposing very young spotted sea trout (Figure 5) to either physically (wave-action) dispersed oil or chemically (Corexit) dispersed oil triggers an increase in production of the oil metabolizing gene (CYP1A).[3] In juvenile spotted sea trout however, the gene was only triggered in fish exposed to PAHs from physically dispersed oil.

Salinity (i.e., how salty the water is) can also play a major role in the way that animals respond to oil and dispersants. Living in salt marshes, animals encounter a wide range of salinities while living in salt marshes. Through laboratory studies with Gulf killifish, scientists found that mixtures of oil and dispersant were more toxic to the fish at low salinities than at relatively higher salinities.[2] Scientists concluded that the fish were either more sensitive at low salinities and/or were not as able to breakdown of PAHs in low salinity environments.

UV light is another example of an environmental factor that can impact the outcome of exposure to oil and dispersants. One species of copepod exposed to UV light and chemically dispersed oil had a 35 percent higher death rate compared to copepods exposed to oil and dispersants but not UV.[13] The effects due to UV light may not be crucial however, as this species of copepod spends the day at deeper water depths, and only migrates to surface waters at night.

The presence of other species can also affect the outcome of oil exposure in copepods.[11] Protozoa are microscopic, one-celled organisms. When protozoa co-occur with copepods, negative effects (e.g., decreased fertility and accumulation of PAHs) occured in copepods exposed to oil.

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4. **Oil exposure can impair vital development and bodily function**

Proper heart development and hatching success are undoubtedly important in ensuring the survival of individual fish and populations of species. Exposure to sediments from an area heavily oiled during DWH delayed and reduced hatching success in killifish eggs.[15] Further, fish that hatched from eggs exposed to oiled sediments were smaller than fish from eggs that were not exposed to oiled sediments. Heart problems occurred in the oiled sediment exposed fish as well, including reduced heart rate and **edema** (fluid filling the sac surrounding the heart). The results of one study suggest that this might be because PAH exposure affects the normal flow and function of ions in the heart tissue.[19]

Mahi-mahi juveniles that were exposed to PAHs in the laboratory could not swim as fast as individuals that had not been exposed to PAHs (Figure 6).[20] Further, mahi-mahi juveniles that hatched from eggs exposed to PAH had reduced swimming rates. These eggs were exposed to PAH levels 25 times lower than the PAH exposure directly to juveniles, yet had the same effect on juvenile swimming speed. Reduced swimming speed could translate into fewer young surviving into adulthood, leading to fewer individuals able to reproduce and continue the population.

Some studies suggest that the energy needed to break down foreign chemicals (i.e., PAHs and

dispersants) can come at the cost of growth. For example, both young and juvenile spotted sea trout exposed to either dispersant or PAHs were significantly smaller than unexposed individuals (Figure 6).[3] This suggests that the fishes' bodies used energy to breakdown the dispersant and PAHs instead of putting that energy toward growth. However, the effects in individuals exposed as juveniles were not permanent. Several weeks after being exposed, the body size of the juveniles exposed to dispersants and PAHs became similar to individuals who had not exposed to these chemicals.

To learn more about the research being conducted on the Deepwater Horizon spill, visit the Gulf of Mexico Research Initiative website at www.gulfresearchinitiative.org. Visit the program website at: http://gulfseagrant.org/oilspilloutreach to view other publications related to this theme.

Glossary

Bioaccumulation – The accumulation or build-up of chemicals in the tissues of an organism. In the aquatic world, the bioaccumulated chemical can enter an organism via several methods, including their food, gills, and other tissue membranes.

CYP1A – Gene that helps the body metabolize, or breakdown, foreign chemicals (e.g., PAHs).

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Edema – Fluid filling the sac surrounding the heart.

Gene expression – A gene that is expressed is 'turned on' or triggered, producing a response within the body.

Metabolism – The breakdown of chemicals by the body.

Polycyclic aromatic hydrocarbon (PAH) – A group of hydrocarbons commonly found in oil, tar, burned wood and animal fats. More than 100 PAHs exist; some can cause cancer, birth defects, mutations, and/or death.

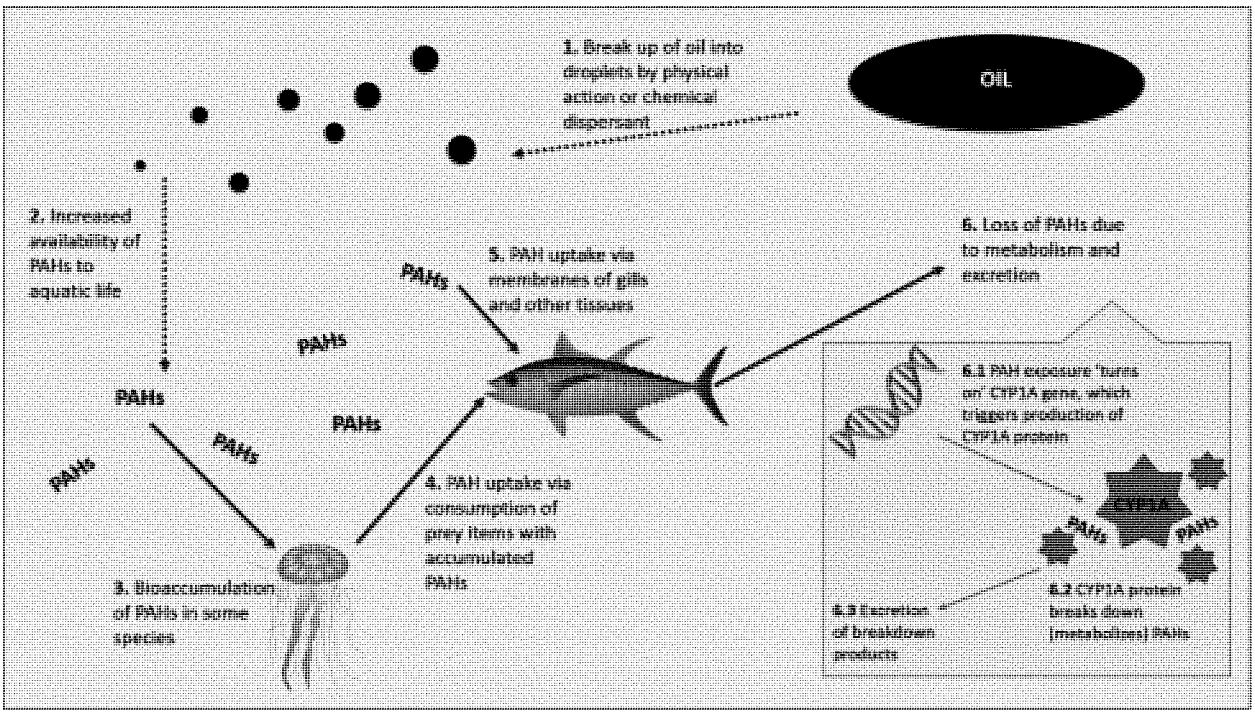

Figure 1. Diagram of possible ways polycyclic aromatic hydrocarbons (PAHs) from oil enter aquatic animals and animal responses (i.e., uptake, bioaccumulation, metabolism, excretion). Image credit: E.S. Maung-Douglass, with contributions from D. Tracey, J. Thomas, T.Saxby (IAN-UMCES Image Library).

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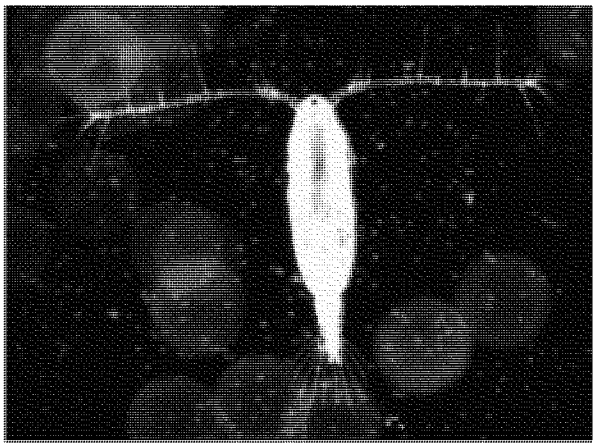

Figure 2. Copepods are tiny crustaceans that live in the water column of estuaries and the ocean. Copepods are typically a couple of millimeters (mm) in length (a dime is 1.35 mm thick). Copepods serve as an important food source for many larger organisms. Photo credit: Thomas Kiørboe.

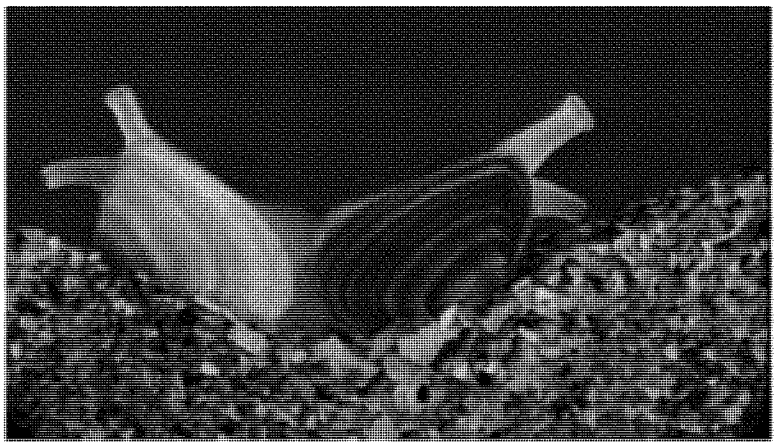

Figure 3. Coquina clams filter water using tube-like siphons and then extract their food from the surrounding waters. PAHs can build up in their tissues while they filter water, allowing scientists to use them as an indicator of oil contamination. Photo credit: R. Hermes, South Carolina Dept. of Natural Resources.

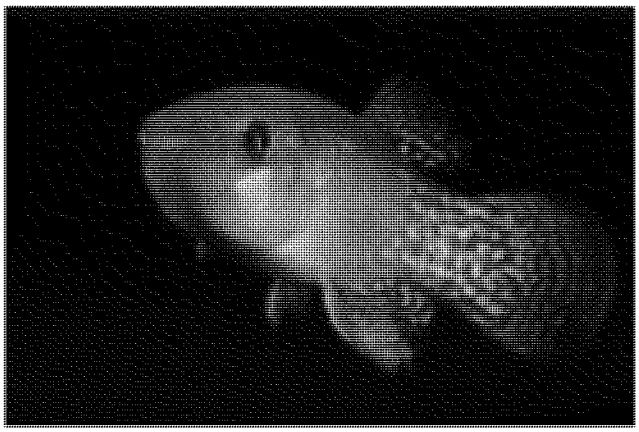

Figure 4. Killifish are a species of fish that are common to the marshes of the Gulf coast. GoMRI-funded scientists are studying this species to better understand the impacts of oil on aquatic life. Photo credit: Whitehead lab group.

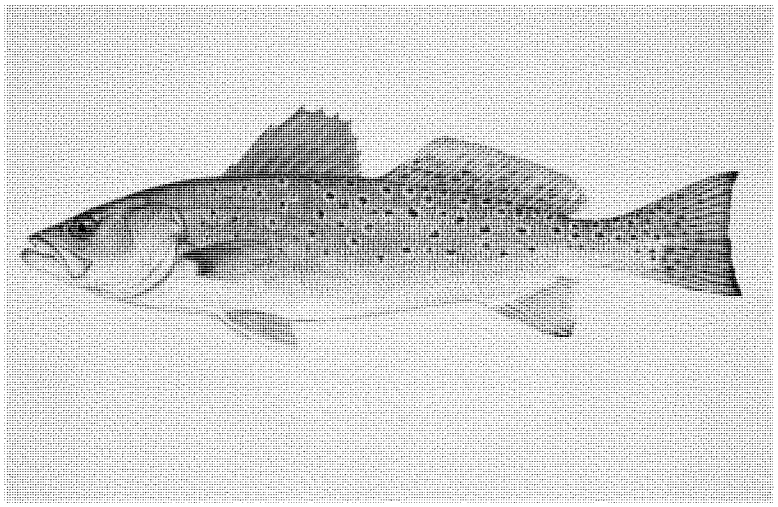

Figure 5. Spotted sea trout are recreational sport fish that GoMRI-funded scientists are studying. Image credit: Raver Duane, U.S. Fish and Wildlife Service.

Figure 6. Mahi-mahi are large, predatory fish that spawn in the Gulf of Mexico. This is the juvenile form of the species. Photo credit: Florida Museum of Natural History.

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This work was made possible in part by a grant from BP/The Gulf of Mexico Research Initiative, and in part by the Mississippi-Alabama Sea Grant Consortium, Florida Sea Grant College Program, Louisiana Sea Grant College Program and Texas Sea Grant College Program. The statements, findings, conclusions and recommendations do not necessarily reflect the views of these organizations. This is publication number GOMSG–G–15-001.

GoMRI and Sea Grant sidebar

The Gulf of Mexico Research Initiative (GoMRI) is a 10-year research program administered by the Gulf of Mexico Alliance and led by an independent academic research board. GoMRI aims to mitigate impacts of oil pollution and stressors on both the marine environment and public health from the 2010 Deepwater Horizon oil spill, as well as improve society's understanding of oil spill issues. Emerging information can be found on GoMRI's website at http://gulfresearchinitiative.org.

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Chemical Dispersants and Their Role in Oil Spill Response

Larissa J. Graham
Christine Hale, Emily Maung-Douglass, Stephen Sempier, LaDon Swann, and Monica Wilson

On April 20, 2010, an explosion on the Deepwater Horizon oil rig, located 42 miles southeast of Venice, Louisiana, killed 11 people. Before the ruptured wellhead was capped on July 19, 2010, it released an estimated 4.9 million barrels, or approximately 200 million gallons, of Louisiana sweet crude oil into Gulf of Mexico waters.[1,2,3]

Emergency responders attempted to clean up the oil and prevent it from reaching the shoreline by skimming, burning and applying nearly two million gallons of **dispersants**. This was the largest application of dispersants in U.S. history.[4]

How were dispersants used during the Deepwater Horizon oil spill?

Two types of dispersants were used during the Deepwater Horizon oil spill: **Corexit** 9500 and Corexit 9527. Corexit 9527 was used first and applied until responders exhausted the supply. They then switched to Corexit 9500 and continued using it throughout the response efforts. Both types of Corexit had been preapproved by federal guidelines for use during a spill.[4,5]

Responders used airplanes to apply approximately one million gallons of dispersants over 300 square miles of oiled surface waters (Figure 1).[1,4] Trained responders also applied dispersants from boats in areas close to the well site where crews were working to reduce the amount of dispersant in the air. The use of dispersants was not allowed within 2.3 miles of any vessel, within 3.45 miles of the shoreline or visible marine life, or in areas where the water depth was less than 33 feet deep.[4] According to the U.S. Coast Guard, 98 percent of the aerial application of dispersants occurred more than 11 miles offshore.[4]

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Where were dispersants sprayed?
To see the flight path of each plane that sprayed dispersants or to access more aerial maps related to the *Deepwater Horizon* oil spill, visit the Environmental Response Management Application website at: http://gomex.erma.noaa.gov/erma.html.

Corexit 9500 was also applied beneath the surface, using a remotely operating vehicle that could inject dispersant directly into the wellhead nearly one mile down.[1] It is estimated that 771,000 gallons of dispersants were used underwater near the wellhead.[4]

How do dispersants break up oil?

A typical commercial oil dispersant contains solvents that help keep the chemicals mixed so it can be applied to the oil, additives which help the chemicals dissolve into the oil, and **surfactants** which work to break up the oil into small droplets.

Once the oil is dispersed, the smaller oil droplets mix into the water column and are then carried away by currents, settle on the bottom, or evaporate.[6] These smaller oil droplets are

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more available to nature's "oil-eating" bacteria found in our oceans than large oil slicks (Figure 2). These bacteria have adapted over time to use oil as food and, in the process, naturally break it down and remove it from the environment.

When are dispersants used to clean up oil?

To determine the most effective cleanup method or methods that should be used during an oil spill, responders look at the trade-offs of each method to determine the best course of action.[6,7] Applying dispersants was just one of many strategies that emergency responders used at the Deepwater Horizon site during the spill. Other responses included burning the oil at the water surface, as well as mechanically recovering it using skimmers or other equipment (Figure 3).

Dispersants are typically used when other cleanup methods would not be effective either because the spill is too large, the water is too rough, or the spill is too far away to use mechanical recovery equipment.[6] Dispersants can be used over a wide range of conditions, including rough seas, and can be deployed rapidly by aircraft.[7] Dispersants can prevent an oil slick from reaching the shoreline which can reduce the oiling of coastal wildlife and sensitive habitats, such as coastal wetlands, mangroves, and beaches. These habitats are very difficult to clean once they have become oiled. [7]

However, dispersants are not equally effective on all types of oil and can be inefficient on patchy slicks.[6,7] They do not work well under very windy conditions because the dispersants can drift in the wind while it is being applied or waves can wash the dispersants off the slick before it can penetrate and mix with the oil.[6] Dispersed oil is also harder to clean up mechanically, so using dispersants can make other cleanup methods less effective.[7]

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Applying dispersants beneath the surface was a new technique but was approved during the Deepwater Horizon oil spill because it would minimize human contact with dispersants and would allow a quicker response time because it could be used at night and in foul weather. [1]

How are dispersants regulated and monitored?

Dispersant use is regulated under the National Contingency Plan (NCP). The NCP guidelines outline which dispersants can be used during a spill, where they can be used, and the amount that should be used.[8]

Once a dispersant is selected for application, it is monitored using Special Monitoring of Applied Response Technologies (SMART) guidelines. SMART guidelines are not used to look at the effects or impacts of dispersed oil. Instead, they provide real-time information to allow for science-based decision making when determining whether dispersants should be used and how well they are working.[9]

The SMART monitoring program allowed responders to determine if dispersants were effectively breaking up oil and, if so, how quickly.[4] The U.S. Coast Guard, NOAA, U.S. EPA, U.S. Centers for Disease Control and Prevention, and the U.S. Bureau of Safety and Environmental

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Enforcement are all part of this program.[4] During the Deepwater Horizon oil spill, trained observers flew over the oil slick and sampling teams collected water samples that measured the amount of dispersed oil. Dispersant application measures were then modified based on the monitoring results.[4]

The U.S. EPA also conducted air monitoring to test for two chemicals that are found in Corexit. In 2010, air samples were collected off the coast of Louisiana during four days following the aerial application of dispersants. Neither chemical was detected in the samples taken 30 minutes after dispersant application.[10] Onshore air quality sampling was also conducted along shoreline sites in Louisiana, Mississippi, Alabama, and Florida in 2010. The air was tested for two dispersant components that were most likely to be in the air in measurable amounts after spraying. Low levels of chemicals were found but could not be traced back directly to dispersant application. However, all chemicals were below levels that are likely to cause negative health effects. All of the data from these monitoring efforts are available on U.S. EPA's website at http://www.epa.gov/bpspill/dispersant-air-sampling.html.[11]

According to the U.S. Coast Guard's On-Scene Coordinator Report, the U.S. EPA and the U.S. Coast Guard were satisfied with dispersant use during the Deepwater Horizon oil spill. These agencies also stated that dispersants had been an important tool in stopping the spill's impact and had prevented more damage to marshes, wetlands, beaches, and coast's economy. They also stated that the information that was collected during the spill generally supported continued application of dispersants.[4]

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The On-Scene Coordinator Report
This report was submitted to the National Response Team and documents the response efforts during the Deepwater Horizon oil spill. This report provides a timeline of the spill as well as the efforts that were made to address the potential impacts to public health related to the spill. This report can be found at:
http://masgc.org/assets/uploads/publications/873/2_coordinator_report_dwh.pdf.

Can dispersants harm marine animals?

With advances in technology, dispersants used today are less harmful to the environment than the more toxic dispersants used prior to 1970.[6] However, dispersants still contain chemicals that are known to have a negative impact on aquatic life**.** Dispersed oil contains **polycyclic aromatic hydrocarbons (PAHs)** which are found in crude oil and natural gas. As these chemicals are mixed into the water column, they pose a risk to aquatic animals and habitats.[6]

Concerned with the long-term effects that dispersant could have on aquatic life, the U.S. EPA directed BP to scale back the overall use of dispersants until more was known about the potential impacts. The U.S. EPA conducted an independent toxicity study in the laboratory for the dispersants that were being used in during the Deepwater Horizon oil spill.[5] In addition to Corexit 9500, eight other approved dispersants were tested on two aquatic test species: Gulf

mysid, a small shrimp, and the inland silverside, a fish that resides in coastal waters in the Gulf of Mexico.[5]

The results showed that none of the dispersants, when tested alone, caused serious impacts to the shrimp or silversides. Corexit 9500 and one other dispersant (JD-2000) were generally less toxic to silversides than the other dispersants that were tested. Corexit 9500 that was mixed with oil was, generally, no more or less toxic than eight other dispersants that were tested.[5] Corexit 9527 was not tested during these studies because the dispersant was no longer being used in response efforts.

The extent of damage that dispersants, dispersed oil, and oil can have on aquatic life is still under debate. Some peer-reviewed research studies have found dispersants to be less toxic than oil alone, and other studies have shown that dispersants or oil plus dispersant are more toxic than oil alone.[6] The impacts of dispersants or oil plus dispersant also depends on the type of animal and what stage of life it is in.[6]

What studies are still ongoing?

Many questions remain about the impacts of dispersants on the ecosystem, environment, and human health. The Gulf of Mexico Research Initiative and other research programs are looking at alternative dispersant use and technology, how dispersants react with oil under various conditions, the environmental impacts of currently approved dispersants, and the impact that dispersants have had on human health.

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More information about these ongoing studies can be found on GoMRI's website at http://gulfresearchinitiative.org. Other publications focusing on dispersants can be found on the Sea Grant oil spill science outreach website at: www.gulfseagrant.org/oilspilloutreach.

Glossary

Corexit – Corexit is a type of chemical dispersant that was used to break up oil slicks during the *Deepwater Horizon* oil spill.

Dispersants – Dispersants are chemicals that are used during oil spill response efforts to break up oil slicks and prevent the oil from impacting of marine life and coastal habitats.

National Contingency Plan (NCP) – The NCP is a federal document that outlines response efforts for oils spill and other hazardous substance spills.

Polycyclic aromatic hydrocarbons (PAH) – a group of hydrocarbons commonly found in oil, tar, burned wood and animal fats. More than 100 PAHs exist and some are known to cause cancer, birth defects, mutations, or death.

Special Monitoring of Applied Response Technologies (SMART) – SMART is a cooperative

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monitoring program that is used during oil spill response efforts to determine if dispersant application is effective.

Surfactants – Surfactants are compounds that work to break up oil. Dispersants contain surfactants which break the oil slick into smaller droplets that can more easily mix into the water column.

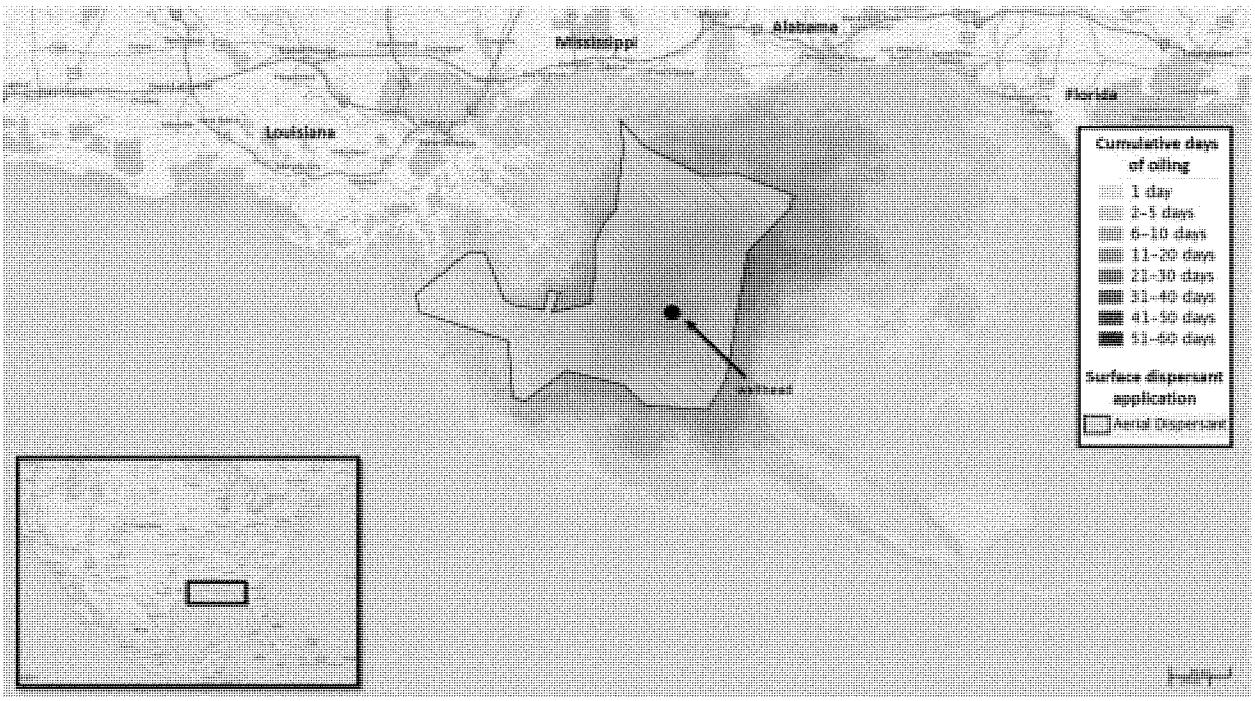

Figure 1. This map shows the area that was oiled during the *Deepwater Horizon* oil spill (gray). In response to the oiling, dispersants were applied to surface water (yellow). Dispersants were also sprayed by boats close to the wellhead and at subsurface depths (not shown on this map). Credit: Environmental Response Management Application.

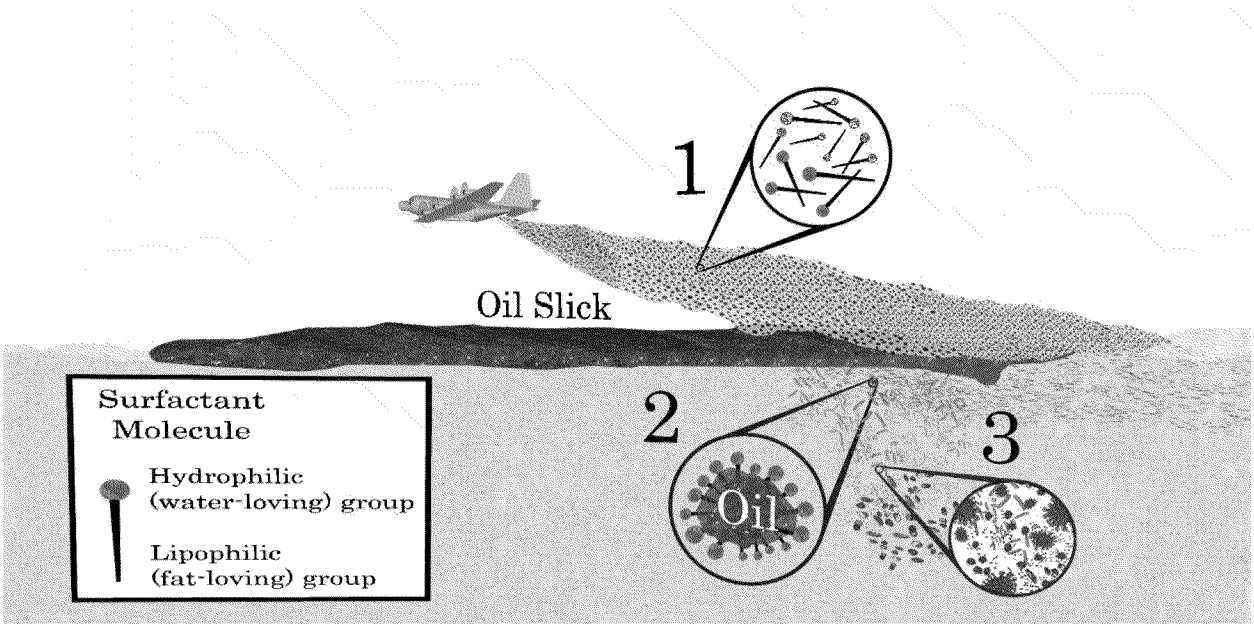

Figure 2. Dispersants, which are one strategy used to respond to an oil spill, contain molecules that have one end that is attracted to water and one end that is attracted to oil (1). When dispersants are applied to an oil slick, these molecules attach to the oil, allowing the oil slick to be broken up into smaller oil droplets (2). These smaller droplets can then be mixed into the water column and are naturally broken down by bacteria and other organisms (3).

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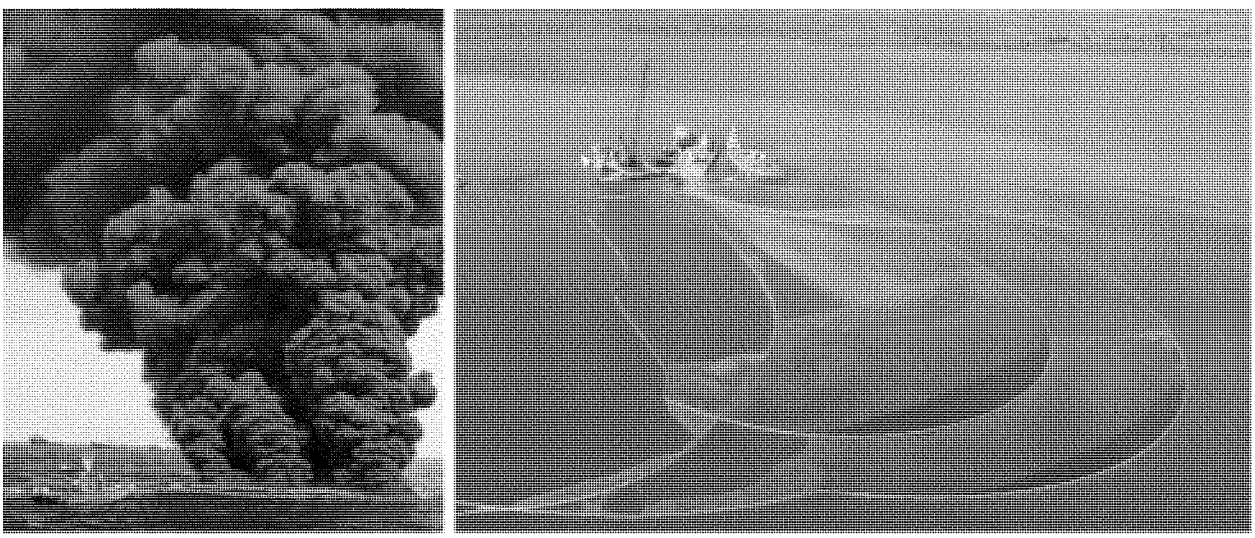

Figure 3. Controlled burning (left) and skimming (right) are two response techniques used to remove oil from the water surface after an oil spill. Credit: NOAA's Office of Response and Restoration.

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GoMRI and Sea Grant sidebar

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Persistence and Effectiveness of Dispersants used during the Deepwater Horizon Oil Spill

Monica Wilson
Larissa Graham, Chris Hale, Emily Maung-Douglass, Steve Sempier

The large volume of dispersants used during the 2010 Deepwater Horizon (DWH) oil spill raised many questions about the use of **dispersants** and highlighted the importance of understanding their effect on the marine environment. The research presented in this outreach publication as well as ongoing studies provide answers to some of these questions.

After the Deepwater Horizon oil spill at the Macondo well (the site where the DWH oil spill occurred), responders applied approximately 1.8 million gallons of chemical dispersants, **Corexit** 9500 and 9527, to oiled waters from April 22 – July 19, 2010. Roughly 771,000 gallons of dispersant were injected directly into the flow of oil and gas from the wellhead (Figure 1).[1]

The DWH oil spill was the first spill occurring at substantial depth, nearly one mile below the ocean's surface, and what is known about the outcome and persistence of oil or dispersants in the deep is scarce[1,2.] Studies that predict where the oil will go and how long it will stay in the environment are based primarily on sea surface spills, not subsurface oil spills. Deep waters are high in pressure and low in temperature and so dispersed oil may react differently in these environments.

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How Dispersants Work

Applying chemical dispersants does not reduce the total amount of oil entering the environment, but rather changes the chemical and physical properties of oil. These changes affect the oil's transport and how the oil may interact with the environment. Chemical dispersant can also speed up the natural process of removing oil from the environment. Dispersants cause oil slicks to break into smaller droplets, making the oil more available to bacteria that naturally remove it from the water. Dispersants also increase the amount of oil that mixes into the water column, through wind and wave action, reducing the risk of oil contamination to shoreline habitats. However, increasing the amount of oil that mixes into the water column also risks increasing marine life's exposure to oil.[3]

Effectiveness

Both chemical and environmental factors can determine a dispersant's effectiveness at breaking up the oil. The type of oil being dispersed, the amount of oil present, how **weathered** the oil is, the type of dispersant being used, and how it is applied can impact how well a dispersant will work. Physical properties of the water such as temperature, water **salinity**, and wave energy also impact the effectiveness of the dispersant.[4] Dispersants are found to be less effective on oils that have:

- Higher **viscosity**, the oil is thick and doesn't flow easily;

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- Been weathered causing the oil to become more **viscous**;
- Cooled significantly below their **pour point**; or
- **Emulsified**.[5]

Surface application of dispersants

During the DWH spill, dispersants were applied at the surface by plane and boats, and were exposed to direct sunlight. Scientist have expressed concern that sunlight could break down some of the components found in the dispersant, Corexit, and make it ineffective. To understand the overall effectiveness of the dispersant mixtures, scientists tested the two main components found in Corexit (2 butoxyethanol and propylene glycol) to see how sunlight would affect them. Results suggested that the exposure to sunlight did not reduce how effective the two components were.[6]

Another consideration at the surface level is the presence of floating or submerged materials such as sea sand, mangrove leaves, seaweed, and seagrass, which could interfere with the effectiveness of dispersants. In lab studies, scientists tested the role of different natural materials on dispersant effectiveness, and discovered an interesting connection. When small amounts of floating oil were present, natural materials such as seaweed and seagrass absorbed the oil. The adsorption reduces the amount of oil dispersed into the water column, making the dispersant less effective. However, dispersant effectiveness was improved when large amounts of floating oil were present, because the seaweed and seagrass transferred oil into the water column as they moved up and down during mixing (Figure 2).[7] This allowed the dispersed oil to mix into the water column.

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Deep water application of dispersants

According to the U.S. EPA, the use of dispersants at the Macondo wellhead was the first time dispersant was used to respond to the threat of oil in deep water. While sub-surface dispersants were being applied, the federal government required regular examination of how effective the dispersants were and how they were affecting the environment, water and air quality, and human health through a monitoring program. Results[8] from the program indicated that the use of dispersants at the wellhead was effective at reducing the amount of oil reaching the surface. It also showed that the amount of dispersant used was less than what would be needed if the oil reached the surface. The U.S. EPA could discontinue the use of dispersants at any time if negative impacts were found to outweigh the benefits.[9] The monitoring plan that responders had to follow to ensure the protection of the environment and public health is available on U.S. EPA's website and listed in the reference section.[10]

Independent studies conflicted with the U.S. EPA results. To test the effectiveness of dispersants, scientists developed a **hydrodynamic model** that recreated the conditions that occurred during the DWH oil spill. Results from the model suggested that the dispersant was not effective, and applying the dispersant at the wellhead may not have changed the amount of oil rising to the surface. The model also showed that the sizes of the oil particles being released at depth prior to the application of dispersant were already small and neutrally buoyant, meaning they were neither sinking nor rising, due to the relatively small pipe diameter and

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large ejection speed at the wellhead.[11]

Persistence of Dispersants

To understand how long dispersants persist below the sea surface in both nearshore and offshore environments, scientists measure the concentration of dioctyl sodium sulfosuccinate, or DOSS, a **surfactant** that is found in Corexit.

DOSS, or dioctyl sodium sulfosuccinate, is a primary component of Corexit 9500 and 9527 which were both used during the Deepwater Horizon oil spill. DOSS lowers the attraction of oil and water molecules allowing them to mix. DOSS is a common ingredient in consumer products such as detergents, cosmetics and laxatives, and therefore, through our wastewater system can end up in lakes, rivers, and coastal waters.[12]

Nearshore studies

Nearly four years after the spill, scientists found DOSS in oiled beach samples collected on Gulf of Mexico beaches. The samples, collected between June 2012 and January 2014 from Florida, Alabama, Mississippi and Louisiana beaches, include tar balls and sand patties formed by weathered oil that moved into shallow waters and mixed with sand. The amount of oil and DOSS in these samples was patchy and inconsistent. This is due to the samples originating from offshore mats of oil which are formed when weathered oil from the surface moves into shallow waters, mixes with sand, and sinks.[13]

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Is the dispersant found in the nearshore environment always linked to the Deepwater Horizon spill? Although DOSS concentrations have been used to track Corexit in the environment, DOSS does not always have a link to dispersant use. After the spill, the community of Orange Beach, Ala., set up its own environmental sampling and analysis plan to determine if chemicals from Corexit were present in nearshore and inland waters. The results showed that there was a presence of DOSS in the collected water samples, however, it did not originate from Corexit. In the Gulf of Mexico, DOSS concentrations decreased and were undetectable as testing got further from the wellhead[1]. The concentration of DOSS found in the Orange Beach samples was higher than would be expected given the distance of Orange Beach to the wellhead. Instead, DOSS likely appeared in stormwater pollution from nearby communities which have used detergents, cosmetics, laxatives and other everyday products that contain DOSS.[14]

Offshore Studies

During the DWH oil spill, most of the elevated concentration levels of DOSS occurred at depths of 3200-4000 ft, due to the application of the dispersants at the wellhead (Figure 3). Studies suggest that marine life that live in the deep water or in the water column may have been exposed to 1-10 **ppb** of DOSS or 10-100 ppb of Corexit near the actively flowing wellhead. The amount of DOSS and Corexit that marine life was exposed to decreased with distance from the wellhead.

So far, scientists have not been able to determine whether applying the dispersants was

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successful in making oil drops smaller or isolating the oil in the deep ocean.[1] Studies show that DOSS and possibly other chemicals found in Corexit became trapped in the deep plumes. Two possible explanations for this are:

1. Dispersants were not effective in the deep water environment - DOSS dissolved into the water while it was rising from the wellhead, through separation with water and natural gas, and became trapped in the deep water oil plume at roughly 3,600 ft. If DOSS dissolved completely it would suggest that the dispersant was not able to effectively disperse the oil.
2. Dispersants were highly effective - Corexit was found in small oil droplets trapped in the plume. If DOSS was deposited in these small oil droplets, then it would suggest that the dispersant was highly effective and caused the oil to breakdown.[1]

Scientists also found concentrations of DOSS in other deep water environments, such as deep-sea coral communities, up to six months after the spill. Scientists think that the breakdown of DOSS is much slower in deeper, cooler waters where sunlight cannot penetrate.[15,16] Coral communities located 4500 feet below the surface and as far as 7 miles from the wellhead showed visible signs of stress. The corals showed signs of poor health, including tissue loss, skeletal plate enlargement, and excess mucous production. They were also covered in brown clumps of material containing weathered oil from the well. Corals located further from the wellhead, more than 13 miles away, had no visible signs of stress or oiled material.[13]

Do we need to be concerned with the persistence of dispersants in the Gulf of Mexico? Scientists are learning more but because this was the first time dispersants were applied in such a large volume and in deep water, the question still remains unanswered. Future research from programs such as the Gulf of Mexico Research Initiative (GoMRI) will continue to perform studies on the use of dispersants to determine their persistence and effects on the marine environment.

More information about these ongoing studies can be found on GoMRI's website at http://gulfresearchinitiative.org. Other publications focusing on dispersants can be found on the Sea Grant oil spill science outreach website at: www.gulfseagrant.org/oilspilloutreach.

Glossary

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Dispersants – Dispersants are chemicals that are used during oil spill response efforts to break up oil slicks and prevent the oil from impacting of marine life and coastal habitats.

Emulsification – occurs when two liquids combine, with one being suspended in the other. For crude oils it refers to the process where sea water droplets become suspended in the oil by mixing due to turbulence.

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Hydrodynamic model – computer-based models used as a tool to describe the way a body of water moves.

Pour point – lowest temperature at which a liquid remains fluid (pourable).

ppb – or parts per billion, is the concentration of something in water or soil. For example, 1 ppb is equal to one drop of liquid in a tanker truck, which contains about 13,000 gallons of water.

Salinity – the average concentration of dissolved salts in a body of water.

Surfactant – Surfactants are compounds that work to break up oil. Dispersants contain surfactants which break the oil slick into smaller droplets that can more easily mix into the water column.

Viscosity – measure of a fluid's resistance to flow.

Viscous - sticky, thick consistency.

Weathered oil – Oil becomes weathered when processes such as evaporation, bacterial decomposition, or exposure to sunlight change the chemical composition and physical appearance of oil.

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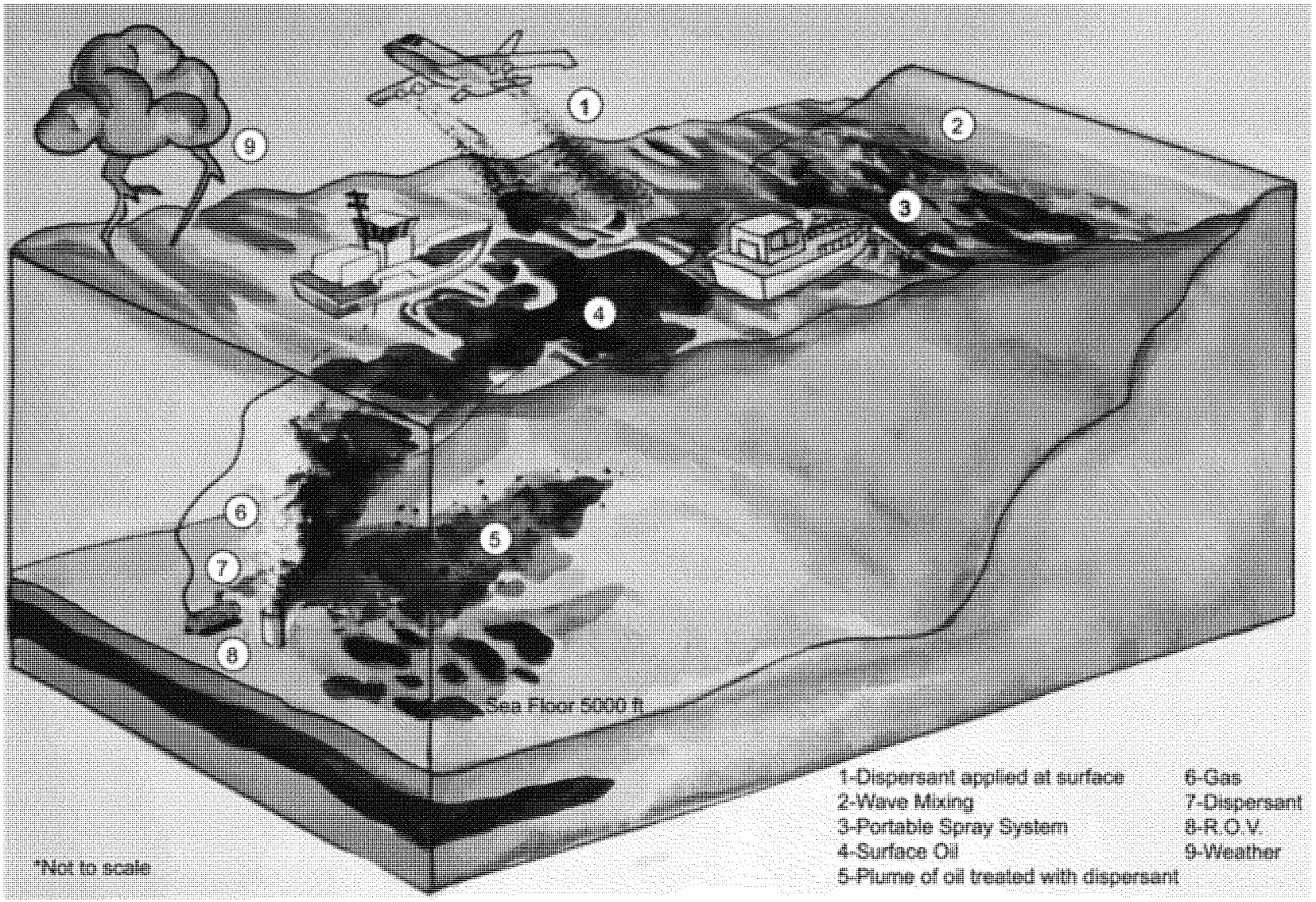

Figure 1. Illustration showing the transport of the oil and how dispersants were applied during the Deepwater Horizon oil spill. Florida Sea Grant illustration.

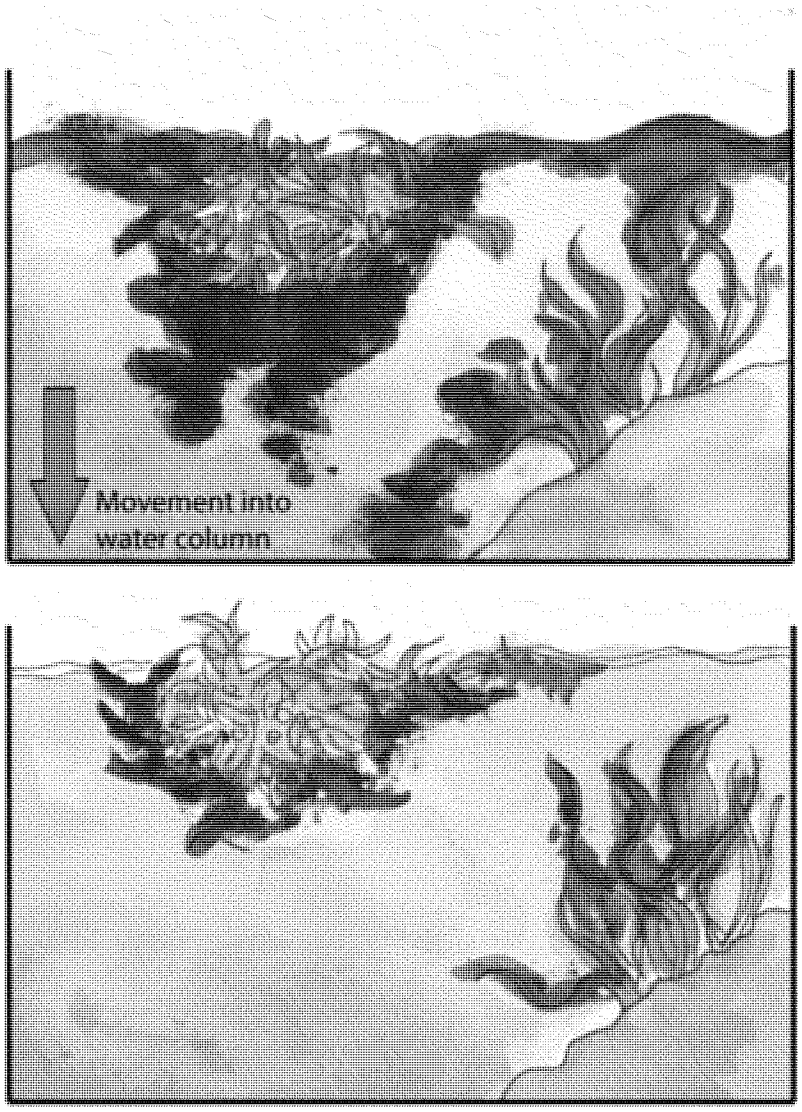

Figure 2. The effect of partially submerged natural materials on the transfer of oil from the surface to the water column. Top: With large amounts of floating oil (shown in brown) the natural materials transfer the oil from the oil floating layer to the water column making more oil available to be dispersed and breakdown. Bottom: With relatively small amounts of floating oil present the natural materials retain the oil, causing less oil in the water column, and reducing the effectiveness of the dispersant. Florida Sea Grant illustration.

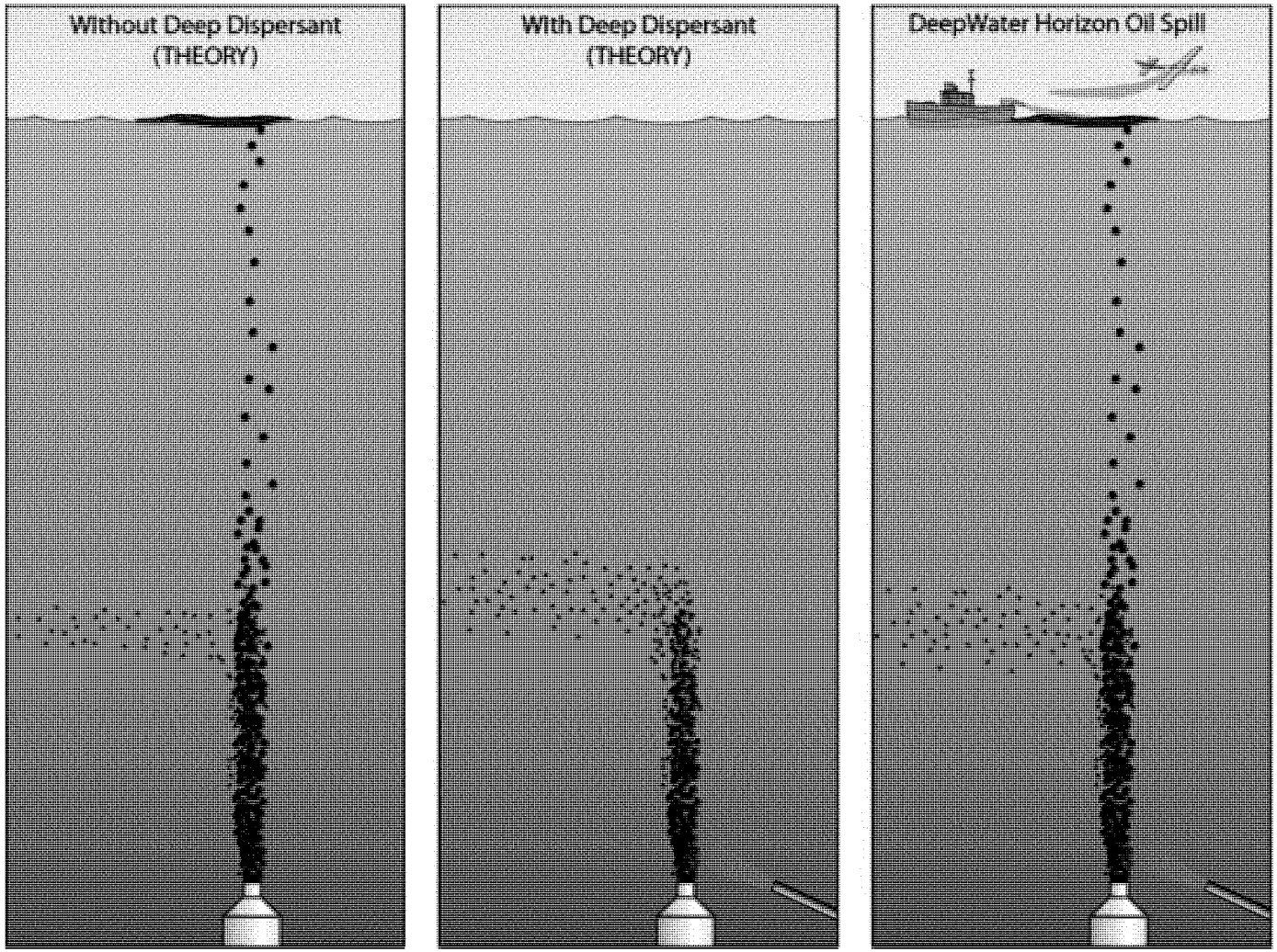

Figure 3. Graphic showing the theoretical fate of the oil with and without subsurface dispersants (first two images) and what occurred during the DWH (third image). Figure from Kujawinski.[1]

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This work was made possible in part by a grant from BP/The Gulf of Mexico Research Initiative, and in part by the Mississippi-Alabama Sea Grant Consortium, Florida Sea Grant College Program, Louisiana Sea Grant College Program and Texas Sea Grant College Program. The statements, findings, conclusions and recommendations do not necessarily reflect the views of these organizations. This is publication number MASGP-15-014.

GoMRI and Sea Grant sidebar

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The Gulf of Mexico Research Initiative (GoMRI) is a 10-year research program administered by the Gulf of Mexico Alliance and led by an independent academic research board. GoMRI aims to mitigate impacts of oil pollution and stressors on both the marine environment and public health from the 2010 Deepwater Horizon oil spill, as well as improve society's understanding of oil spill issues. Emerging information can be found on GoMRI's website at http://gulfresearchinitiative.org.

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Top 5 Frequently Asked Questions about the Deepwater Horizon oil spill

Emily Maung-Douglass, Monica Wilson, Christine Hale, Larissa Graham
Steve Sempier

In April 2010, the Deepwater Horizon (DWH) oil spill occurred about 50 miles offshore of Louisiana. It released approximately 4.9 million barrels of oil from the Macondo well almost one mile below the surface. Roughly 1.84 million gallons of dispersants were used to break-up the oil to reduce the amount of oil reaching the shoreline. This bulletin addresses the five most common questions that tourists to the Gulf Coast have surrounding how oil was cleaned up, where the oil moved in the environment, and the ecological and health impacts of the spill.

Question #1: Is Gulf seafood safe to eat?

The DWH oil spill left some consumers with concerns about eating Gulf seafood. Research has shown that Gulf seafood harvested from waters that are open to fishing is safe to eat.

During the DWH oil spill, federal agencies, such as National Oceanic Atmospheric Administration (NOAA), U.S. Food and Drug Administration (FDA) and U.S. Environmental Protection Agency (EPA), worked with Gulf of Mexico states to develop and implement a comprehensive, coordinated, multi-agency program to ensure seafood safety. State agencies conducted their own sampling in state waters after the federal-state program ended.[1]

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In total, federal and state agencies tested more than 22,000 seafood samples for **polycyclic aromatic hydrocarbons (PAHs)**, the toxic part of oil, and **dioctyl sodium sulfosuccinate (DOSS)**, a chemical found in dispersants. Not a single sample came back with levels of PAHs or DOSS above the "level of concern" established by the U.S. Food and Drug Administration.[1,2,3,4,5,6] PAH levels in shrimp, for example, were 100,000 to 1,000,000 times lower than the levels of concern (Figure 1).

To learn more about the sampling that occurred, and to access the data from these sampling programs, read our bulletin about seafood safety at the Oil Spill Science Outreach website (http://gulfseagrant.org/oilspilloutreach).

How much is too much?
In 2011, when seafood testing was ongoing, the Louisiana Department of Wildlife and Fisheries and the Louisiana Department of Health and Hospitals stated that an average consumer could eat 63 pounds of peeled shrimp, 130 oysters, or 9 pounds of finfish every day for 5 years before reaching the FDA's level of concern for oil contamination.[7]

Question #2: What were/are the impacts to wildlife?

The Gulf of Mexico is home to many types of wildlife, all living in different yet connected habitats. This can make the question of "How did the DWH oil spill affect wildlife?" complicated for scientists to answer. To gain a big picture understanding of the question, scientists look at DWH oil spill impacts to the different coastal environments (e.g., wetlands, the deep sea and oyster reefs), and impacts on the wildlife that live in these habitats. Figure 2 depicts some of the many considerations scientists have when sifting out what is and is not known about impacts to wildlife and their habitats.[1]

As an example, scientists have learned that exposing a fish to oil and dispersant mixtures in the laboratory has negative effects on that fish.[2,3,4] The chemicals found in oil and dispersants interfere with the heart development, growth, and swimming ability of young fish. Such findings have led scientists to further study if oil and dispersant mixtures can cause declines in whole **populations** of fish in the wild. Understanding this is important since different populations of animals in are all dependent upon one another, and so the decline of one species could mean trouble for other species.

While oil and dispersant mixtures effect individual fish tested in the lab, scientists have not found consistent evidence that the DWH oil spill has impacted fish populations and **communities** in the wild.[5,6] Studies that involve catching and counting fish have found that the oiled habitats are just as abundant with fish as they were before the oil spill. This suggests, that despite harm to some individual fish, the oil spill might not have injured the fish population as a whole. Scientists continue to work to understand why oil and dispersants impact individual fish more than populations of fish. This will require long-term studies to understand the many players and layers involved in ecosystem research.

Question #3: Where did the oil go and where is it now?

Using satellite imagery, NOAA determined that the surface slick from the DWH oil spill reached a maximum of 29,000 square miles (Figure 3). During and after the spill, oil mixed with Gulf of Mexico waters and made its way to coastal and deep-sea sediments. Oil moved along the coastline towards Florida and the coasts of Mississippi and Alabama, into the marshes of Louisiana, and along the Texas continental shelf, impacting about 1,100 miles of Gulf coastline.[1,2]

In addition to the oil on the surface of the water, oil was also found beneath the surface southwest of the wellhead one month after the spill. Two areas of oil were found at different depths.[3,4]

Of the 4.9 million barrels of oil that spilled, 17% was recovered at the wellhead by a pipe

insertion tube, 13% was naturally dispersed as the oil came out of the pipe at high speeds, ~25% was dissolved in the water column, and up to 30% was unaccounted for (Figure 4).[5] Recent studies show that some of this unaccounted oil has settled onto the seafloor.[6,7] Approximately 1,200 square miles of seafloor has been contaminated with various concentrations of oil from the Macondo well.[6] Oil residue on the seafloor could harm marine life and could stay around for a long period of time. Cold temperatures, lack of sunlight, and low oxygen can slow the breakdown of oil.[7,8]

Question #4: What cleanup techniques were used and how were they implemented?

During the DWH oil spill, responders employed a combination of methods to remove the oil. Offshore, responders focused on removing the oil using large skimmers and in situ burning.

Skimmers are devices used for removing oil from the sea's surface before it reaches the coastline (Figure 5). During the DWH oil spill, skimmers were used near the spill source; near-shore, within three nautical miles; and inshore at beaches, bays, and marshes.[2] During in situ burning oil was corralled with fire-proof boom and then ignited (Figure 6). [3]

Dispersants were used to break up the oil and prevent it from reaching the shorelines (Figure 7). They were applied in three ways:

- A remotely operated vehicle (ROV) applied dispersant directly into the oil and gas flow coming from the wellhead
- Boats sprayed dispersant at the surface near the well site
- Planes sprayed dispersant at the surface to disperse oil slicks that were more than 5 nautical miles from the well site

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Near shore, emergency responders focused on protecting the shoreline, especially sensitive areas, using skimmers and containment booms (Figure 8).[2] Booms float on the surface of the water and act as physical barriers to floating oil.

In an ideal situation, floating oil is quickly contained by booms. However, water currents, waves and winds can cause oil to make its way over and under the boom. Booms can be placed across inlets so that oil cannot pass through into sensitive areas.[3]

Once the oil made its way to shore, responders used the Shoreline Cleanup Assessment Technique (SCAT) to determine how they would clean the coastline. Responders monitored the shoreline, recorded the amount of oil, type of shoreline, habitat and animals found in the area, and noted archeological or historic sites.[2] Based on this information, an appropriate clean-up plan was created.

Question #5: Do dispersants make it unsafe to swim in the water?

Exposure to Corexit, the dispersant that was applied during the DWH oil spill, has been a public health topic of interest. At high levels, like those experienced by responders working with Corexit, this dispersant can cause respiratory problems and skin irritation.[1] Given that information, people have asked if Corexit affect humans swimming in the Gulf of Mexico.

Scientists at the EPA and National Institutes of Health (NIH) determined that Corexit does not impact the body's reproductive hormone system.[3] In May-June 2010, several teams of scientists sampled waters from the Gulf of Mexico at locations one-quarter to 11 miles southwest of the wellhead. They collected water ranging from the surface to more than 0.4 miles below the surface.[2] The water was tested for DOSS, one of the active ingredients in Corexit used to trace the dispersant's path in the environment. The outcomes of the EPA and NIH study, and an additional study by the FDA, suggest that levels of Corexit in the waters of the Gulf of Mexico should not pose a concern for swimmers. In fact, if we use DOSS as an estimate for the quantity of Corexit, it would take Corexit levels nearly 2 to 720 times higher than those found in samples near the wellhead during the spill to cause toxicity in human liver cells.[3,4]

Glossary

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Community - Groups of different species of organisms interacting with one another and with the environment in a specific region.

Dioctyl sodium sulfosuccinate (DOSS) – DOSS is a primary component of both Corexit formulas used in the Deepwater Horizon oil spill. It can lower the attraction within oil and water molecules and hinder the formation of large oil slicks on the surface of the ocean. DOSS can also be found in consumer products such as detergents, cosmetics and laxatives and therefore can be found in coastal waters.

Naturally dispersed – oil coming out of the pipe at high speeds into the water column, causing some of the oil to spray off in small droplets.

Polycyclic aromatic hydrocarbon (PAH) – a group of hydrocarbons commonly found in oil, tar, burned wood and animal fats. More than 100 PAHs exist and some are known to cause cancer, birth defects, mutations or death.

Population - organisms of the same species inhabiting a specified area.

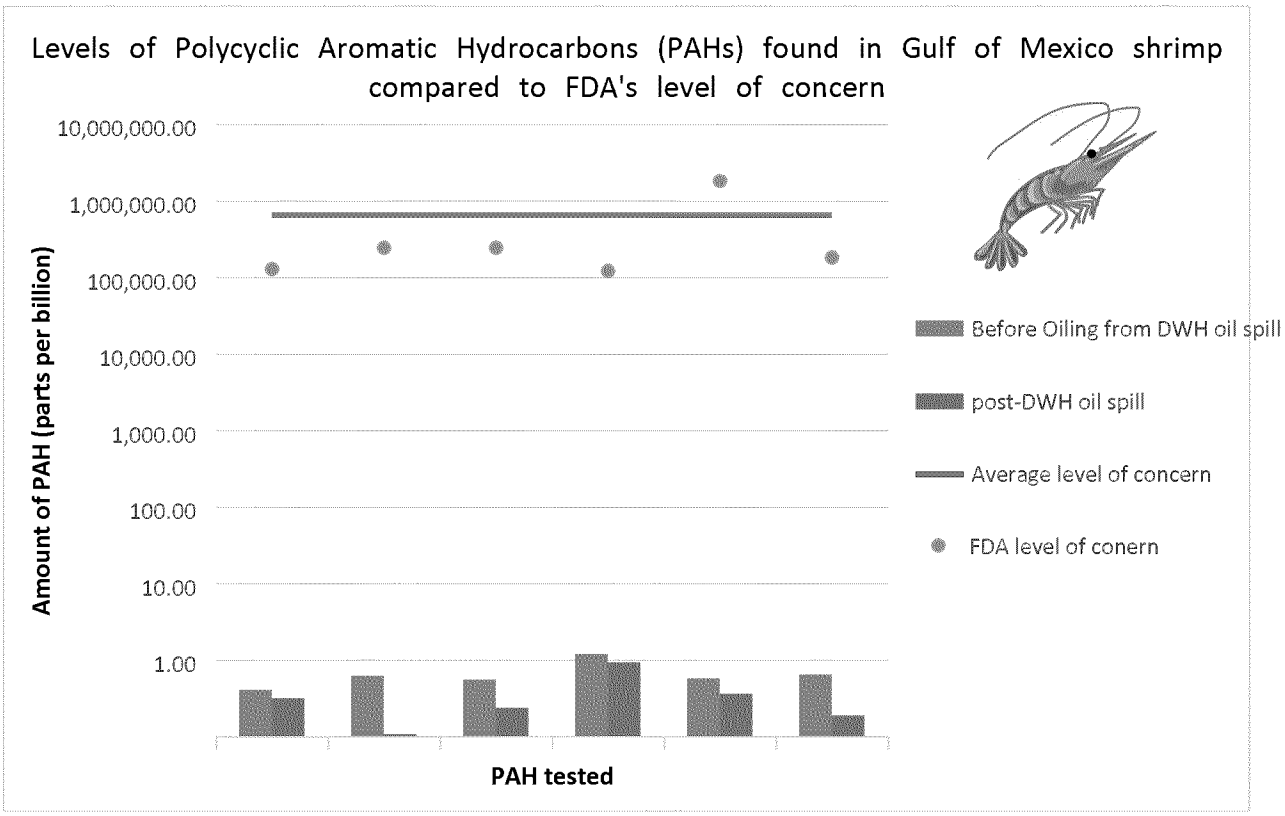

Figure 1. The levels of chemicals found in shrimp that were tested (blue and red bars) were below the level of concern that were set by FDA (green circles).

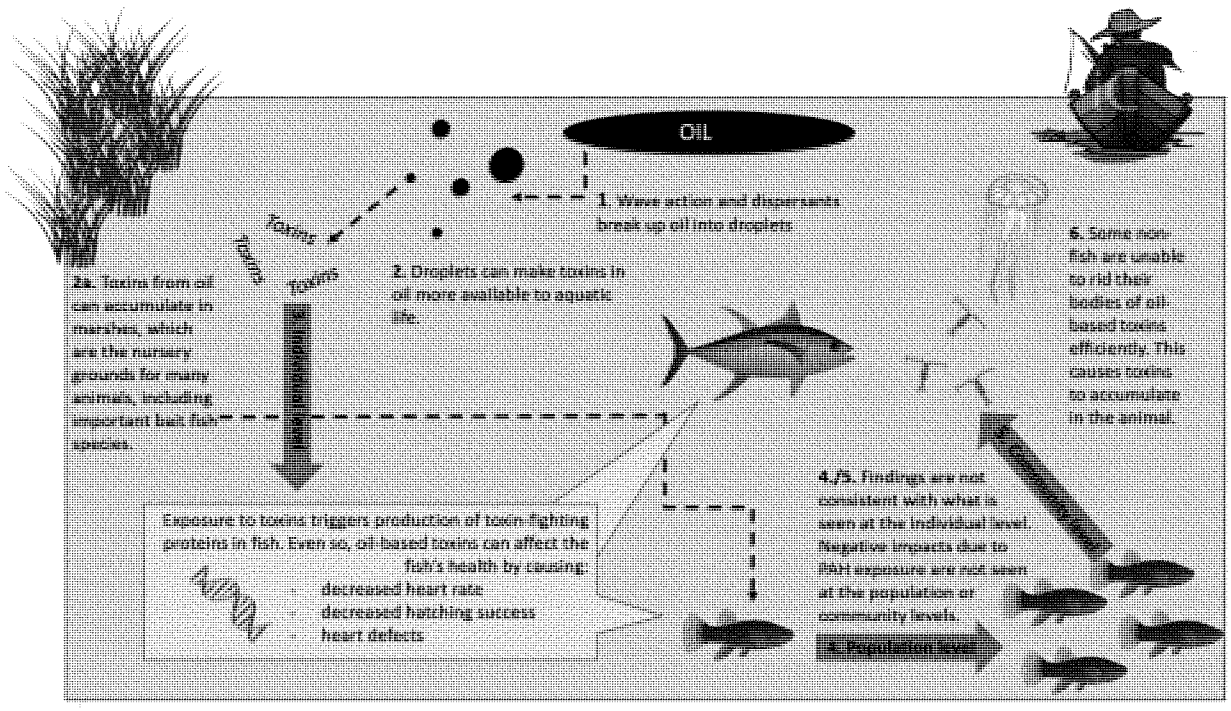

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Figure 2. Diagram of the effects of polycyclic aromatic hydrocarbons (PAHs) on aquatic animals – responses at the individual, population, and community levels. Image credit: E.S. Maung-Douglass, with contributions from D. Tracey, J. Thomas, T.Saxby (IAN-UMCES Image Library).

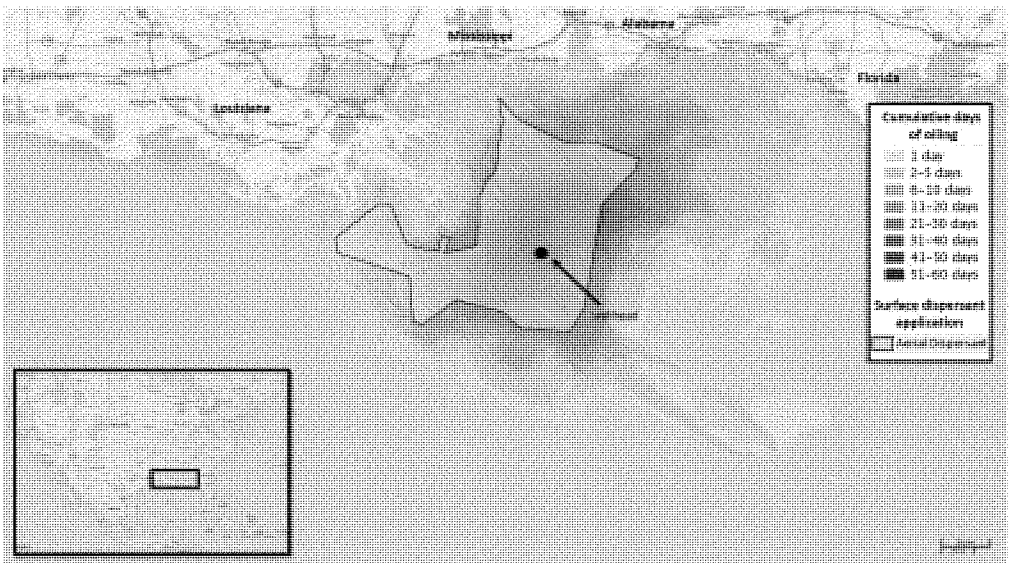

Figure 3. This map shows areas that were oiled during the *Deepwater Horizon* oil spill (gray) and where dispersants were applied via plane (yellow). Dispersants were also sprayed by boats and at subsurface depths (not shown on this map). Credit: Environmental Response Management Application.

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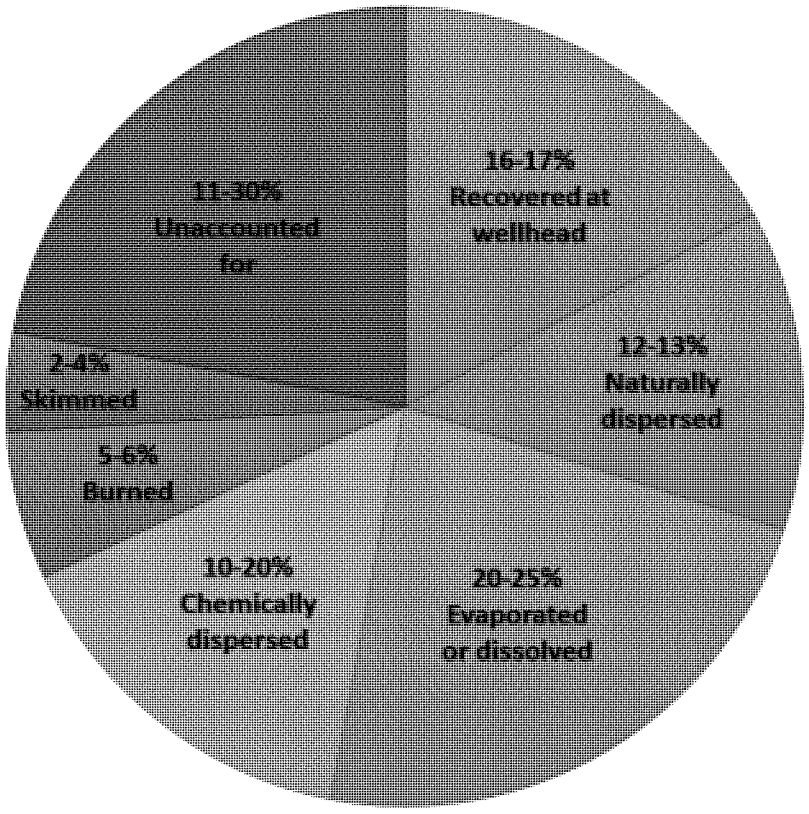

Figure 4. An estimate of what happened to approximately 200 million gallons oil from the DWH oil spill. Data from Lehr, 2014.

[Figures below will be imbedded with the text so that no figure description will be required]

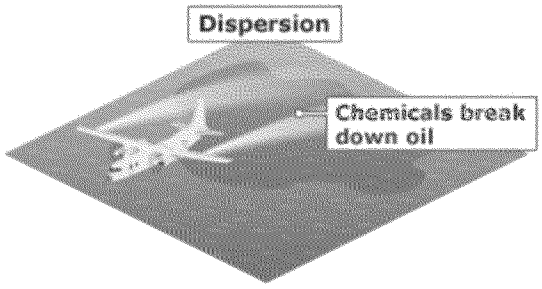

Figure 5.

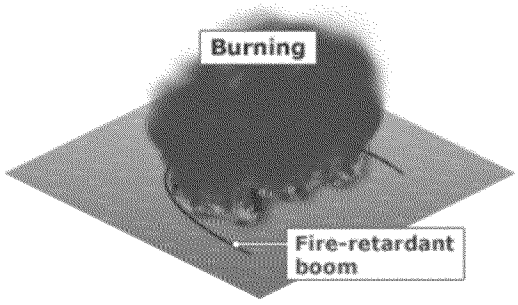

Figure 6.

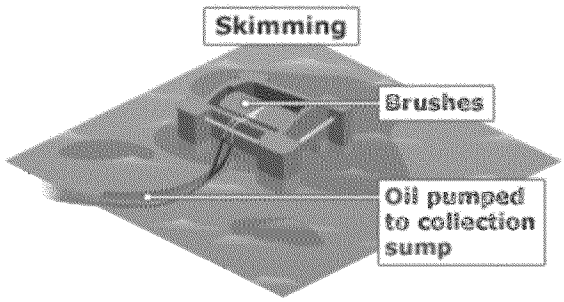

Figure 7.

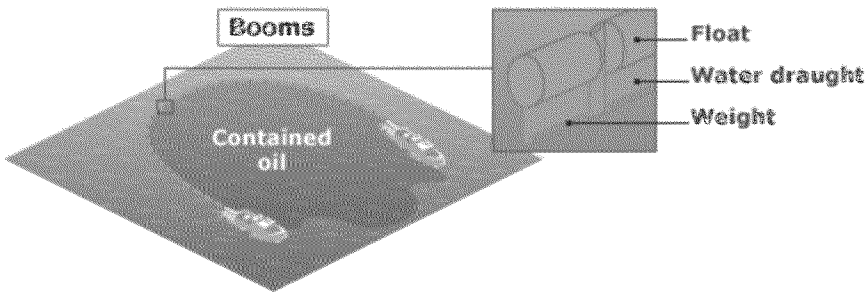

Figure 8.

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Question 1: Is the seafood safe to eat?

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Question 4: What cleanup techniques were used and how were they implemented?

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Question 5: Do dispersants make the water unsafe to swim?

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This work was made possible in part by a grant from BP/The Gulf of Mexico Research Initiative, and [illegible] sissippi-Alabama Sea Grant Consortium, Florida Sea Grant College Pro[illegible] a Grant College Program and Texas Sea Grant College Program. The stat[illegible] conclusions and recommendations do not necessarily reflect the views of the [illegible] his is publication number MASGP-15-014.

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Cc: Kim Jennings[Jennings.Kim@epa.gov]
From: Matthiessen, Craig
Sent: Wed 5/11/2016 2:50:22 PM
Subject: FW: Resources at Risk Document for HWCG Drill - Example for Environmental Tradeoffs (NEBA) Discussion
HCWG Drill Resources at Risk NOAA.docx

Ran across this; forgot to send.

From: Drieu, Mike [mailto:Mike.Drieu@anadarko.com]
Sent: Monday, May 02, 2016 9:46 AM
To: 1145tg@listserve.api.org
Subject: FW: Resources at Risk Document for HWCG Drill - Example for Environmental Tradeoffs (NEBA) Discussion

Thanks to NOAA for sending latest RAR info that could be used for NEBA section in API subsea dispersants document we are using on. It is 15 pages and shows extensive detail and good references.

If this is accepted as baseline for future concurrence packages for subsea dispersant use, we may consider using this entirely and incorporate as another Annex.

Thanks,

Mike Drieu

Anadarko Petroleum Corporation

"Enhance Preparedness; Reduce Risk"

EHS Advisor

(O) 832.636.8493

(F) 832.636.0435

(M)281.844.0813

From: Paige Doelling - NOAA Federal [mailto:paige.doelling@noaa.gov]
Sent: Friday, April 29, 2016 2:58 PM
To: Drieu, Mike; Robert Simmons; Braddock, Mary; aahnell@exponent.com; John Temperilli; Bess, Amanda S; Brandon Klopfenstein; Horace Bussey; Jon Unwin; Nedwed, Tim J; Cramer, Marty:; Roland Goodman; Condon, Michael W; Walker, Samuel; Steve Buschang
Subject: Resources at Risk Document for HWCG Drill - Example for Environmental Tradeoffs (NEBA) Discussion

Hi Mike,

In support of the upcoming HWCG drill, I had NOAA's resources at risk contractor, Research Planning, Inc, develop the attached resources at risk document.

In my opinion, it contains the appropriate level of detail for an incident-specific evaluation of dispersant use. I am forwarding it along to the work group to inform the planned discussions on the NEBA part of the guidance document.

I used the circulation list from the last invitation, so if I've left anybody out, please forward along.

Also, because all SSCs don't think exactly alike, I've asked my fellow SSCs to take a look at it as well.

I plan on attending the work group meeting in May, and hoepfully will be able to attend some of the later ones as well.

See you in May,

Paige

--

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DRILL- DRILL- DRILL Resources at Risk for the northern Gulf of Mexico (GOM)

I. Spill Source Information

This report was prepared on 27 April 2016. Information in this report is meant to cover a release of approximately 6,500 barrels per day of Louisiana crude originating on May 10th at 28°40'59.913" N and 88°10'34.391" W. The spilled product is moving north and east, and will impact the shoreline primarily in Mississippi, Alabama, and Florida if it makes landfall.

II. Geographic Region Covered

The resources covered in this report are those expected to be found in the offshore area corresponding to block MC-300, the adjacent continental shelf, and coastal zone extending from lease block MC-300 to the shore from the Chandeleur Islands, LA to Destin, FL.

III. Oil type, behavior and effects to impacted species

Louisiana crude is a light crude that has an API of 37. It has moderate concentrations of toxic compounds and is moderately volatile. Observations during aerial surveys indicate that the crude oil readily emulsifies (both during its 5,000 ft rise to the water surface and by wave action on the sea surface). Thick emulsified oil occurs as large patches (tens of meters in diameter), long streamers, and smaller tarballs. Large areas of sheens are associated with the emulsified oil. The oil could concentrate in convergence zones, in patches of Sargassum (where sea turtles and birds may also concentrate).

Oil that reaches nearshore and coastal areas will mostly be weathered crude oil from the well. These relatively large accumulations of emulsified oil can heavily coat intertidal areas. The emulsified oil could also become mixed with sand, either in the surf zone or after stranding onshore. These oil:sand mixtures are heavier than water and could accumulate as submerged oil mats in nearshore areas off Gulf sand beaches. They can become buried by the movement of offshore bars, be buried within the beaches, and persist for years. The oil can become trapped in and form thick deposits along fringing marsh shorelines. The stability of the emulsions, once stranded on the shoreline and sheltered from wave action, is uncertain. One possibility is that the emulsion could break, releasing liquid oil that could be only moderately weathered (emulsification slows weathering processes such as evaporation and dissolution). The release of liquid oil inside the marsh fringe or on beaches could cause significant additional impacts to benthic, water-column, and water-surface resources in these shallow water habitats. Animals may not avoid the weathered emulsified oil, particularly if it does not provide any indication of hazards (e.g., it might not smell oily, could look like natural debris), and animals could still attempt to feed in the open areas between the patches that would still have some sheen. Further away from the source, tarballs (oil <10 cm in diameter), tar patties (oil >10 cm), and occasional tarmats may strand along the shoreline. These oil deposits could range in texture from soft, emulsified oil to semi-hardened outer layers. The oil may adhere to aquatic vegetation, birds, fur-bearing mammals, and reptiles. Oil coming ashore will be weathered so oil effects are likely to

be a result of coating and smothering of shoreline resources, ingestion of tarballs by sea turtles, and the persistence of oil in sediments.

Background on Potential Effects

The impacts arising from oil spills on aquatic species in open waters likely varies by species and with the rate at which oil partitions and dilutes in the water column, and with the co-occurrence of sensitive life stages and both physically and chemically dispersed oil. Species that may be at increased risk of exposure to chemically dispersed oil are those entrained within and traveling with the water mass containing the chemically dispersed oil (e.g., small species, embryos, larvae, zooplankton), followed by slow-moving species and life stages. Highly mobile species (e.g., adult shrimp, pelagic fish) may be less likely to be exposed to high concentrations of chemically dispersed oil due to dilution and avoidance.

Toxicity Studies

Exposure of aquatic species, and in particular early life stages, to physically and chemically dispersed oil can lead to lethal and non-lethal but ecologically important impacts (Teal and Howarth, 1984; Albers, 1995; NRC, 2005), but the onset of these impacts depends on several factors including oil concentrations and exposure duration. A growing body of literature (e.g., Carls *et al.*, 1999; Heintz *et al.*, 1999; Heintz *et al.*, 2000; Incardona *et al.*, 2004; Incardona *et al.*, 2005; Incardona *et al.*, 2011; Incardona *et al.*, 2013; Mager *et al.*, 2014; Esbaugh *et al.*, 2016) has shown that under controlled laboratory conditions fish embryos exposed for several hours post hatch to low oil concentrations (>1 mg/L oil, dissolved polycyclic aromatic hydrocarbons [PAHs] in the low µg/L range) develop gross abnormalities, with permanent impacts potentially causing reduced survival later in life (Incardona *et al.*, 2013). These impacts have been documented under laboratory conditions on embryos of pelagic species (i.e., yellowfin tuna [*Thunnus albacares*], Southern bluefin tuna [*T. maccoyii*], yellowtail amberjack [*Seriola lalandi*], and mahi mahi [*Coryphaena hippurus*]), some of which occur in the Gulf of Mexico (Incardona *et al.*, 2014; Mager *et al.*, 2014; Esbaugh *et al.*, 2016). However, the impacts arising from oil spills on fish embryos in open waters and their recruitment to the larval stages likely varies with the rate at which oil partitions and dilutes in the water column, as well as with the co-occurrence of fish embryos and the chemically dispersed oil. As a point of reference, a large proportion of water samples (75%) collected during the *Deepwater Horizon* oil had total PAH concentrations <1 µg/L, though water samples in the immediate vicinity of the wellhead had concentrations >1,000 µg/L (Boehm *et al.*, 2016). In contrast to these sensitive life stages, juveniles and adults are generally highly mobile and may only be temporarily exposed to chemically dispersed oil given their ability to move in and out of the water masses containing the entrained oil.

One of the greatest limitations in understanding the potential impacts related to dispersant use in open waters is the lack of data derived using relatively realistic exposure conditions. Even greater uncertainties and data limitations exist on the potential impacts of subsea dispersants.

Despite these limitations, toxicity data from controlled laboratory studies could provide conservative estimates of potential impacts. Toxicity data are commonly reported as lethal or effects median concentrations (LC50 and EC50, respectively[1]). With regards to dispersants alone, data based on spiked exposures[2] show that most data fall within the slightly to practically nontoxic range[3], with most data falling within the practically nontoxic range. Even for sensitive species, most toxicity values for COREXIT 9527 and COREXIT 9500, regardless of exposure conditions, are >20 mg/L, falling within the range of what is considered slightly toxic. Similarly, the reported toxicity of South Louisiana crude oil chemically dispersed with COREXIT 9500 from 96-h (LC50s and EC50s combined) constant static exposure[4] ranges from 4.84 to 18 mg THC/L (n=8 records) (NOAA/ERD, 2015), falling within the moderately to slightly toxic range.

Potential Levels of Concern

Derivation of potential thresholds of concern could be achieved by the use of Species Sensitivity Distributions (SSDs). SSDs are cumulative distributions of toxicity data that allow for comparisons of the relative sensitivities of aquatic species dispersed oil, and they are useful in that they could be used to calculate the 5th percentile Hazard Concentration (HC5), or concentrations assumed to be protective of 95% of all species in the SSD. While HC5 values may not be necessarily protective of all aquatic organisms, and particularly of those known to be most sensitive to oil, their derivation is often conservative enough to a large range of sensitivities. Conservative estimates HC5s for COREXIT 9527 and COREXIT 9500 are 8.38 mg/L and 4.04 mg/L, respectively, falling within the moderately toxic range. However, these concentrations are assumed to be worst case, as exposure concentrations under standard dispersant applications (ASTM, 2010a; ASTM, 2010b) are not expected to remain constant in the water column, and at any given moment are likely below these concentrations. Based on modeled information of toxicity data (96-hr exposures) for South Louisiana crude oil, the conservative HC5 estimate is 0.97 mg THC/L with a 95% confidence interval of 0.63-1.49 mg THC/L (Bejarano and Barron, 2014). These values fall within the upper and lower ends of the highly toxic and the moderately toxic range, respectively. As a point of reference the range of oil concentrations in the chemically dispersed underwater plume range from non-detectable levels to 6,130 mg/L, with a geometric mean of 1.09 µg/L (Boehm *et al.*, 2011). Given that this oil release is smaller in volume (6,500 bbl/d) than the estimated release rate of the *Deepwater Horizon* oil spill (ca. 50,000-60,000 bbl/d[5]), the THC concentrations would be expected to be lower.

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[1] The LC50 is the concentration lethal to 50% of the exposed test population, while the EC50 is the concentration that causes an adverse non-lethal effect to 50% of the exposed test population. As a general rule, the smaller the LC50 or EC50 values, the greater the toxicity.

[2] Spiked or spiked flow-through tests are tests that address the dilution that occurs in open waters by reproducing under laboratory conditions rapid changes in concentrations within the water column.

[3] Toxicity LC50 and EC50 categories for aquatic organisms are as follows: Very highly toxic <0.1 mg/L, Highly toxic 0.1-1 mg/L, Moderately toxic >1-10 mg/L, Slightly toxic >10-100 mg/L and Practically nontoxic >100 mg/L Source: http://www2.epa.gov/pesticide-science-and-assessing-pesticide-risks/technical-overview-ecological-risk-assessment-0

[4] Exposures that do not account for the natural dilution that occurs in open waters.

[5] Source: Oil Budget Calculator Deepwater Horizon

Potential Impacts

As describe above, HC5 values could be used as surrogate for threshold concentration, with the lower confidence value for South Louisiana crude oil (0.63 mg/L; 96-hr exposures) serving as a conservative threshold to assess potential impacts to the most sensitive life stages. While these concentrations may be possible, it is unlikely that these concentrations would remained elevated for a long period given the dilution that may occur within the water column. Although short exposures have the potential to negatively impact embryos, natural mortality of larvae is high, and the projected plume is limited in geography compared to most larval distributions. Therefore, impacts on entire populations are unlikely. However, given that early life stages of several species (**Table 1**) may be present in the area and their spatial distribution overlap with the water mass containing chemically dispersed oil, it is expected that a portion of each species' cohort would be exposed. Because most other aquatic groups (i.e., sea turtles, marine mammals) are able to swim through water mass containing chemically dispersed oil, potential impacts are likely minimal. A greater risk of exposure may result from inhalation of volatile compounds and smothering at the water surface.

(http://www.restorethegulf.gov/sites/default/files/documents/pdf/OilBudgetCalc_Full_HQ-Print_111110.pdf)

Table 1. List of representative species in the offshore area of interest with early life stages at risk of potential exposure to the water mass containing chemically dispersed oil.

Species	Spatial Overlap with Early Life Stages	Potential Impacts
White and brown shrimp	Spawning inshore of the area of interest; eggs and larvae may be present	Early life stages in shelf waters may be exposed and experience mortality. It is not likely that a large proportion of the population is exposed to oil, given the timing and location of the spill relative to these species' habitats.
Blue crab	Spawning inshore of the area of interest; eggs and larvae may be present	
Bluefin tuna, yellowfin tuna	Spawning in the area; eggs and larvae are present	Early life stages may be exposed and larval mortality can occur. Given that natural mortality rates are high, population level impacts are unlikely.
Swordfish	Larvae may be present year-round in the area	Early life stages may be exposed. It is not likely that a large proportion of the population is exposed to oil, given the timing and location of the spill relative to these species' habitats.
Other pelagic species (e.g., dolphinfish, blackfin tuna, blue marlin, dolphinfish, wahoo, whale shark, white marlin, amberjack, mackerel)	Early life stages may be present in the area; spawning mostly in a different geography.	
Red grouper, scamp, and red, lane, gray and vermilion snapper	Spawning in the area; eggs and larvae may be present	

IV. Shoreline Resources at Risk

Shorelines in the area of impact consist of barrier islands (including Breton, Cat, Ship, Horn, Petit Bois, Dauphin, Santa Rosa, Okaloosa Islands) with mainly fine-medium grained sandy beaches. Mainland shorelines are primarily salt marshes with interspersed pockets of fine- to medium-grained sand beaches. Fresh- and brackish-water marshes may be present in some areas depending on localized freshwater input. Manmade shorelines (riprap, seawalls) are also present in developed areas. Some sheltered flats are present and may be exposed dependent on wind conditions. Riprap jetties are present at the mouth of Destin inlet (East pass) and Perdido Pass.

Because of the broken nature of the interior shoreline, the thick emulsified oil patches and tarballs could penetrate deeply beyond the outer "shoreline" depending on wind conditions, into areas that are very shallow, muddy, and difficult to access. The emulsified oil will readily adhere to marsh vegetation and could form thick bands on the vegetation as water levels vary. There is

also the possibility that the emulsions could break after stranding on the marsh and release liquid oil, which could spread over a much larger area than the footprint of the emulsified oil patches.

Emulsified oil deposited on fine-medium grained beaches is unlikely to penetrate deep into the sediment (<4 mm); however, depending on local conditions, accumulation of sand may result in rapid burial of stranded oil. Some of the barrier islands have a low elevation and could be overwashed during high wind conditions. If oil was present at that time, it could be transported across the islands and either buried in the washover fan or deposited in the marshes on the leeward side of the island. On outer sand beaches, the tarballs and tar patties will collect in debris lines near the high tide mark. Depending on the tides and the concentration of tarballs in the water, the collection zone may be from less than a meter to several meters wide. There may also be scattered tarballs across the rest of the beach face, but in much lower concentrations. The outer shell of the tarball may be heavily weathered by the time it reaches these beaches, making it less sticky with less of a tendency to pick up sediments. However, the inside of the tarball may still be relatively fresh, so if pressure is applied, the outer skin will rupture and the tarball may adhere to whatever it is in contact with. Also when stranded out of the water, the daytime heating may melt the tarballs causing them to adhere to whatever surface they are on at the time. Depending on the beach cycle, the tarballs and patties can become buried during depositional cycles. Therefore, rapid removal is important.

Oil may adhere to rough surfaces, such as riprap and seawalls, leaving a band at the high-water line. In the riprap areas, emulsified oil and tarballs may collect in the crevices between the rocks; there is often debris in these crevices, which can also become oiled, which can be a source for chronic reoiling.

V. Biological Resources at Risk

Threatened, Endangered, and Special Concern (T/E) Species

Birds

Louisiana - Brown pelican (LA SE, over 8,500 pairs) are present and nesting on and around the Chandeleur Islands. Red knot (FT) are present on the shores of the Chandeleur Islands.

Mississippi - Brown pelican (MS SE) and snowy plover (MS SE, nesting) are present on Mississippi barrier islands and Mississippi mainland shorelines. Brown pelican are also present on Mississippi nearshore waters.

Alabama - Least bittern (AL State Protected (SP)), white ibis (AL SP, nesting in locations east of Mobile Bay), mottled duck (AL SP, nesting), northern harrier (AL SP) are present on the back sides of AL barrier islands. Reddish egret (AL SP) are present on and around AL barrier islands and in nearshore waters west of Mobile Bay. Snowy plover (AL SP) is present on islands surrounding Dauphin Island Bay, and it is nesting on Pelican Island, a large sandbar south of Dauphin Island. Wilson's plover (AL SP) is present and nesting on islands surrounding Dauphin

Island Bay and Pelican Island. American oystercatcher (AL SP) is present and nesting on Pelican Island and ocean beaches east of the mouth of Mobile Bay. Willet (AL SP) is present and nesting on the west end of the Mobile Point peninsula and is present on islands surrounding Dauphin Island Bay and ocean beaches east of the mouth of Mobile Bay. Black skimmer (AL SP), common tern (AL SP) and gull-billed tern (AL SP) are present and nesting on Pelican Island. Caspian tern (AL SP) are present on the back sides of AL barrier islands, islands surrounds Dauphin Bay, and beaches at the west end of the Mobile Point peninsula. Royal tern (AL SP) is present in nearshore waters west of Mobile Bay and in waters on the back side of barrier islands east of Mobile Bay. Sandwich tern (AL SP) is present on ocean beaches east of the mouth of Mobile Bay. Seaside sparrow (AL SP) is present and nesting on the islands north of Dauphin Island Bay.

Florida - Black skimmer (FL Species of Special Concern (SSC)), brown pelican (FL SSC), and least tern (FL ST) are present throughout the Florida potential impact area. Piping plover (FT, FL ST) are present on ocean beaches and the back sides of barrier islands throughout the Florida potential impact area. Reddish egret (FL SSC, occasional) and snowy egret (FL SSC, occasional) are present in lagoons/ponds? behind the beach east of Destin. Snowy plover (FL ST) are present and nesting on beaches of barrier islands from the FL/AL border to the east end of Santa Rosa Island.

Reptiles

Five species of endangered or threatened sea turtles inhabit the Gulf of Mexico. Of those, Kemp's ridley (FE, LA E, MS E, AL SP) , leatherback (FE, LA E, MS E, AL SP) and loggerhead (FT, LA T, MS E, AL SP) are most likely to be present in offshore waters near the source of the spill. Turtles are most likely to be encountered in offshore waters (> 5.6 km from shore), and less than 100 m in depth, and are more frequently sighted from spring to fall. Loggerhead turtles are known to frequent oil production platforms. Juvenile turtles are often found associated with *Sargassum* mats, where oil can also accumulate. Nearshore, Kemp's ridley are abundant, loggerheads are common, Green (FE in Florida, FT elsewhere; LA T, MS E, AL SP) are occasional visitors, leatherbacks are rare, and hawksbill (FE, LA E, MS E, AL SP) are very rare or rare.

Sea turtle nesting season is in progress. Nesting occurs in the area of impact, and is summarized below:

- Loggerheads nest on beaches east of Ship Island, MS in low-medium concentrations
- Greens nest in low concentrations on beaches in Alabama and Florida
- Kemp's ridley nest in Alabama in low concentrations
- Leatherback nesting has occurred in the Panhandle of Florida but is rare

Diamondback terrapins (AL SP) can be found along the gulf shoreline in the area of impact.

Direct contact with oil may irritate the eyes, mouth, and nostrils of turtles. Turtles may also ingest tarballs while foraging.

Fish

Gulf sturgeon (FT, LA E, MS E, AL SP) and smalltooth sawfish (FE) may be present in the GOM in the area of impact. Most sturgeon are migrating upstream at this time of year; however, some may remain in coastal areas. Juvenile and adult sawfish may be present in coastal areas and on the continental shelf off of the Florida coast. Both species are demersal and are not common around the spill site, so impacts are likely to be limited. Populations of Alabama shad (AL SP) occur in coastal waters likely to be impacted. Adults return to saltwater habitats in Apr-May after spawning upstream.

Marine mammals

Of the 29 species of marine mammals known to occur in the Gulf of Mexico, all are protected and six (sperm, sei, fin, blue, humpback and North Atlantic right whales) are listed as endangered under the ESA. Of these, only the sperm whale is considered to commonly occur, in the northern Gulf of Mexico. Areas beyond the 100 m isobath are important habitat for endangered Sperm whale (FE, LA E). West Indian manatee (FE, LA E, MS E, AL SP), occurs primarily in Florida bays, estuaries and coastal waters but their range appears to be expanding, and could also be present in sheltered waters in Alabama, Mississippi, and Louisiana. The primary risk of oil spills to marine mammals is inhalation of volatile compounds from fresh oil and ingestion of oiled prey.

Terrestrial mammals

The Perdido Key Beach Mouse (FE, AL SP) is present on beaches and in dune habitats on Perdido Key. Alabama Beach Mouse (FE, AL SP) can be found on beaches from Fort Morgan to Gulf State Park in Alabama. Mice can ingest tarballs and encounter subsurface oil while burrowing, exposing them to the toxic components of oil.

<u>Other Birds</u>

Offshore birds

High concentrations of common tern occur offshore in the impact area. Other offshore bird species present in the area include: Audubon's shearwater, band-rumped storm-petrel, black-capped petrel, brown booby, herring gull, laughing gull, Leach's storm-petrel, long-tailed jaeger, magnificent frigatebird, masked booby, pomarine skua, red-billed tropicbird, sooty tern, Wilson's storm-petrel.

Nearshore and shoreline birds

Louisiana - American oystercatcher (26 pairs), least tern (123 pairs), and Wilson's plover (164 pairs) are present and nesting on the Chandeleur Islands. Over 5,000 pairs of terns are present and nesting on the southern Chandeleur Islands. Scaup (100,000s) occur nearshore just east of the Chandeleurs Islands. American white pelican (10s) may be present immediately around the

Chandeleur Islands. "Nearshore" birds present in waters off Louisiana extend to the edge of the continental shelf and include: gulls, magnificent frigatebird, parasitic jaegar, pomarine skua, royal tern, and sandwich tern.

Mississippi - Birds present on and immediately surrounding Mississippi barrier islands include nesting marsh birds (clapper rail, king rail, least bittern), shorebirds (American oystercatcher [nesting], killdeer, sanderling, semipalmated plover [nesting], willet [nesting], Wilson's plover [nesting]), terns (black skimmer, gull-billed tern [nesting], least tern, royal tern, sandwich tern), raptors (bald eagle [nesting], osprey [nesting]), gulls, wading birds (black-crowned night-heron [nesting], cattle egret, great blue heron, great egret, green heron, little blue heron, reddish egret, snowy egret, tricolored heron, yellow-crowned night-heron [nesting]), dabbling ducks, and migratory songbirds. Many of the same species are found along the mainland shoreline of Mississippi, including several species of shorebirds, raptors, and several species of gulls and terns. Birds present in Mississippi salt marshes include the aforementioned wading bird and marsh bird species, marsh-obligate passerines, rails, and several species of waterfowl (including blue-winged teal, Canada goose [nesting], hooded merganser [nesting], mottled duck [nesting], and wood duck [nesting]). Nearshore birds in Mississippi include gulls, terns, waterfowl and sea ducks, common loon, and pied-billed grebe.

Alabama - Birds present on and immediately surrounding Alabama barrier islands include brown pelican, nesting marsh birds (clapper rail, king rail, sora), shorebirds (black-bellied plover, black-necked stilt, killdeer [nesting], least sandpiper, lesser yellowlegs, sanderling, semipalmated plover, solitary sandpiper, stilt sandpiper, western sandpiper), gulls (Bonaparte's gull, herring gull, laughing gull, ring-billed gull), raptors (bald eagle, osprey), wading birds (great blue heron [nesting], great egret [nesting], green-backed heron [nesting], green heron [nesting], snowy egret [nesting], tricolored heron), and waterfowl (mallard, Canada goose [nesting]). Many of the same species are found along the mainland shoreline of Alabama, including raptors, gulls, terns, and marsh birds. Birds present in Alabama salt marshes include the aforementioned wading bird and marsh bird species, rails, and waterfowl. Nearshore birds in Alabama include gulls, terns, raptors, brown pelican, magnificent frigatebird, northern gannet (common), common loon, horned grebe, and pied-billed grebe.

Florida - Birds present on and immediately surrounding Florida barrier islands include shorebirds (black-bellied plover, dunlin, sanderling, semipalmated plover, short-billed dowitcher, willet [nesting], Wilson's plover), terns (Forster's tern, common tern, royal tern), gulls (laughing gull, ring-billed gull), double-crested cormorant, osprey. Many of the same species are found along the mainland shoreline of Florida, including osprey and several species of gulls and terns. Birds present in lagoons behind beaches east of Destin include bald eagle, gull-billed tern, shorebirds (least sandpiper, lesser yellowlegs), and wading birds (great blue heron, great egret, green heron, yellow-crowned night-heron). Nearshore birds in Florida include gulls (laughing gull, ring-billed gull), terns (common tern, royal tern), and osprey.

Oil can adhere to the feathers reducing insulation, water buoyancy, and water repellency, leading

to sickness or death from hypothermia and/or drowning. Diving birds, such as cormorants and loons, are usually at high risk during oil spills because they spend nearly all their time on the water surface. Wading birds, shorebirds, dabbling ducks, gulls, and terns, can also be severely impacted by oil in some cases. Wading birds and some shorebirds may be directly oiled and can become oiled on the upper body and feathers by coming in contact with oiled vegetation or wrack. Direct oiling of birds reduces the buoyancy, water repellency, and insulation provided by feathers, and may result in death by drowning or hypothermia. Preening of oiled feathers may also result in ingestion of oil resulting in irritation, sickness, or death. Bird oiling may continue even after the floating oil slicks have been removed, depending on the extent of oiled habitat. Oil brought back to the nests by adult birds may kill or injure eggs and young birds. All species can potentially ingest oil while feeding. Wading birds and marsh birds (i.e. American bittern) eat small fish, insects, and crustaceans and may be at risk of coming in contact with oil on the water or oiled marsh vegetation while feeding.

Other Marine Mammals

Offshore - A small population of Bryde's whale, the only baleen whale to commonly occur in the Gulf, inhabits the shelf break region in the northeastern Gulf. Pods of transient Killer whales have been sighted with increasing frequency over the past several decades in the Gulf of Mexico, including off the Mississippi Delta. Other species that may be found in the vicinity of the spill site include: Blainville's beaked whale (common), Clymene dolphin (low), Cuvier's beaked whale (common), Dwarf sperm whale (common), False killer whale (rare), Fraser's dolphin (Rare), Gervais' beaked whale (common), Killer whale (low), Melon-headed whale (common), pantropical spotted dolphin (abundant), pygmy killer whale (low), pygmy sperm whale (common), Risso's dolphin (common), Rough-toothed dolphin (low), Short-finned pilot whale (common), spinner dolphin (low), striped dolphin (common). Little information is available on the reproduction and calving of offshore whales and dolphins in the Gulf. However, a number of species do breed and calve in winter through early summer.

Nearshore and inshore - Atlantic spotted dolphins may be present on the shelf. Bottlenose dolphin are abundant and common in bays, estuaries and inter-bay passes in the northern Gulf of Mexico, and have less opportunity to avoid oil than do offshore whales and dolphins. Bottlenose dolphin may breed and calve throughout the year.

The primary risk of oil spills to toothed whales and dolphins is inhalation of volatile compounds from fresh oil. Bottlenose dolphins exposed to oil during the Deepwater Horizon Oil Spill have shown hormonal abnormalities and high incidences of lung disease from inhaling the toxic components of oil. Oil may foul the baleens of baleen whales if they encounter oil while feeding.

Terrestrial mammals

Muskrats, nutria and other small mammals can be found in brackish-freshwater marshes. The Santa Rosa Beach mouse is present on Santa Rosa Island. Unless exposed to the oil for prolonged periods, mortality is not expected. Terrestrial mammals are at risk of oiling of fur and ingestion during attempts to clean themselves.

Habitats

Offshore - The spill source is in an area of high habitat suitability for deepwater coral species. Known deepwater coral ecosystems are in the impact area, including Viosca Knolls. DeSoto Canyon is a large geologic feature in the impact area that harbors many deepwater reefs and other benthic communities. Due to the high habitat suitability, other deepwater coral reef systems that have not yet been discovered may be in the impact area as well. Sargassum is found on the top of the water column, and has higher concentrations in summer months in the GOM.

Inshore - Seagrass is present on the sound side of the Chandeleur Islands, the Mississippi barrier islands and Dauphin Island, and in the lower portion of Perdido Bay. Seagrass may be present at other locations in addition to these.

Deepwater corals exposed to oil suffer mortality of the portions of colonies exposed, and the fauna dependent on the corals are likely impacted as well, though less is known of these impacts. Care should be taken to leave seagrass beds undisturbed during cleanup, so that the grasses can grow back during the summer growing season. It is doubtful that the oil will be mixed into the substrate, unless there is a lot of disturbance during clean up. It is possible that fauna hiding or living in the grass will be exposed to and impacted by the oil.

Invertebrates

Offshore - Deep benthic environments support unique invertebrate communities, including brittle stars, red crab, hermit crabs, red shrimp, squat lobsters, isopods, sea pends, sea cucumbers, anemones and sponges.

Shelf - Commercially valuable invertebrates likely to be impacted by the spill include white shrimp and brown shrimp. Brown shrimp spawning may be occurring in waters between 46-90m deep, Brown shrimp spawn from Sep-May, and the peak months are Sep-Nov and Apr-May. White shrimp are abundant and spawning from May-Nov, and are generally found in waters less than 30m deep. Blue crab spawning is ongoing throughout the summer and larvae may be present. Females are found in high abundance in shallow areas of the Gulf of Mexico during the spawning season as they release their eggs. Squid may be spawning in the water column Mar-Nov. Pink shrimp may be present.

Inshore - Extensive oyster beds occur on the sound side of the barrier islands in the area of impact, particularly in Mississippi Sound. Oyster spawning is triggered by rising temperatures

and salinities, and typically begins in May and runs through Nov. Brown shrimp are abundant in estuarine waters late summer through fall. Larval white shrimp and blue crab will begin moving inshore in May-Jun to estuarine nursery areas. Blue crabs may be present in nearshore and inshore waters.

Early life stages (eggs, larvae) of invertebrates are sensitive to exposure to the toxic components of oil, which could have both immediate and delayed impacts to the populations. Shrimp eggs are pelagic and buoyant; however, later larval stages have the ability to regulate their position vertically throughout the water column.

Fish

Offshore - Bluefin tuna are abundant and spawning in the vicinity of the spill source through May; eggs and larvae may be present in the area of impact. Yellowfin tuna are also spawning in the area from May-November and swordfish larvae may be present year-round, however neither have been observed in high densities in the spring. Dolphinfish may be spawning year round. Pelagic species such as blackfin tuna, blue marlin, bluefin tuna, dolphinfish, swordfish, wahoo, whale shark, white marlin, yellowfin tuna are present in offshore waters. Early life history stages of these species may be present.

Demersal fish species likely present in the vicinity of the release site are likely to include sixgill shark, eels and cusk-eels.

Shelf - Many species of reef fish are present on the continental shelf in the area of impact, including commercially important snapper and grouper species. Larval duration for most of these species is approximately a month, and larvae are pelagic. Grouper species that may be spawning in the area of impact include (spawning months in parentheses): red grouper (May-Jul) and scamp (Mar-May). Snapper species spawning in area of impact include: Red snapper (Mar-Nov), lane snapper (Mar-Aug), gray snapper (Jun-Nov), and vermilion snapper (Apr-Nov). A summary of 17 years of SEAMAP data indicates that higher larval abundances have been observed in fall samples compared to spring (Mar-May) surveys for most snapper species, whereas groupers have only been observed in the spring in low densities.

Several species of coastal sharks can be found in the nearshore and shelf waters of the northern Gulf of Mexico, arriving in May and remaining until the fall. Shallow coastal waters are important pupping grounds for some of these species, including Atlantic sharpnose shark, Blacktip shark, finetooth shark, scalloped hammerhead, and possibly lemon sharks. Other shark species present include whale, bull, great hammerhead, shortfin mako, and spinner sharks.

Many forage species begin spawning in coastal waters in the spring and continue through the fall, including anchovies, sardines, mullet, and herrings.

Other species that may be spawning (and therefore have eggs or larvae present) in nearshore waters include: Atlantic tripletail (May-Sep), White trout (Mar-Oct), Squid (Mar-Nov), Ballyhoo

(Mar-Jul), Atlantic spadefish (Apr-Sep), Great barracuda (Apr-Oct), Kingfishes (Apr-Aug), Florida pompano (larvae present through May), Great barracuda (Apr-Oct), amberjack and Spanish mackerel (Apr-Oct), spotted seatrout (Apr-Sep).

Inshore - Marsh habitats are extremely productive and support high biodiversity and abundance of resident estuarine fish. Estuarine areas are important nursery grounds for many commercial species, including snappers, groupers. Inlets and passes are often sites of fish spawning.

Larval and juvenile stages of fish are at a greater risk from the toxic components of oil. Embryonic and larval exposure to PAHs from crude oils has been linked to cardiac defects in pelagic fish species, such as yellowfin tuna. Oil mixed into the water column can adhere to the gills of a fish, causing lethal or sublethal effects.

VI. Human-Use Resources

Lease block MC-300 is within the bluefin tuna Habitat Area of Particular Concern (HAPC) for spawning bluefin tuna.

Species with Essential Fish Habitat in shelf and offshore near the waters of spill include whale shark, bigeye thresher shark, bluefin tuna, skipjack tuna, longbill spearfish, swordfish, white marlin, roundscale spearfish, yellowfin tuna, silky shark, angel shark, blue marlin, longfin mako shark, oceanic whitetip shark,scalloped hammerhead shark, finetooth shark, bignose shark, bull shark, shortfin mako shark, bluefin tuna, longbill spearfish, sailfish, spinner shark, blacknose shark, smooth dogfish, Atlantic sharpnose shark, sandbar shark, and tiger shark.

Federally designated Essential Fish Habitat (EFH) is present in coastal and inshore waters for stone crab, shrimp, reef fish, red drum, coral, and coastal migratory pelagic species.

The area of impact is a productive commercial fishing area and a popular recreational fishing destination. Should the oil make landfall, it has the potential to impact economically important amenity beaches in Mississippi, Alabama, and Florida.

Management Areas present in the area of impact include Gulf Islands National Seashore, Bon Secour NWR, Breton NWR, and numerous state-protected areas. Critical habitat occurs in the area and is summarized by species below:

- Loggerhead sea turtle - Beaches on Horn and Petit Bois Islands, the Alabama shoreline east of Mobile Bay, and Perdido Key. Marine critical habitat occurs in the GOM offshore of the spill site.
- Perdido Key Beach Mouse - Perdido Key
- Alabama Beach Mouse - sites present in Bon Secour NWR and Gulf State Park
- Piping Plover - many of the barrier islands west of Mobile Bay and along Mississippi Sound, Fort Morgan, some sites on Santa Rosa Island
- Gulf sturgeon - Mississippi Sound, Pascagoula Bay, Pensacola Bay and tributary rivers.

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To: Hodges, Jennifer[Hodges.Jennifer@epa.gov]
From: Matthiessen, Craig
Sent: Tue 2/16/2016 6:58:06 PM
Subject: Task Completed: Info about Oil Dispersements

-----Original Task-----
Subject: Info about Oil Dispersements
Priority: Low

Start date: Mon 2/8/2016
Due date: Tue 2/16/2016

Status: Completed
% Complete: 100%
Date completed: Tue 2/16/2016
Actual work: 0 hours

Requested by: Hodges, Jennifer

An undergrad student from Old Dominion University contacted us to request an interview for a science blog on the oil dispersant, Corexeit 9500. Could we talk about how to respond, when you have a moment. Do we have a web page(s) with relevant information? Thanks,

George Hull, Director
Office of Media Relations
U.S. EPA
Tel. 202-564-0790

From: Ben Maxie [mailto:bmaxi001@odu.edu]
Sent: Friday, February 05, 2016 1:25 PM
To: Press <Press@epa.gov>
Subject: Info about Oil Dispersants

Hi,
I'm an undergraduate researcher and science writer for a graduate school marine science blog. I'm working on an article about oil dispersant toxicity, specifically Corexit 9500A. Could I arrange a brief interview on the subject either by phone or email? I am unsure where to direct this inquiry and thought that the press email would be appropriate, but if not could you refer me to a better contact email?
Thank you,
Ben Maxie

--
Benjamin Maxie
Undergraduate Student, Biological Sciences

Old Dominion University
757-287-6238

Subject: Task Update: Info about Oil Dispersements
Priority: Low
Info about Oil Dispersements

Subject:	Info about Oil Dispersements
Start Date:	Monday, February 08, 2016
Due Date:	Tuesday, February 16, 2016
Priority:	Low
Status:	Completed
Percent Complete:	100%
Date Completed:	Tuesday, February 16, 2016
Total Work:	0 hours
Actual Work:	0 hours
Owner:	Matthiessen, Craig
Requested By:	Hodges, Jennifer

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Benjamin Maxie
Undergraduate Student, Biological Sciences
Old Dominion University
757-287-6238

Subject: Info about Oil Dispersements
Priority: Low
Status: Completed
Percent Complete: 100%
Start Date: Mon 2/8/2016 12:00:00 AM
Due Date: Tue 2/16/2016 12:00:00 AM
Owner: Matthiessen, Craig

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Benjamin Maxie
Undergraduate Student, Biological Sciences
Old Dominion University
757-287-6238

To: Hodges, Jennifer[Hodges.Jennifer@epa.gov]
Cc: Gregory Wilson[Wilson.Gregory@epa.gov]; Vanessa Principe[Principe.Vanessa@epa.gov]; Leigh DeHaven[DeHaven.Leigh@epa.gov]
From: Matthiessen, Craig
Sent: Tue 2/16/2016 4:54:32 PM
Subject: RE: Info about Oil Dispersants

Hi, Jenn;

I don't know that anyone 'wants' to talk to this student but I think we could do it sometime. Thanks - Craig

From: Hodges, Jennifer
Sent: Tuesday, February 16, 2016 10:47 AM
To: Matthiessen, Craig <Matthiessen.Craig@epa.gov>
Subject: FW: Info about Oil Dispersants

Good Morning Craig –

Please let me know if you or anyone from your office wants to talk to this student. I am also reaching out to OPA to see if/how they want to handle.

Thanks,

Jenn

Jennifer R. Hodges (formerly Myers)

(Acting) Special Assistant

Office of Emergency Management

Office of Land and Emergency Management

U.S. Environmental Protection Agency

Hodges.Jennifer@epa.gov

(o) 202-564-2055

From: Hull, George
Sent: Friday, February 05, 2016 2:53 PM
To: Hodges, Jennifer <Hodges.Jennifer@epa.gov>; James, Kennetta <James.Kennetta@epa.gov>
Subject: FW: Info about Oil Dispersants

Jennifer and Kennetta,

An undergrad student from Old Dominion University contacted us to request an interview for a science blog on the oil dispersant, Corexeit 9500. Could we talk about how to respond, when you have a moment. Do we have a web page(s) with relevant information? Thanks,

George Hull, Director

Office of Media Relations

U.S. EPA

Tel. 202-564-0790

From: Ben Maxie [mailto:bmaxi001@odu.edu]
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Thank you,

Ben Maxie

--

Benjamin Maxie

Undergraduate Student, Biological Sciences

Old Dominion University

757-287-6238

To: Vanessa Principe[Principe.Vanessa@epa.gov]; Leigh DeHaven[DeHaven.Leigh@epa.gov]; Gregory Wilson[Wilson.Gregory@epa.gov]
Cc: Kim Jennings[Jennings.Kim@epa.gov]
From: Matthiessen, Craig
Sent: Tue 2/9/2016 12:44:16 PM
Subject: FW: Info about Oil Dispersants

FYI – see below.

From: Hodges, Jennifer
Sent: Monday, February 08, 2016 4:47 PM
To: Matthiessen, Craig <Matthiessen.Craig@epa.gov>
Subject: RE: Info about Oil Dispersants

Wonderful, there is no due date so I said take until Tuesday!

Jennifer R. Hodges (formerly Myers)

(Acting) Special Assistant

Office of Emergency Management

Office of Land and Emergency Management

U.S. Environmental Protection Agency

Hodges.Jennifer@epa.gov

(o) 202-564-2055

From: Matthiessen, Craig
Sent: Monday, February 08, 2016 4:43 PM
To: Hodges, Jennifer <Hodges.Jennifer@epa.gov>
Subject: Re: Info about Oil Dispersants

Yep. This belongs to my group. We can check it out tomorrow.

R. C. Matthiessen

Sent from my iPhone

On Feb 8, 2016, at 4:34 PM, Hodges, Jennifer <Hodges.Jennifer@epa.gov> wrote:

Good Afternoon Craig –

Does this item belong with your group?

Thank you – adding to the calendar and task bar now.

Jenn

Jennifer R. Hodges (formerly Myers)

(Acting) Special Assistant

Office of Emergency Management

Office of Land and Emergency Management

U.S. Environmental Protection Agency

Hodges.Jennifer@epa.gov

(o) 202-564-2055

From: Hull, George
Sent: Friday, February 05, 2016 2:53 PM
To: Hodges, Jennifer <Hodges.Jennifer@epa.gov>; James, Kennetta <James.Kennetta@epa.gov>
Subject: FW: Info about Oil Dispersants

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George Hull, Director

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U.S. EPA

Tel. 202-564-0790

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Ben Maxie

--

Benjamin Maxie

Undergraduate Student, Biological Sciences

Old Dominion University

757-287-6238

Subject: Task Accepted: Info about Oil Dispersements
Priority: Low
Info about Oil Dispersements

Subject:	Info about Oil Dispersements
Start Date:	Monday, February 08, 2016
Due Date:	Tuesday, February 16, 2016
Priority:	Low
Status:	Not Started
Percent Complete:	0%
Total Work:	0 hours
Actual Work:	0 hours
Owner:	Matthiessen, Craig
Requested By:	Hodges, Jennifer

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Benjamin Maxie
Undergraduate Student, Biological Sciences
Old Dominion University
757-287-6238

Subject: Info about Oil Dispersements
Priority: Low
Status: Not Started
Percent Complete: 0%
Start Date: Mon 2/8/2016 12:00:00 AM
Due Date: Tue 2/16/2016 12:00:00 AM
Owner: Matthiessen, Craig

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Tel. 202-564-0790

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Ben Maxie

--
Benjamin Maxie
Undergraduate Student, Biological Sciences
Old Dominion University
757-287-6238

To: Hodges, Jennifer[Hodges.Jennifer@epa.gov]
From: Matthiessen, Craig
Sent: Mon 2/8/2016 9:43:26 PM
Subject: Re: Info about Oil Dispersants

Yep. This belongs to my group. We can check it out tomorrow.

R. C. Matthiessen
Sent from my iPhone

On Feb 8, 2016, at 4:34 PM, Hodges, Jennifer <Hodges.Jennifer@epa.gov> wrote:

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Thank you – adding to the calendar and task bar now.

Jenn

Jennifer R. Hodges (formerly Myers)

(Acting) Special Assistant

Office of Emergency Management

Office of Land and Emergency Management

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Hodges.Jennifer@epa.gov

(o) 202-564-2055

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Benjamin Maxie

Undergraduate Student, Biological Sciences

Old Dominion University

757-287-6238

To: James Bove[Bove.James@epa.gov]
Cc: Leigh DeHaven[DeHaven.Leigh@epa.gov]; Gregory Wilson[Wilson.Gregory@epa.gov]; Vanessa Principe[Principe.Vanessa@epa.gov]
From: Matthiessen, Craig
Sent: Fri 10/23/2015 6:29:37 PM
Subject: FW: SCG 10-19-15 follow up to SCG's 9/15/15 meeting request with EPA OSWER Assistant Administrator, reveals SCG meeting request to be denied, clarification required!

FYI. We will strategize with OEM OD/DOD next week on next steps. One challenge is to try to distill this email down to the key item(s) Mr. Fakouri wants via a meeting/conference call with EPA. Any advice you might have is welcome. Thanks - Craig

From: Brooks, Becky
Sent: Friday, October 23, 2015 12:51 PM
To: Matthiessen, Craig <Matthiessen.Craig@epa.gov>
Subject: FW: SCG 10-19-15 follow up to SCG's 9/15/15 meeting request with EPA OSWER Assistant Administrator, reveals SCG meeting request to be denied, clarification required!
Importance: High

So you have.

Becky Brooks

Special Assistant

Office of Solid Waste and Emergency Response

U.S. Environmental Protection Agency

ph. 202-566-2762

From: David Fakouri [mailto:dfakouri@dfaa.us]
Sent: Thursday, October 22, 2015 2:56 PM
To: Stanislaus, Mathy <Stanislaus.Mathy@epa.gov>
Cc: williamcassidy@gmail.com; 'Brian_mcnabb@cassidy.senate.gov' <Brian_mcnabb@cassidy.senate.gov>; 'david_doss@vitter.senate.gov' <david_doss@vitter.senate.gov>; 'kyle_ruckert@vitter.senate.gov' <kyle_ruckert@vitter.senate.gov>; luke.letlow@mail.house.gov;

'wyatt.labrano@mail.house.gov' <wyatt.labrano@mail.house.gov>; terri.fish@mail.house.gov; joa.finley@mail.house.gov; Paul.sawyer@mail.house.gov; 'david.cavell@mail.house.gov' <david.cavell@mail.house.gov>; virgil.miller@mail.house.gov; charles.henry@mail.house.gov; Robreno, Andrew (Andrew.Robreno@mail.house.gov) <Andrew.Robreno@mail.house.gov>; SubraCom@aol.com; Mccarthy, Gina <McCarthy.Gina@epa.gov>; David Fakouri <dfakouri@dfaa.us>; Elkins, Arthur <Elkins.Arthur@epa.gov>; taylorC@ag.state.la.us; 'phillipst@ag.state.la.us' <phillipst@ag.state.la.us>; 'Thomas.Enright@la.gov' <Thomas.Enright@la.gov>; agc@agcrowe.com; psammarco@lumcon.edu
Subject: SCG 10-19-15 follow up to SCG's 9/15/15 meeting request with EPA OSWER Assistant Administrator, reveals SCG meeting request to be denied, clarification required!
Importance: High

10/22/15

Mr. Mathy Stanislaus

US EPA Assistant Administrator

Office of Solid Waste and Emergency Response (OSWER)

Dear Assistant Administrator Stanislaus,

Earlier this week, I called your office with the specific intent to follow up with you and/or your staff, regarding SCG's month old meeting request with your OSWER department; of which has not been acknowledged, with no response afforded to SCG. The person who answered your phone, preceded to directly informed me that my offices 9/15/15 meeting request with you, was denied.

Please be aware that this revelation(if true) disturbs me greatly. Because a denial by you (Mr. Stanislaus), OSWER leadership refusing to meet and discuss this dispersed crude oil contamination chemical poisoning environmental direct threat to public health affirms that the environmentally trapped dispersed crude oil contamination is not going to be allowed to be detoxified by US EPA. The reality of our US EPA and US EPA OSWER not allowing the immediate detoxification/removal of (the toxic to human health) dispersed crude oil contamination from the GOM coastal zone, affirms that EPA is consciously allowing millions of innocent American citizens to unprecedented total exposure (to manmade) toxic environmental contamination (chemically dispersed crude oil contamination) which in due time, will result in

scientifically confirmed human illness and shortened life for all who have persistently received exposures where they live, work and recreate in the GOM coastal zone region.

Understanding fully the following:

a. The GOM contamination problematic situation being allowed to persist in the GOM and the GOM coastal zone, is by choice; as NCP listed technology, has existed since 1996 which detoxifies and removes completely from the environment, the identified confirmed toxic hydrocarbon based environmental contamination. Please review page 11 of the attached 11/7/2013 letter from SCG to Gina McCarthy.

•□□□□□□□□ This NCP technology was denied the right of use by EPA in 2010, despite official multiple request for its use for no justified reason; as three coastal RRT member states directly requested its use; in addition to the responsible party, (BP) which also requested its use twice during the DWH incident response. The historical facts are clear, EPA refused to allow safer less toxic more effective proven technologies in 2010.

b. EPA ignored best known available published scientific data available in 1998, from NIOSH authored WHO ICHEM CICADS 10 document; confirming the fact that 2butoxyethanol is confirmed by NIOSH (CDC) to directly negatively impacted both human health and the environment when it is introduced in water environments.

c. The fact that 2butoxyethanol in 2010 was a major component of utilized chemical dispersants: Corexit 9527 and 2010 utilized existing global stockpiles of Corexit 9500 dispersant that was also introduced into the GOM, which EPA allowed BP to use and interface with the crude oil contamination in 2010.

d. The fact that EPA knew that this particular synthetic solvent was present in both NCP listed technologies,(as confirmed by page 20 of the 1999 EPA NCP NOTEBOOK). EPA officials possess prior scientific understanding from NIOSH, that adverse human health from exposure to crude oil contamination interfaced with these chemical dispersants that are confirmed to contain 2botoxyethanol; incidence of adverse human exposure to the environmental contamination, adverse human health occurrence was scientifically understood to occur.

e. The fact that since the 2010 DWH incident response, the GOM dispersed crude oil contamination problematic situation has been officially passed off to the public as the dispersed crude oil to not pose an threat to human health affording the public to believe that it behaves in like and similar manner as natural crude oil behaves; when in fact, there is a great difference with respect to direct impacts to human health, in particular human protective skin. As human skin no longer is a protector but a receptor to the confirmed toxic to human health environmental contamination, allowing transdermal entry into human blood and circulatory systems.

•□□□□□□□□ SCG compelled reimbursable micro research of 2butoxyethanol. presented to US EPA in 2013; affirms concisely both how and why dispersed crude oil behaves differently when the contamination is allowed to be exposed to humans in moist environments. As such is clearly confirmed in the attached 11/7/2013 SCG executive summary letter to Gina McCarthy.

f. The fact that legal federal authority (EPA) and other executive branches of government (CDC) have somewhat under reported the direct human adverse health threat, which the GOM dispersed crude oil contamination directly represents; as this contamination impacts human health with human allowed exposure. CDC-NIOSH contradicts itself in its reporting to the public for unknown reasons.

•□□□□□□□□ The NIOSH authored the 1998 WHO ICHEM CICADS 10 document on 2butoxyethanol. NIOSH clearly affirmed the fact that human exposure to 2butoxyethanol directly impact human blood as it passes thru human skin in human blood circulatory systems directly adversely impacting human health. In 2011 NIOSH issues a skin (SK) classification on this chemical. Understanding that this synthetic solvent is also called ethylene glycol mono butyl ether. This chemical mixes with any chemical in the environment and allows it to pass into human blood depositing in human circulatory systems. Persistent re exposure causes chemical sensitivities to result, prolonged persistent re exposure result in human illness and shortened life.

▪· All of this data was presented to US EPA SCG in 2013, directly requesting EPA to allow detoxification mitigation to remove the environmentally trapped dispersed crude oil contamination; confirmed not able to experience microbial degradation due to confirmed toxicity realities due to the presence of 2butoxyehtanol and the DOSS components of both utilized chemical dispersants (see items (1 and 2) on pages 3 and 4 of the attached 11/7/2013 SCG letter to Gina McCarthy). Persistent re exposure of the civilian population is confirmed as long as this contamination is allowed to persist in the GOM coastal zone region, (See Item 3 and 4, pages 4 and 5, of the attached 11/7/2013 SCG letter to Gina McCarthy). As this contamination has the direct ability to pass directly from the environment into human blood and the human circulatory system with incidental and vapor exposure contact, directly impacting human health persistently as long as it is allowed to remain in the environment.

▪· CDC's February, 25 2011 VOC bulletins, understate the 2010 dispersed crude oil environmental contamination exposure to human blood, with respect to VOC blood contamination. As both CDC, NIOSH and EPA were fully aware that the 2010 DWH incidence response involved the use of chemical dispersants containing unprecedented volumes of 2butoxyethanol as unprecedented volumes of chemical dispersant were introduce to interface with approximately 200 million gallons of crude oil. CDC, NIOSH and EPA underreported the direct threat to public health. Human blood contamination test, affirm the dispersed crude oil contamination directly impacted human health. Persistent human exposure to this type of environmentally trapped (toxic to human health) contamination persistently impacts public health. Prolonged (from 4/2010 to present) repeated human exposure, forms chemical sensitivities and shortened life in humans.

•□□□□□□□□ Please refer to Dr. Mike Harbuts video message in this hyperlink

http://www.sciencecorps.org/gulf_oil_spill_health_hazards.html Dr. Harbuts message to physicians which is online, directly affords the public and elected leadership alike, the ability to understand how adverse human health results from allowed human exposure to dispersed crude oil. See SCG's attached 11/7/2013 letter to Gina McCarthy.

g. The reason why the 2010 DWH is under the direct control and authority of EPA OSWER, is the fact the salt dome was fractured in 2010 during the DWH accident, Subsequent ongoing uncontrollable subsea discharges are now reality involving significant volumes of uncontrollable subsea discharge. Of which is confirmed by the you tube video found on line https://www.youtube.com/watch?v=SLKG0Kqjm1o. AS this video source has not been verified, the 1/14/2011 BK Lim Letter to congressman Upton and Shimkus referencing similar uncontrollable subsea discharges/fissuring. The uncontrollable subsea discharge referenced is why OSWER represents legal governing authority for the 2010 DWH incident.

Mr. Stanislaus, and others in receipt of this letter, it should be clearly obvious, why SCG was greatly disturbed, when we were told that EPA OSWER denied SCG's 9/15/15 direct meeting request with OSWER with open invitations to identified members of the Louisiana Congressional delegation having the direct option to attend SCG's requested meeting. AS noted by this letter, we sincerely hope OSWER official will change their mind and allow a critically necessary meeting to discuss the contamination reality in order to approve emergency detoxification mitigation for the GOM and the GOM coastal zone. Understanding fully that no coastal restoration that is planned for this region using the recent BP settlement proceeds can be allowed without detoxification mitigation. Directly because, any coastal restoration activity disturbing the earthen sediments will directly re expose an already exposed, at risk of depopulating, civilian skill domestic work force. Detoxification mitigation must be allowed or the GOM coastal zone regions public health and economics will be lost.

Any threat (real or perceived) to the Louisiana Mississippi River Industrial Corridor and its skilled domestic work force must be viewed as a direct national security threat to our nation, in addition to our national economy.

▪· DETOXIFICATION of the GOM and the GOM coastal zones trapped dispersed crude oil contamination is directly required for public health preservation reasons.

o AS per OSWER directive No. 9355.4-28 https://clu-in.org/download/char/oswerdirective9355jan04.pdf Page (2) Requirements for Monitoring:

▪· *REQUIREMENTS FOR MONITORING CERCLA statutory authority regarding monitoring gives the U.S. EPA authority to undertake monitoring to identify threats [42 U.S.C. § 9604(b)] and defines removal and remedial actions as inclusive of any monitoring reasonably required to*

ensure that such actions protect the public health, welfare, and the environment [42 U.S.C. § 9601(23) and 42 U.S.C. § 9601(24)], respectively. Section 121(c) of CERCLA [42 U.S.C. § 9621(c)], as amended by the Superfund Amendments and Reauthorization Act (SARA) of 1986, together with the implementing regulation in the National Oil and Hazardous Substances Pollution Contingency Plan (NCP), requires that "if the President selects a remedial action that results in any hazardous substances, pollutants, or contaminants remaining at the site," post-response reviews be conducted every 5 years to ensure protection of human health and the environment. The NCP states that the focus of the 5-year review should be review of monitoring data to evaluate whether the remedy continues to provide for adequate, risk-based protection of human health and the environment (40 CFR § 300.430 (f)(4)(ii)(2002)).

▪· Understanding the dispersed crude oil contamination has been ignored and abandoned by EPA, not classified as a threat to public health officially. It is safe to assume the dispersed crude oil contamination has been allowed to remain at the contamination site. Then the 5 year monitoring is required by OSWER directives denote above. SCG's 9/15/15 meeting request was justified and responsibly necessary and justified for public health preservation reasons. Understanding EPA's historical receipt of SCG 2013 research data thru congressional mail, facilitated by the Office of US Congressman Dr. William Cassidy; SCG subsequent presented research confirming that the dispersed crude is a confirmed officially recognized chemical poisoning threat to public health. Therefore by this OSWER directive, the dispersed crude oil contamination threat to human health must be allowed to be mitigated (detoxified), as it has been confirmed possible to effectively mitigate (clean up and completely removed from the environment) using existing NCP listed technology confirmed in the 11/7/2013 SCG letter to Gina McCarthy already mentioned in this letter.

Restating, Mr. Stanislaus, if in deed SCG's meeting request has been denied, please justify the denial in a direct timely letter to all. Conversely, If indeed the meeting has not been denied, please advise when and where the meeting will be facilitated in the near term.

Please allow me to restate the objective of SCG's 9/15/15 meeting request with US EPA OSWER assistant Administrator Mathy Stanislaus: SCG only wishes to have the dispersed crude oil contaminating to be safely and timely removed from the GOM coastal zone region and have SCG's past due and forthcoming billing to EPA, be paid with SCG being appointed independent oversight over the clean up to insure transparency. The recognized need to have an independent 3rd party like SCG to be appointed as independent oversight over the detoxification efforts for the GOM and the GOM coastal zone region is due to the fact that it is both necessary and logical. Solely predicated by situation at hand, which has over the last 65 months resulted in SCG justified persistent efforts attempting to get legal federal oversight (EPA officials) to follow the mission of EPA.

Mr. Stanislaus and others copied in this email, please be aware that Dr. Wilma Subra has already attested to the accuracy of SCG presented data to EPA, as well as SCG presented threat assessment to both EPA and State of Louisiana officials. Dr. Subra co-authored the human blood sampling paper, of which affirms the chemical poisoning threat the dispersed crude oil exposure represent to human health. Moreover she is willing to come to Washington to attend the meeting SCG has requested if it is granted. Moreover, if any congressional member would like to ask her questions on this issue please contact Dr. Subra directly. SCG is extremely grateful to Dr. Subra and others who have donated their time, freely collaborate on this issue for public health preservation reasons.

A direct review of the attached documents which accompanied the 9/15/2015 meeting including the attached items to this email; all of which justify SCG direct efforts with EPA on this issue directly because this issue has been intentionally overlooked and under addressed by all.

In closing, I look forward to hearing back from you Mr. Stanislaus, on behalf of US EPA officially, timely. I very much look forward to having a meeting to discuss and find an amicable resolution with EPA, which is must be implemented to resolve the dispersed crude oil contamination issue before it results in human depopulation of our GOM coastal zone region and contaminates the fresh drinking water aquifers. Of which the civilian population residing in our region depends upon.

Respectfully,

David Fakouri, Strategic Economist

Strategic Consulting Group, LLC

La Economic Foundation, Inc

Corporate members of:

David Fakouri and Associates

Email: Dfakouri@dfaa.us

225 921 9735

Cc;

- Paul Sammarco, Co-author of Human Blood Essay, referenced in document.
- EPA OIG: Arthur Elkins EPA OIG
- Gina McCarthy, EPA Administrator
- La Executive leadership Officials:
- Office of the Governor State of Louisiana (Mr. Thomas Enright) Executive Counsel
- La Attorney General Buddy Caldwell (C. Taylor) Executive Assistant to the AG

(Trey Phillips) 1st Attorney General La DOJ

To: Dana Tulis[Tulis.Dana@epa.gov]; Reggie Cheatham (cheatham.reggie@epa.gov)[cheatham.reggie@epa.gov]; Leigh DeHaven[DeHaven.Leigh@epa.gov]; Gregory Wilson[Wilson.Gregory@epa.gov]; Vanessa Principe[Principe.Vanessa@epa.gov]; James Bove[Bove.James@epa.gov]
From: Matthiessen, Craig
Sent: Tue 9/29/2015 7:24:19 PM
Subject: FW: Request proactive response to Environment Canada proposal
1509 FINAL LTR to EPA re Canada.doc
FINAL Comments Spill Treating Agents.pdf

See below. This will also likely be coming our way via CMS. Craig

From: Riki Ott [mailto:rikiott@gmail.com]
Sent: Tuesday, September 29, 2015 2:08 PM
To: Mccarthy, Gina
Cc: Matthiessen, Craig; Shanna Devine
Subject: Request proactive response to Environment Canada proposal

Dear Administrator McCarthy,

On April 22, 2015, ALERT, a project of Earth Island Institute, submitted extensive, technical, 300-page comments on the EPA rulemaking for the National Oil and Hazardous Substances Pollution Contingency Plan, 40 CFR Parts 110 and 300 [EPA–HQ–OPA–2006–0090; FRL–9689–9–OSWER] RIN 2050–AE87.

We are now writing to share a concern, if you are not already aware, that may impact the final rulemaking, given the U.S.–Canada efforts to harmonize environmental (and other) laws and policies: In early July 2015 Environment Canada opened a rulemaking on product use in oil spill response and is proposing to allow interim use of two Corexit dispersants – EC9500A and EC9527A – the very same ones that EPA may be restricting or eliminating in the U.S. (Canada Gazette, Vol. 149, No. 27, July 4, 2015. http://gazette.gc.ca/rp-pr/p1/2015/2015-07-04/html/reg1-eng.php)

Specifically, Environment Canada is proposing interim use regulations that would give carte blanche preauthorization for these Corexit dispersants with essentially no guidelines or conditions for use other than stating that it will develop final use criteria within the next five years. In the interim period and in response to a spill, the relevant offshore board's Chief

Conservation Officer may decide to use the Corexit dispersants – and any other spill treating agents that may be listed/preauthorized – based on a determination of "net environmental benefit," for which there are also no conditions or criteria in the proposed interim use regulations.

Meanwhile, the U.S. EPA is now seeking through its rulemaking to increase the likelihood of achieving net environmental benefit of dispersant and other product use, and the overall soundness of the data, by requiring: (1) more detailed – public – information about product ingredients (i.e., no confidential business information); (2) improved and updated efficacy and toxicity testing protocols and new thresholds of performance (i.e., including chronic toxicity tests, minimum efficacy standards, and maximum toxicity standards); (3) testing on both product and oil-product combinations to better simulate environmental conditions and help ensure that products will perform as intended; (4) advanced monitoring during product use and long-term environmental monitoring post use; (5) protection for endangered species; (6) consideration of human health impacts; (7) certain prohibitions on product use; (8) specific protocol to remove products from the list or to stop use of products once initiated; and (9) specific protocol to transition from the old rules to the new rules. Further, the U.S. EPA also grants authority in area response plans to develop area-specific conditions of product use, including dispersants. The proposed Canadian interim use regulations lack most of this detail, as we describe in our comments to Environment Canada (enclosed).

In its rulemaking, Environment Canada states that it is striving to list products that are compatible with products that are likely to be used in the United States. However, its proposed regulations may have the opposite effect and could create very awkward situations in cross-border oil spill incidents. It is clearly desirable to use products that are listed for use in both countries.

We therefore request that U.S. EPA take proactive measures – at its earliest convenience – to encourage the Canadian Prime Minister of the Environment and Environment Canada to propose that no specific spill treating agent products be included in the interim use regulations. Instead product use should be contingent upon development and adoption of final use regulations that establish a set of testing requirements, standards, and conditions to evaluate and determine what products are likely to achieve a net environmental benefit and to minimize harm to human health. Further, conditional use requirements should be developed in conjunction with local governments as part of area response plans, because communities live with the consequences of these policies. (For example, the Union of BC Municipalities unanimously passed Resolution A4, calling for resources and training and a decision-making role to prepare for and manage oil spill impacts on their communities.
http://www.ubcm.ca/assets/Resolutions~and~Policy/Resolutions/2015-ResolutionsBook-for-web_lowres.pdf)

We have enclosed the comments submitted to Environment Canada from concerned citizens and public nonprofit organizations in Canada and the U.S. to give you more detail about our specific concerns with the Canadian rulemaking – and the need for proactive measures from the EPA Administrator.

Thank you for your consideration. We would appreciate being informed of any action that is taken.

Sincerely,

Riki Ott, PhD, Director

ALERT Project

www.alertproject.org

Shanna Devine, Investigator

Government Accountability Project

www.whistleblower.org

cc: Craig Matthiessen, Office of Solid Waste & Emergency Response

U.S. Environmental Protection Agency
Office of the Administrator 1101A
1200 Pennsylvania Avenue NW
Washington, DC 20460

September 29, 2015

Via email: McCarthy.Gina@EPA.gov

Dear Administrator McCarthy,

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Specifically, Environment Canada is proposing interim use regulations that would give carte blanche preauthorization for these Corexit dispersants with essentially no guidelines or conditions for use other than stating that it will develop *final use criteria within the next five years*. In the interim period and in response to a spill, the relevant offshore board's Chief Conservation Officer may decide to use the Corexit dispersants – and any other spill treating agents that may be listed/preauthorized – based on a determination of "net environmental benefit," *for which there are also no conditions or criteria in the proposed interim use regulations*.

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Sincerely,

Riki Ott, Director
ALERT Project
www.alertproject.org

Shanna Devine, Investigator
Government Accountability Project
www.whistleblower.org

cc: Craig Matthiessen, Office of Solid Waste and Emergency Response

To: Leigh DeHaven[DeHaven.Leigh@epa.gov]
From: Matthiessen, Craig
Sent: Thur 8/13/2015 7:56:26 PM
Subject: FW: fyi on interesting paper on modeled dispersed oil tox
Vikebø et al. 2015.pdf

FYI

From: Barron, Mace
Sent: Thursday, August 13, 2015 2:31 PM
To: Wilson, Gregory; Principe, Vanessa; Matthiessen, Craig
Cc: Conmy, Robyn
Subject: fyi on interesting paper on modeled dispersed oil tox

Environmental Science & Technology

Article

pubs.acs.org/est

Dispersants Have Limited Effects on Exposure Rates of Oil Spills on Fish Eggs and Larvae in Shelf Seas

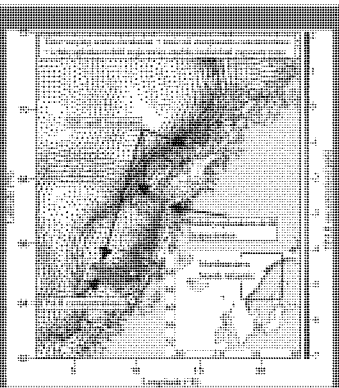
Frode B. Vikebø,*,† Petter Rønningen,‡ Sonnich Meier,† Bjørn Einar Grøsvik,† and Vidar S. Lien†

†Institute of Marine Research, Box 1870, Nordnes, N-5817 Bergen, Norway

‡SINTEF, Strindvegen 4, 7465 Trondheim, Norway

* Supporting Information

Early life stages of fish are particularly vulnerable to oil spills. Simulations of overlap of fish eggs and larvae with oil from different oil-spill scenarios, both without and with the dispersant Corexit 9500, enable quantitative comparisons of dispersants as a mitigation alternative. We have used model simulations of a blow out of 4500 m^3 of crude oil per day (Statfjord light crude) for 30 days at three locations along the Norwegian coast. Eggs were released from nine different known spawning grounds, in the period from March 1st until the end of April, and all spawning products were followed for 90 days from the spill start at April first independent of time for spawning. We have modeled overlap between spawning products and oil concentrations giving a total polycyclic hydrocarbon (TPAH) concentration of more than 10 or 0.1 ppb (µg/l). At these orders of magnitude, we expect acute mortality or sublethal effects, respectively. In general, adding dispersants results in higher concentrations of TPAHs in a reduced volume of water compared to not adding dispersants. Also, the TPAHs are displaced deeper in the water column. Model simulations of the spill scenarios showed that addition of chemical dispersant in general moderately decreased the fraction of eggs and larvae that were exposed above the selected threshold values.



INTRODUCTION

The development of petroleum resources in the marine environment comes with the risk of introducing substances toxic to the inhabitants of the near-field waters. This may be part of normal production[1] or accidental spills.[2,3] National authorities therefore impose requirements on the oil industry of assessing risks before allowing search, development, and production of petroleum resources in their respective economic zones. Whether the risks are acceptable is a political question that is debated on by considering both the risk assessment and corresponding recommendations by the responsible governmental agencies along with the potential profit. A risk assessment typically involves mapping marine resources and physical oceanic features to enable numerical estimates of exposure to oil by key marine species in various oil-spill scenarios (OSSs). Field observations enable biophysical models to be adapted to the area of interest and to marine resources that have been prescreened to be most vulnerable. For the Lofoten-Barents Sea, this has been identified to be early life stages (ELS) of fish and seabirds.[4,5]

If the authorities allow for petroleum extraction, accidental spill of oil may occur. This will result in oil being introduced to the sea at a certain rate, depth, and duration. The oil characteristics, the dynamics of the ocean and atmosphere immediately above, and the presence and composition of oil degrading bacteria determine spatiotemporal oil dispersal, degradation, emulsification, and evaporation. At this point, the responsible oil companies and governmental agencies need to address plans for combating the oil. Several options are at hand. The options for controlling the dispersal of oil are to burn or collect it (surface spill only), or to add chemical dispersants, with the aim of causing the least possible harm to the marine environment and its inhabitants. In this study, we will focus on the use of chemical dispersants.

Research and public debate on the use of dispersants have recently been fueled by the massive use after the Macondo blow-out in 2010. In total, 780 000 m^3 of oil was spilled during 86 days, and a total of 7000 m^3 of dispersants was used at the surface and at the oil release site at approximately 1500 m in depth.[6] Until now, history has shown that use of dispersants may cut both ways. It is suggested that the use of 10 000 tonnes of dispersants in connection with the Torrey Canyon shipwreck had larger environmental impacts than the 119 000 tonnes of oil itself[7] due to the toxicity of the dispersants used at that time. Contrary, it was estimated that the 446 tonnes of dispersants used during the 72 000 tonnes release of oil after the Sea Empress shipwreck in 1996 prohibited between 57 000 - 110 000 tonnes of oil emulsion to reach shore and thereby reduced the environmental impacts.[8] It is believed that the use of dispersants during the Macondo blow-out reduced the amount of oil reaching the shore by trapping it at great depths and increasing the biological degradation of the oil. However, the fate and the impacts of the oil spill still remain uncertain.[9,10]

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In short, the introduction of dispersants shifts the oil droplet spectra toward smaller droplet sizes. Oil droplet sizes and densities, together with the ambient density of the seawater and the level of vertical mixing, determine the vertical displacement of the individual droplets. Smaller droplet sizes due to the introduction of dispersants result in less buoyancy and parts of the spilled oil descending. At the same time, the reduction in droplet sizes enhances the solvability of the oil and, hence, speeds up the transition from oil droplets to the water accommodated fraction (WAF). In turn, this will increase the availability of oil to microbial biodegradation favored by smaller droplets with a higher surface to volume ratio and dissolved oil.[11-13] There are studies that have shown that dispersants may inhibit bacterial degradation of oil,[14] but this has been questioned and attributed to the unrealistic high doses used in the experiments.[15] It has been shown that bacteria can degrade oil at high rates even at low temperatures, although the population growth of the bacteria at these temperatures is low.[12,16-18]

Prior studies have shown that fish ELS are particularly sensitive to total polycyclic aromatic hydrocarbon (TPAH) concentrations, and exposure to low concentrations of TPAHs (1-20 µg/l) is associated with irreversible heart failure, which leads to a number of secondary effects from loss of circulation, like spinal and jaw deformities, that again results in reduced swimming and feeding, and ultimately death during larvae stages (e.g., see refs 19-24). Hence, adding dispersants speeds up the transition from large droplets to smaller droplets, and TPAHs in the WAF before the concentration of toxic components are reduced to below threshold levels for effects due to dilution. While many studies indicate elevated toxicity as a result of introducing dispersants,[25-29] they all attributed this to enhanced concentrations of TPAHs due to the promotion of smaller droplets and hence increasing fraction of oil in WAF. At open sea, biodegradation and dilution rapidly decrease concentrations of toxic components, and the overall effect of introducing dispersants is therefore not obvious. However, there are also studies indicating that chemically dispersed oil appears to be less toxic than mechanically dispersed oil as shown by gene transcription.[30] While dispersants are toxic themselves, their effective doze are higher than what can be expected in the water column during realistic operations.[15] It is therefore not to be expected that oil and dispersants have synergistic effects besides the enhanced amount of small droplets and WAF.[29]

Less attention has been paid at the potential benefits of actively using dispersants to guide oil plumes away from particularly vulnerable species. The use of dispersants, as opposed to not using them, implies oil distributed deeper in the water column. This may in turn affect the dispersal of oil if horizontal currents vary with depth,[31] equivalent to the dispersal of plankton.[32] Numerical predictions supported by measurements of oil dispersal and fate and distribution of relevant marine resources enable such considerations.[31]

We hypothesize that the introduction of dispersants increases the near-field concentrations of toxic components of the oil (here represented by the TPAHs) due to generation of lesser oil droplets and consequently more oil in WAF, but at the same time decreases the volume of water contaminated with toxic levels above effect concentrations reported for fish ELS due to biodegradation and dilution. As a consequence, we expect that introducing dispersants does not increase the amount of fish ELS experiencing levels of oil above effect concentrations. To study this, we simulate the dispersal and fate of oil from three sites at the continental shelf along the Norwegian coast and the corresponding exposure of Northeast Arctic (NEA) cod ELS with and without applying dispersants (Figure 1). We quantify

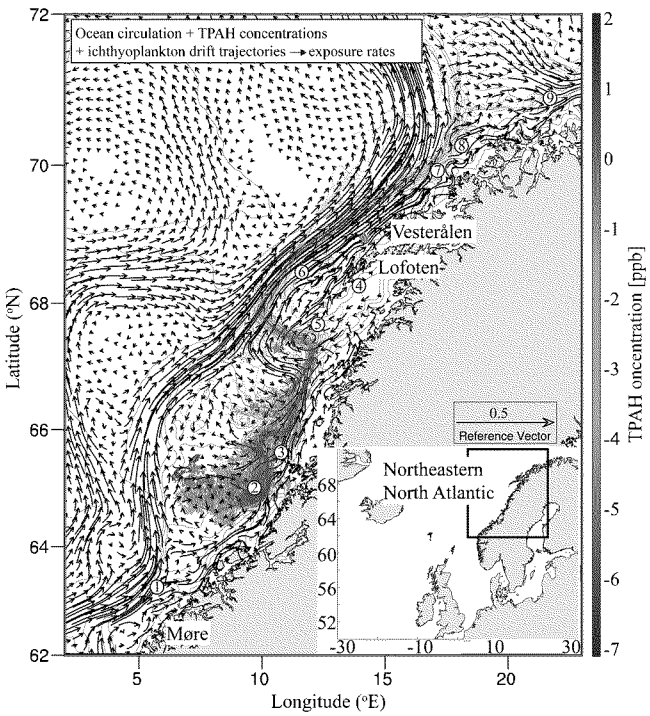

Figure 1. Monthly mean circulation at 20 m depth for April 1997. Blue stars indicate the three oil spill locations investigated here. Oil spilled from the southernmost location results in concentrations (maximum concentration in the water column) of TPAHs according to the colorbar (log 10 ppb). The nine different known SGs considered here are indicated with numbers enclosed by circles. Red lines indicate random examples of egg/larvae drift trajectories originating from SG 2.

the fraction of individuals that are exposed to concentrations of TPAHs of more than 1.0 or 0.1 ppb (µg/l). At these orders of magnitude, we expect acute mortality or sublethal effects, respectively, as described in ref 3. By doing so, we may quantify the (1) effects of using dispersants on the fraction of spawning products exposed to above-threshold levels of TPAHs and (2) how this varies with spill site and distance to the spawning ground (SG). In turn, this allows us to discuss the potential for (3) utilizing dispersants for guiding an oil plume spatially to minimize environmental impact here exemplified by the overlap of fish ELS and toxic components of the oil.

MATERIALS AND METHODS

To quantify the effect of adding dispersants to potential oil slicks on spatiotemporal oil distribution and overlap with fish ELS, we build on the study by Vikebø et al.[31] by adding dispersants sufficient to fully treat all oil released in spill scenarios 1-3. By comparing with scenarios where no dispersants are added, we may contrast the effects on NEA cod ELS. In short, we released 4500 m^3 d^{-1} of oil (Statfjord light crude) at three locations along the coast (65.00° N N7.00° E; 67.00° N N10.33° E; 68.67° N N13.92° E) at the surface April 1, 1997 with duration of 30 days. The overlap (%) of TPAHs with NEA cod ELS from nine spatially separated SGs, distributed from Møre to the Finmark coast (Figure 1), were

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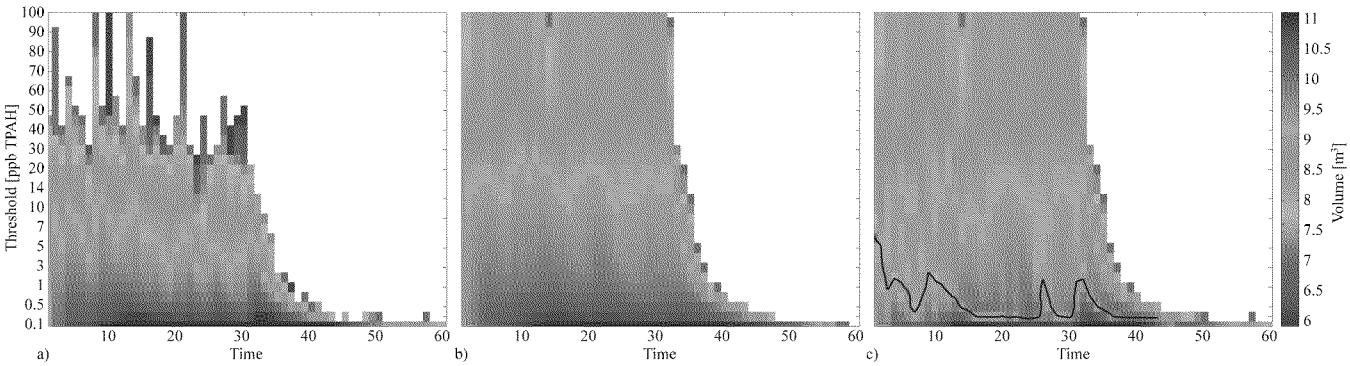

Figure 2. Volume (log 10, m^3) of water with concentrations of TPAHs above threshold values ranging from 0.1 - 100 ppb as a function of time without (a) and with (b) dispersants. The absolute difference between the two is shown in panel c. The solid thick line indicates where they are equal. Below this line, concentrations without dispersants are highest and opposite above this line. The colorbar range 6 - 11 is equivalent to volumes of 1 km^3 of 1 m depth to 100 km^3 of 10 m depth.

quantified for TPAH concentrations at two different vertical levels, either the maximum TPAHs in the water column or the TPAH concentrations at the depth of the diurnally migrating larvae. This is because empiri tells us that NEA cod ELS do migrate vertically according to day or night but that this behavior is uncertain due to scarse data and varying ambient environmental conditions. Hence, it is therefore also relevant to consider the maximum TPAH concentration in the water column at the same lon, lat position and compare this to the concentration if also considering the actual depth of the individual.

Ocean Model ROMS. The ocean model used is the Regional Ocean Model System (ROMS; http://www.myroms.org/). It provides daily mean three-dimensional physics to the oil drift and fate model OSCAR and the individual-based NEA cod egg and larval model. The simulation period (1989 - 2008), area (Nordic Seas and the Barents Sea), spatial resolution (4 × 4 km^2 and 30 vertical sigma layers), boundary forcing, and model performance are described in refs 33 and 34 indicating that coastal shelf and shelf slope dynamics are well reproduced.

Oil Drift and Fate Model OSCAR. The oil drift and fate model OSCAR[35 - 37] is a pseudolagrangian three-dimensional model where particles resemble oil components and predicts spatiotemporal dispersal along with buoyancy effects on vertical displacements, hydrocarbon dissolution, and hydrate formation.[31] The OSCAR model represents oil by 25 pseudocomponents and is here set up to only report on the TPAH concentrations. The pseudocomponents included in the OSCAR model are given in ref 38. Of these, the TPAHs comprise two different pseudocomponents for Naphtalenes and two different pseudocomponents for TPAHs.

OSCAR features the possibility of modeling response actions by introducing dispersants at various rates and locations. This includes surface application of dispersants from either seaborne or airborne vessels. These response vessels account for storage capacity of dispersants, efficiency of application methods, equipment, and weather conditions.[39] A primary function of dispersant agents is to reduce the oil - water interfacial tension and thereby promote breakup of oil into smaller droplets due to turbulence and breaking waves in the surface layer of the sea.[40]

To compare results with and without the use of dispersants, we choose to avoid the complexity of modeling response vessels. Instead, the oil spill model assumes that application methods, efficiency, weather conditions, and amount of dispersant available is sufficient to fully treat the entire release of oil. This treatment is performed immediately after release to the sea, causing the oil to be fully mixed into the water column as droplets and dissolved constituents. Weathering effects on surface slicks, such as emulsification and evaporation, therefore no longer occur. Furthermore, it is assumed that the reduction in oil - water interfacial tension and the turbulence in the surface layer are sufficient to break the oil into droplets with a diameter of order 10 μm. These assumptions result in an oil-in-water dispersion of near-neutrally buoyant droplets and neutrally buoyant dissolved constituents. The oil remains submerged in the upper water column, where the primary contributors to transport are advection by ocean currents and turbulent diffusion.

ELS Individual-Based Model for NEA Cod. The ELS biophysical model is a particle-tracking model, with build-in modules for individual physiological and behavioral responses in eggs and larvae to ambient forcing. Particles, representing either eggs or larvae, move according to a daily mean modeled circulation archive established with the ROMS model application as described above. Each particle keeps track of the daily temperature exposure allowing for temperature-dependent growth according to ref 41. The egg stage duration is set to 21 days. During this period, the particles are displaced vertically with a binned random walk[42] according to their buoyancy[43] and mixing as reported by the turbulence scheme in the ocean model. After hatching of the eggs, the larvae start migrating vertically depending on the light availability and their individual size. Clearly, there are many factors that might affect larvae behavior,[32,44,45] but our knowledge of this, and field samples of the individual larval state and environmental conditions, is limited. Hence, we have incorporated a diurnal migration dependent on the individual larval swimming capability (here a function of larval length) and the light availability. The larvae are set to ascend during night toward an upper limit of 5 m and descend during day toward a lower limit of 40 m.[46,47,44]

At each of the nine different SGs,[48,49] we introduce 10 500 particles released every third day across 60 days from early March until late April. Each particle is transported according to the currents at the time and location of the respective spatiotemporal varying positions. By coupling the model output of the ELS individual-based model and the oil drift and fate model OSCAR, we keep track of the time-varying TPAH concentrations along the individual egg and larval drift trajectories. To assess overall effect of the various OSSs, we

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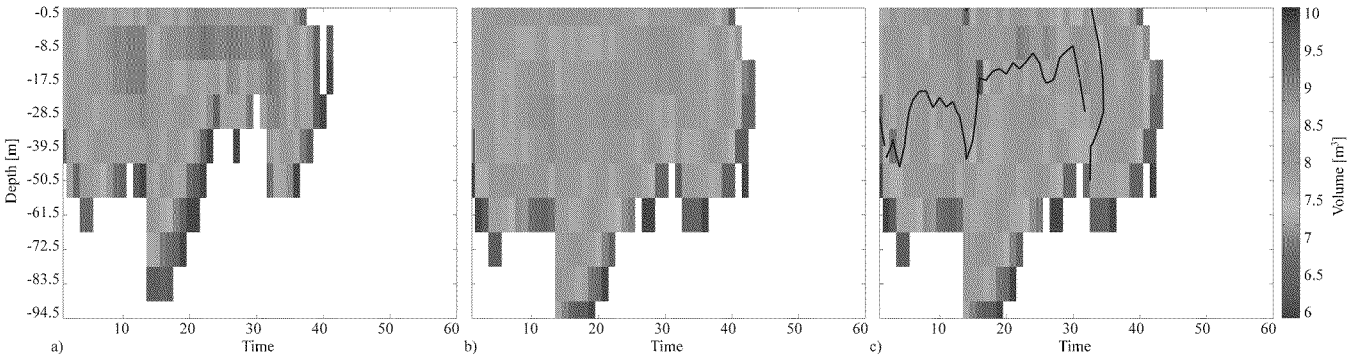

Figure 3. Volume (log 10, m^3) of water per vertical meter with concentrations of TPAHs above 1 ppb in the cases without (a) and with (b) dispersants. The absolute difference between the two is shown in panel c. The solid thick line indicates where they are equal. Above this line, concentrations without dispersants are highest and opposite below this line.

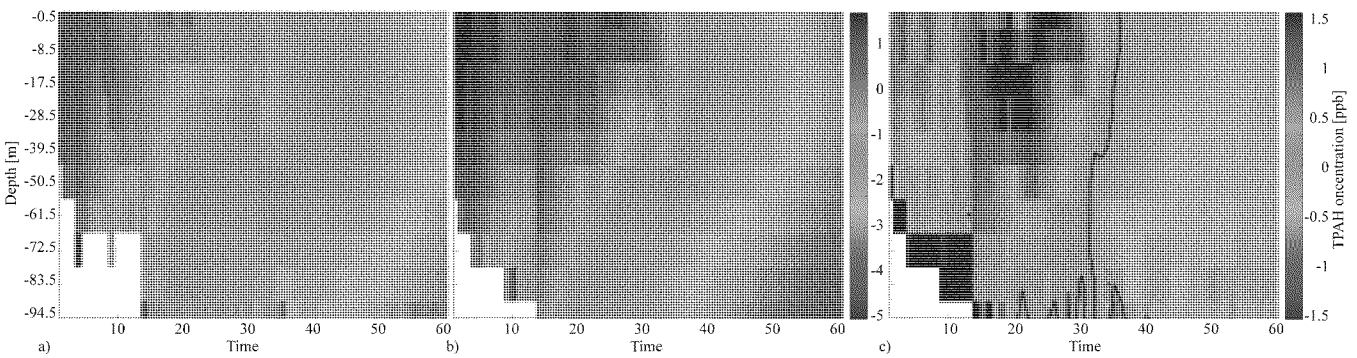

Figure 4. Mean horizontal concentrations of water masses with TPAH concentrations above 1 ppb per depth interval without (a) and with (b) dispersants. The absolute difference between the two is shown in panel c. The solid thick line indicates where they are equal. To the right of this line, concentrations without dispersants are highest and opposite to the left of this line.

scale the different SGs according to recent years of temporal and spatial spawning intensities.[49] The SGs 1-9 contribute with approximately 5, 5, 5, 20, 10, 20, 15, 10, and 10% of the eggs, respectively. Considering each particle as a super-individual representing multiple eggs and larvae enables us to scale the particle release according to our empirical knowledge of spatial and temporal spawning intensities.

RESULTS

General Features of TPAH Dispersal. The OSCAR model simulates the concentrations of dissolved TPAHs in the water column as a function of time after the oil spill starts, without and with dispersants (Corexit 9500). Figure 2 shows the total volume of water (log 10, m^3) with concentrations above various threshold levels of TPAHs from 0.1, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 14, 16, 18, and 20 to 100 ppb with increment 5 ppb, as a function of time after the oil spill starts, without (a) and with (b) dispersants (Corexit 9500) as a result of OSS 1. As expected, the water volume with minimum values of TPAHs above the lowest threshold level (0.1 ppb, on the order of 3×10^{11} m^3) is several hundred thousand times greater than for the high threshold levels (100 ppb, on the order of 3×10^6 m^3). The corresponding difference in volume estimates (c) is also shown (b minus a), along with a solid black line showing where they are equal. Clearly, for low threshold levels, below about 8 ppb TPAHs and less depending on time, the total volume of water above the respective threshold levels of TPAHs is higher in the case without the use of dispersants (Figure 2c). If the considered threshold level is above the black line, it is consistently oppositely higher with use of dispersants. It is similar for the OSS 2 (Figure S1a-c, Supporting Information), while scenario 3 results in a volume estimate being the highest when adding dispersants for most thresholds and times (Figure S4a-c). It is evident that introducing dispersants results in concentrations above thresholds also for elevated threshold levels (Figure 2b), while this is not the case when dispersants are not used (Figure 2a). This is similar for all OSSs.

Figure 3 shows the total volume (log 10, m^3) of water with concentrations above 1 ppb TPAHs as a function of depth, without (a) and with (b) dispersants. Again, the corresponding difference is shown in the right panel (c). From above, we have learned that at 1 ppb TPAHs, the total volume of water is higher in the case without dispersants. Here, we can see that this is true in the upper part of the water column, down to about 10-40 m depending on the number of days after the spill starts (Figure 3c). Below this depth, the volume of water is higher in the case with dispersants. This is also a dominating feature for OSS2 (Figure S2a-c) but opposite for OSS3 (Figure S5a-c).

Figure 4 shows the mean horizontal concentration for each depth level including only grid cells above 1 ppb TPAH without (a) and with (b) dispersants. The right-hand panel (c) shows the difference in mean concentration estimates. Here, we can see that though the total volume of water masses with concentrations of TPAHs above 1 ppb is higher in the upper water column without dispersants (Figure 3), the mean concentrations are always higher when dispersants are added as long as the spill endures (Figure 4c; day 1-30). However, after the spill has ended, the mean concentrations throughout

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the water column are higher in the case without dispersants. This is similar for OSS2, but not entirely so for OSS3 (Figures S3a - c and S6a - c).

Hence, in general, the introduction of dispersants results in less water being contaminated with TPAHs, but the contaminated water has higher concentrations of TPAHs. Also, the TPAHs are displaced deeper in the water column.

Eggs and Larvae Exposed to TPAHs. Given the fact that processes controlling vertical distribution of NEA cod larvae are only partly known, and here represented numerically according to our current level of knowledge, we summarize the overlap estimates of TPAHs and ichthyoplankton with and without the use of dispersants for two different values of TPAH concentrations in the water column: the maximum and the depth specific values at the time-varying geographical position of each individual. The exposure values then represent the maximum and the best approximation given our current knowledge of larval behavior. In the following, we present the fraction of individuals from the different SGs exposed to above 1.0 or 0.1 ppb PAH at least once during the 60 day drift period. Also, we have indicated which combinations of OSSs and SGs result in exposures more than 1 standard deviation (s.d.) above the mean of all combinations. Furthermore, we add information on recent years observed spawning distribution and spawning intensity and report on the overall effect of the various OSSs on the eggs and larvae, and quantify how the use of dispersants modifies the results. Finally, we quantify the size of the fractions being exposed to various durations above the threshold levels.

Fraction Exposed to >1.0 ppb TPAHs. Figure 5, panel a shows the fraction exposed to >1.0 ppb TPAHs when accounting for maximum concentrations of oil in the water column. If not introducing dispersants, the results show that a southern oil spill (OSS1) mostly affects eggs and larvae from the southern SGs,[1-3] while northern oil spills (OSS3 and partly OSS2) affect eggs and larvae from almost all SGs. The combinations of oil spills and SGs that result in >1 s.d. (corresponds to about 7% of the individuals) are SG1 - 3 for OSS2 and SG5 for OSS3. When introducing dispersants, the fractions of exposed individuals in the case of OSS1 and OSS2 are reduced, while they are either elevated or reduced depending on SGs in the north (OSS3). The same combinations of OSSs and SGs surpass 1 s.d. above the mean when introducing dispersants (except SG2 during OSS2).

Figure 5, panel b shows the fraction exposed to >1.0 ppb TPAHs when accounting for the egg and larval depth-specific concentrations of oil in the water column along the individual trajectories. The general features of the results, both with and without the use of dispersants, are similar to the case when accounting for maximum concentrationTs of PAHs in the water column, but the overall level of exposure is reduced. The level of 1 s.d. above mean is reduced from about 7% to about 5%.

Fraction Exposed to >0.1 ppb TPAHs. Figure 6, panel a shows the fraction exposed to >0.1 ppb PAH when accounting for maximum concentrations of oil in the water column, with and without the use of dispersants. In the case without dispersants, the results reveal that the combination of OSS1 and SG2 results in the highest fraction of exposure amounting to about 58%. Apart from that, the results are similar to the features of the two previous figures, but with much higher exposure levels. Here, 1 s.d. above the mean is about 21%. Introducing dispersants decreases the exposure levels in the south (OSS1 - 2), while it kept them almost fixed in the north. When accounting for the exposure levels at the depth of the

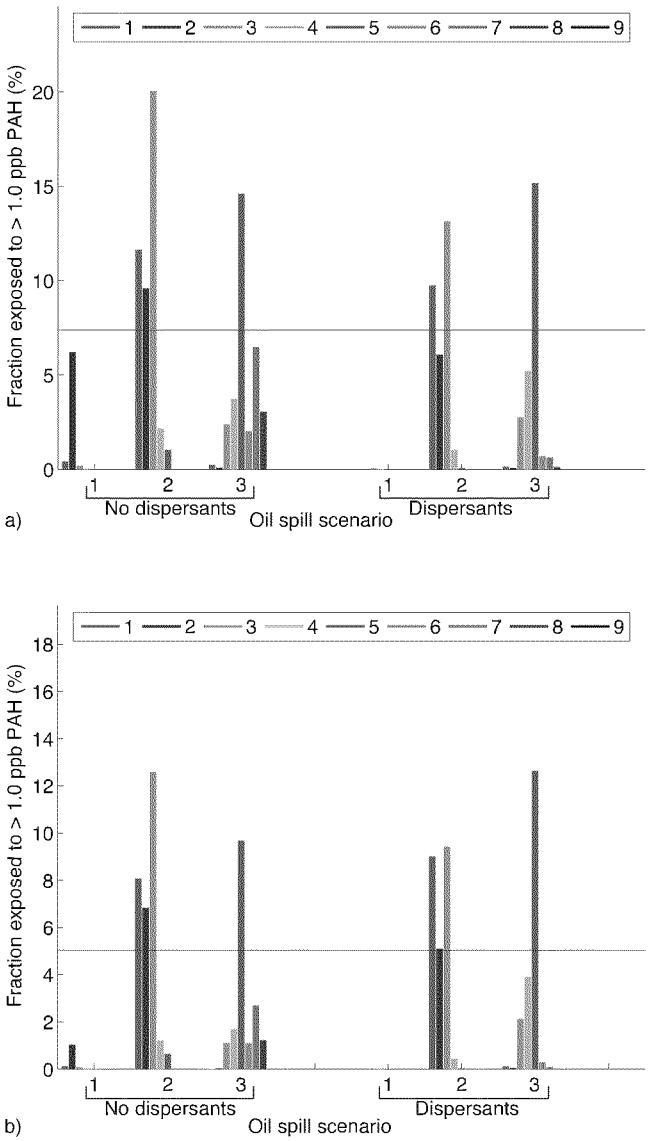

Figure 5. Percentage overlap of the spawning products with TPAH concentrations above 1.0 ppb at least once during the first 60 days after the beginning of the oil spill in OSSs 1 - 3, with and without the use of dispersant, based on the maximum TPAH concentrations in the water column (a) or the individual depth of the offspring (b). The horizontal line denotes one standard deviation above the mean.

individual egg or larvae (Figure 6b), the features of the results are similar, but the exposure levels generally decrease as indicated by the value of 1 s.d. above mean now reduced from about 21 to 17%.

Overall Results When Accounting for Realistic Spawning Distribution and Intensity. Figure 7 shows the fraction of eggs and larvae that are exposed to concentrations above the threshold levels (1.0 or 0.1 ppb) of TPAHs for the different OSSs, with and without the use of dispersants, when accounting for the seasonal and spatial spawning intensity. In general, there is a reduction in the fraction of exposed individuals for OSSs, mostly in the south and moderate farther north, when introducing dispersants. This is the case independent of threshold level 1.0 or 0.1 ppb TPAHs or whether the concentration represents the maximum concentration in the water column or the concentration at the depth of the individuals. Note that sublethal effects affect several times

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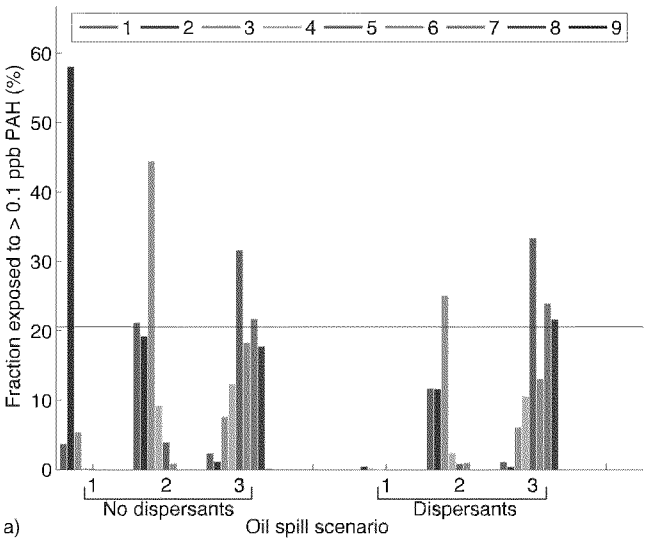

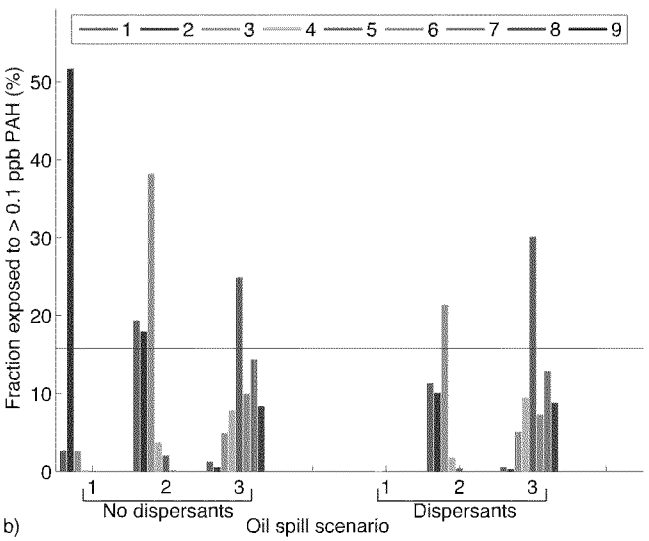

Figure 6. Percentage overlap of the spawning products with TPAH concentrations above 0.1 ppb at least once during the first 60 days after the beginning of the oil spill in OSSs 1-3, with and without the use of dispersant, based on the maximum TPAH concentrations in the water column (a) or the individual depth of the offspring (b). The horizontal line denotes one standard deviation above the mean.

more individuals than those experiencing acute effects, independent of whether one consider TPAH concentrations at the individual depths of eggs or larvae or the maximum in the water column.

Durations of Exposure above Thresholds. Figure 8 shows the fraction of individuals that are exposed to above 1.0 or 0.1 ppb TPAHs for the three different OSSs independent of SGs, without (Figure 8a) and with (Figure 8b) the use of dispersants for different durations. In the case of 1.0 pbb TPAHs, few individuals are exposed to above threshold levels of TPAHs for more than 5 days. At the same time, dependent on the OSS, up to about 50% of the individuals are exposed more than 1 day. In the case of sublethal effects, accounting for the fraction exposed to >0.1 ppb TPAHs, the ratio of individuals exposed to above threshold levels more than a day compared to only a single day increases substantially. In fact, this is now more frequent than only being exposed a single

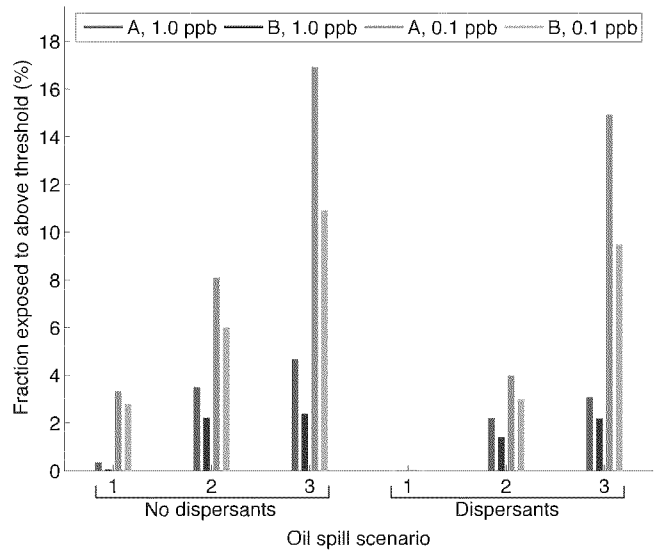

Figure 7. Percentage overlap of offspring with TPAH concentrations above 1.0 or 0.1 ppb at least once during the first 60 days after the beginning of the oil spill in OSSs 1-3, with and without the use of dispersant, based on either the maximum TPAH concentrations in the water column (A) or the TPAH concentrations at the individual depths of the offspring (B) when the seasonal and spatial spawning intensity are incorporated in the analysis.

day. Fewer individuals are affected by above threshold levels of ppb TPAHs when introducing dispersants. However, there is a tendency toward longer durations of exposure.

DISCUSSION

Adding dispersant (Corexit 9500) in case of an oil spill reduces the surface tension of the oil droplets and results in a shift of the oil droplet size spectra toward smaller droplets sizes. In turn, this facilitates both a shift toward more dissolved oil and a displacement away from the surface and into the water column. This also occurs naturally by turbulent mixing caused by, for example, wave breaking and vertical current shear due to wind stress, but adding dispersant chemicals further fuels the process. There are several laboratory studies addressing potential toxic effects of adding dispersant (e.g., 50) and tank studies to quantify changes in the droplet size spectra and concentrations of different oil components in the droplet or WAF. However, to integrate large-scale effects of major oil spills and address how the use of dispersants may contribute to minimize ecosystem effects, one must combine observations and models. Here, we utilize the oil spill and fate model OSCAR, which is parametrized based on observations from both laboratory and field measurements, in combination with an individual-based model for early life stages of NEA cod eggs and larvae to reveal the effects of adding dispersants to a major oil spill.

Adding unlimited dispersant to the oil immediately following the release so that all the oil is fully treated, disregarding the limitations of ship or aeroplane capacities to provide sufficient supplies, results in higher concentrations of TPAHs but in a reduced volume of water compared to a situation where no dispersants are added. Also, adding dispersants causes the TPAHs to be displaced farther down in the water column, and the duration of elevated concentrations of TPAHs after the spill has ended is shortened. However, this is valid for threshold levels of effects around 1.0 ppb TPAHs. If considering threshold levels of toxicity on the order of 10 ppb TPAHs or

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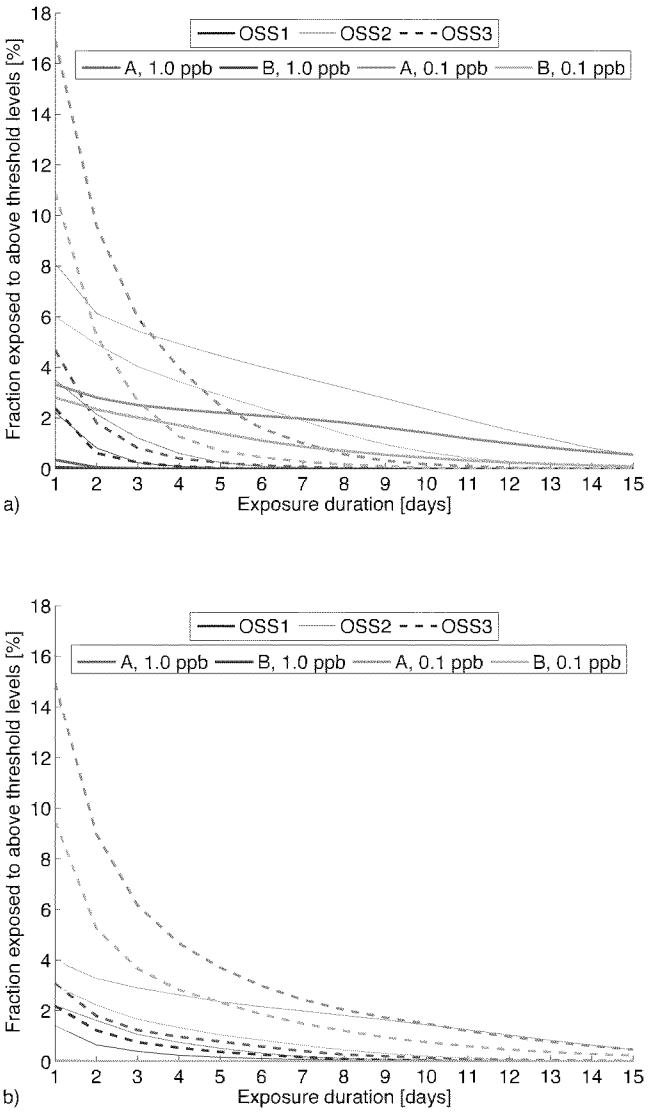

Figure 8. Fraction of individuals exposed to above 1.0 or 0.1 ppb TPAHs for an increasing numbers of days, without (a) or with (b) the use of dispersant, based on either the maximum TPAH concentrations in the water column (A) or the TPAH concentrations at the individual depths of the offspring (B) when the seasonal and spatial spawning intensity are incorporated in the analysis.

higher, the results indicate that the volume of water with above threshold levels of TPAHs is higher when adding dispersants. Hence, establishing accurate no effect concentrations for the marine organism considered is critical to enable assessment of the effects of adding dispersants.

Furthermore, the results show that the location of the oil spill significantly affects the fraction of eggs and larvae that experience above threshold levels of TPAHs. A southern oil spill affects eggs and larvae from nearby SGs, while the northern spills tend to affect offspring from the entire coast, though to a varying degree. This is mainly because the shelf becomes narrower farther north thus limiting the dispersal distance from the coast. At the same time, all individuals that drift toward the nursery grounds of the Barents Sea have to pass close to the spill site. Introducing dispersants to decrease droplet sizes and submerging the oil moderately reduces the fraction of eggs and larvae that are affected by above threshold values of TPAHs. Accounting for maximum concentrations in the water column results in moderately elevated fractions of individuals experiencing above threshold levels of toxins as compared to the modeled depth of the eggs and larvae. However, addressing overlap with concentrations here defined to represent acute or sublethal effects (1.0 or 0.1 ppb TPAHs) makes a significant difference, as sublethal effects affect several times more individuals than those experiencing acute effects. In sum, this emphasizes the importance of continued research on larval behavior and sublethal effects for evaluating the fraction of individuals affected by an oil spill and whether it is recommendable to add dispersant. Also, it is evident from the results presented here that the design of OSSs for oil spill impact assessment is critical.

The duration of exposure heavily depends on the location of the spill. The OSS farthest north results in the shortest exposure, while opposite for the OSS in the south. This is true independent of whether or not dispersants are added. The duration of the exposure may significantly affect the degree of response in the marine organism dependent on the species and stage-dependent net uptake rates.

Toxicity testing in laboratories has focused on acute effects and partly neglected sublethal effects. The reason is obvious. Sublethal effects require long-term monitoring, ideally across generations, while detecting acute effects can be carried out in experiments of much shorter duration and less complexity. This has led to a bias in our knowledge of long-term effects of oil spills. The results here show that a much higher fraction of eggs and larvae experience above threshold levels of TPAHs corresponding to sublethal effects than acute effects. Also, the durations of exposure to such levels of TPAHs are generally longer. While moving toward a consensus in literature on levels and durations resulting in acute effects, the case of sublethal effects is more open. Sublethal effects in many individuals may over time have stronger impact on a population level than acute lethal effects in fewer individuals. This can be the case especially if the sublethal effects lead to developmental disorders in the fish larvae.[20-23] Anyhow, the results presented here indicate that the use of dispersants does not significantly change the fractions of eggs or larvae exposed to either of the two threshold levels.

The situation is more obvious for other marine species. Seabirds breed in colonies along the coast and migrate to feed in an area surrounding the colony.[51] While some seabird species only explore the surface waters, others dive to great depths. Despite their preference for feeding depth, they have to penetrate the surface slick either to feed pelagically or swim down through the water column to reach the preferred prey. If dispersants are added, fewer toxic components of oil will stay at the surface, and more will be submerged as smaller droplets and dissolved. Hence, the use of dispersants may favor seabird survival in case of an accident. On the other hand, the benthic environment may experience more toxic components of oil if dispersants are used. The massive use of dispersants following the Macondo blow-out resulted in deep-ocean intrusion layers of oil that is shown to be the source of elevated levels of hydrocarbons at the seabed.[10] This could be particularly harmful to stationary sponges and corals that filter large amounts of seawater for nutritional uptake while not being able to move out of contaminated areas.[52,53]

Clearly, considering the use of dispersants to minimize ecosystem impacts depends on our understanding of the ecosystem functioning of the area in question. In addition to direct effects, there are secondary effects that complicate such

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considerations, for example, the importance of sponges and corals as spawning locations for fish or the contamination of zooplankton that is fed upon by larval fish. Also, while dispersants may guide part of the oil away from the upper parts of the water column occupied by ELS of fish, it may still affect fish through impacts on SGs in the case when they are located at the seabed (e.g., Norwegian Spring Spawning herring, ref 33).

ASSOCIATED CONTENT

* Supporting Information

For oil spill scenarios 2 and 3: volume (log 10, m^3) of water with concentrations of TPAHs above threshold values ranging from 0.1-100 ppb as a function of time without and with dispersants; volume (log 10, m^3) of water per vertical meter with concentrations of TPAHs above 1 ppb in the cases without and with dispersants; and mean horizontal concentrations of water masses with TPAH concentrations above 1 ppb per depth interval without and with dispersants. This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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DOI: 10.1021/acs.est.5b00016
Environ. Sci. Technol. XXXX, XXX, XXX-XXX

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To: Dana Tulis[Tulis.Dana@epa.gov]; Reggie Cheatham (cheatham.reggie@epa.gov)[cheatham.reggie@epa.gov]; Joshua Woodyard[Woodyard.Joshua@epa.gov]; Roberta Runge[Runge.Roberta@epa.gov]; DeHaven, Leigh[DeHaven.Leigh@epa.gov]; Gregory Wilson[Wilson.Gregory@epa.gov]; J-Troy Swackhammer[Swackhammer.J-Troy@epa.gov]; MarkW Howard[Howard.MarkW@epa.gov]; Vanessa Principe[Principe.Vanessa@epa.gov]
Cc: Kim Jennings[Jennings.Kim@epa.gov]
From: Matthiessen, Craig
Sent: Tue 7/7/2015 11:58:36 AM
Subject: FYI from BNA - Canadian Government Authorizes Offshore Use of Chemicals to Treat Oil, Gas Spills

FYI from BNA Report:

Oil Spills

Canadian Government Authorizes Offshore Use of Chemicals to Treat Oil, Gas Spills

By Peter Menyasz

July 6 — Canada has enacted legislative measures authorizing the use of chemicals to treat spills from offshore oil and gas projects.

Implementing provisions related to the use, under certain conditions, of spill-treating agents (STAs) that are potentially harmful to the environment provides a full range of available responses in the case of an offshore spill, Natural Resources Canada said in an explanatory note accompanying a Cabinet order published in the July 1 issue of the Canada Gazette, Part II.

"Bringing these provisions into force now also provides certainty for the oil and gas sector with respect to the use of STAs," the department said.

The Cabinet order brings into immediate force provisions related to STAs of the Energy Safety and Security Act that the Canadian Parliament gave final approval to Feb. 26. The order also implements provisions permitting transfer of authority over environmental assessments of offshore projects to the National Energy Board and the Canada-Nova Scotia Offshore Petroleum

Board (CNSOPB) to provide for “single-window” assessments.

Treating Spills

The deposit of STAs that could be harmful to the environment is potentially prohibited under federal statutes including the Fisheries Act, Migratory Birds Convention Act, 1964, and the ocean disposal provisions of the Canadian Environmental Protection Act, Natural Resources Canada said.

Spill-treating agents can include dispersants, herding agents, emulsion treating agents, solidifiers, bioremediation agents and surface washing agents used to control the path of offshore oil spills and to mitigate their impact on the environment, the department said.

The Energy Safety and Security Act authorized the National Energy Board, CNSOPB and the Canada-Newfoundland and Labrador Offshore Petroleum Board (CNLOPB) to use spill-treating agents, where appropriate, and authorized Environment Canada to develop regulations by February 2020 to identify chemicals that are deemed acceptable for use in Canada's offshore regions and to impose conditions on their use, it said. The act specified that those provisions were to be implemented by Cabinet order, it said.

The act would permit the use of a spill-treating agent that is:

- listed in regulations issued by Environment Canada;

- specifically included in the oil and gas operator's contingency plan for spills;

- approved by the responsible federal or federal-provincial agency's chief conservation officer on the basis that it offers a net environmental benefit in the circumstances;

- used in accordance with conditions imposed by the Environment Canada regulations that are

being developed; and

• the subject of consultation at the time of the spill between the relevant regulatory body and Environment Canada, during the five-year period in which Environment Canada is developing regulations on the use of STAs.

Other provisions brought into effect by the Cabinet order clarify that the National Energy Board is authorized to perform environmental assessments under the Canadian Environmental Assessment Act in Canada's northern regions, the St. Lawrence River system and the West Coast, and that the Canada-Nova Scotia Offshore Petroleum Board is authorized to conduct environmental assessments in Nova Scotia's offshore.

The Canadian Environmental Assessment Agency published June 30 draft regulations that, once made final, would establish the details of the CNSOPB's conduct of environmental assessments, including establishing a 12-month deadline to conduct assessments (126 DEN A-16, 7/1/15).

Initial Spill-Treating Agents

On July 4, Environment Canada subsequently published draft regulations specifying two initial spill-treating agents it has approved for use in addressing offshore spills, as well as outlining the process through which additional STAs will be identified and assessed.

The draft regulations identify dispersant Corexit EC9500A and surface-washing agent Corexit EC9580A as the first STAs listed for use on the basis of decades of study and demonstrated success in addressing actual oil spills in other jurisdictions, including the U.S.

“Evaluations concluded that these products possess favorable characteristics as oil spill countermeasures and offer the potential for high efficacy coupled with limited toxicity to biota in the marine environment,” the department said in a regulatory impact analysis published in the July 4 issue of the Canada Gazette, Part I.

The draft regulations are open to public comment through Aug. 3.

For More Information

The order is available at http://bit.ly/1GRadBC.

To: Gregory Wilson[Wilson.Gregory@epa.gov]; Vanessa Principe[Principe.Vanessa@epa.gov]; Leigh DeHaven[DeHaven.Leigh@epa.gov]; Barron, Mace[Barron.Mace@epa.gov]; Robyn Conmy (Conmy.Robyn@epa.gov)[Conmy.Robyn@epa.gov]
From: Matthiessen, Craig
Sent: Wed 7/1/2015 5:31:26 PM
Subject: FW: Interview/Comment request from EHP DDL 4 pm 7/1
ehp.1409672.temkin final.pdf

Hi;

See below and attached. We'll respond to the press inquiry. Just wanted to make you aware of the paper. Craig

From: James, Kennetta
Sent: Wednesday, July 01, 2015 1:14 PM
To: Matthiessen, Craig
Subject: FW: Interview/Comment request from EHP DDL 4 pm 7/1

Per our discussion. –Thanks!

Kind Regards,

Kennetta James

202-564-1942

From: Hull, George
Sent: Wednesday, July 01, 2015 11:59 AM
To: Bassler, Rachel; Deitz, Randy; James, Kennetta
Subject: FW: Interview/Comment request from EHP DDL 4 pm 7/1

We've received an inquiry from a reporter with Environmental Health News asking if EPA has any comment on the attached embargoed study on dispersants (study will be released tomorrow). According to the reporter, the study found that a commonly used chemical known as DOSS

(dioctyl sodium sulfosuccinate), which was used in the Gulf spill cleanup as a dispersant, is likely to be an obesogen – a compound that potentially contributes to obesity in people and wildlife. Can you let me know if we have any comment on the study. If we haven't seen this before, its fine to say that we haven't reviewed. The Press Secretary also asked if there was any information that OEM had on dispersants that we should provide to the reporter. We need to get back to the reporter today. Thanks,

George Hull

Office of Media Relations

U.S. EPA

Tel. 202-564-0790

From: Milbourn, Cathy
Sent: Wednesday, July 01, 2015 12:35 AM
To: Allen, Laura; Lee, Monica
Cc: Hull, George; Milbourn, Cathy
Subject: Fwd: Interview/Comment request from EHP DDL 4 pm 7/1

Hi Laura and Monica.

Brian Bienkowski is asking for comment on this study to be published on Thursday regarding dispersants that may cause obesity in animals and humans. I sent the study to ORD and George sent it to OEM.

We can always say we look forward to reviewing the study in lieu of a specific comment or statement.

Thoughts?

Cathy.

Sent from my iPhone

Begin forwarded message:

From: "BBienkowski@ehn.org" <BBienkowski@ehn.org>
To: "Valentine, Julia" <Valentine.Julia@epa.gov>
Cc: "Milbourn, Cathy" <Milbourn.Cathy@epa.gov>, "Jones, Enesta" <Jones.Enesta@epa.gov>
Subject: Interview/Comment request

Good morning,

I am the editor of Environmental Health News. I am writing a story on an embargoed study that suggests that a commonly used chemical known as DOSS (dioctyl sodium sulfosuccinate), which was used in the Gulf spill cleanup as a dispersant, is likely to be an obesogen – a compound that potentially contributes to obesity in people and wildlife.

I've attached a copy of the study. Please respect the Thursday embargo.

I was wondering if someone at the EPA might have some time today/tomorrow to review and chat or send a response about the findings? Let me know what might work -- thanks in advance.

Best,
Brian
--
Brian Bienkowski
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Effects of Crude Oil/Dispersant Mixture and Dispersant Components on PPARγ Activity *in Vitro* and *in Vivo*: Identification of Dioctyl Sodium Sulfosuccinate (DOSS; CAS #577-11-7) as a Probable Obesogen

Alexis M. Temkin, Robert R. Bowers, Margaret E. Magaletta, Steven Holshouser, Adriana Maggi, Paolo Ciana, Louis J. Guillette, John A. Bowden, John R. Kucklick, John E. Baatz, and Demetri D. Spyropoulos

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Journalists: Please link directly to this article whenever possible.

Prepublication copy

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12:01 a.m. Eastern Time

National Institute of Environmental Health Sciences

Environ Health Perspect DOI: 10.1289/ehp.1409672
Advance Publication: Not Copyedited

Effects of Crude Oil/Dispersant Mixture and Dispersant Components on PPARγ Activity *in Vitro* and *in Vivo*: Identification of Dioctyl Sodium Sulfosuccinate (DOSS; CAS #577-11-7) as a Probable Obesogen

Alexis M. Temkin,[1]* Robert R. Bowers,[2]* Margaret E. Magaletta,[1] Steven Holshouser,[4] Adriana Maggi,[5] Paolo Ciana,[5] Louis J. Guillette,[1,6] John A. Bowden,[7] John R. Kucklick,[7] John E. Baatz,[7,8] and Demetri D. Spyropoulos[2,7]

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Address correspondence to D.D. Spyropoulos, Pathology and Laboratory Medicine, MUSC, Darby Children's Research Institute, CRI 207, 173 Ashley Ave., Charleston, SC 29425 USA. Telephone: (843) 792-1625. E-mail: spyrodd@musc.edu

Running title: Obesogenic activity of DOSS

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Acknowledgments: This study was supported by the "Gulf of Mexico Research Initiative" grant GoMR12012-11-344. We are indebted to B. Blumberg, UC Irvine and Barbara Abbott, EPA for providing plasmids used in PPARγ transactivation assays.

Disclaimers: The identification of equipment and materials does not imply recommendation or endorsement by the National Institute of Standards and Technology.

Competing financial interests: A.M. and P.C. declare a potential competing financial interest regarding "repTOP™ PPRE-Luc" mice from Transgenic Operative Products. The remaining authors declare they have no actual or potential competing financial interests.

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Abstract

Background: The obesity pandemic is associated with multiple major health concerns. In addition to diet and lifestyle, there is increasing evidence that environmental exposures to chemicals known as obesogens also may promote obesity. 꿨□η

Objectives: We investigated the massive environmental contamination resulting from the Deepwater Horizon (DWH) oil spill, including the use of the oil dispersant COREXIT in remediation efforts, to determine if obesogens were released into the environment during this incident. We also sought to improve the sensitivity of obesogen detection methods in order to guide post-toxicological chemical assessments. 꿨□η

Methods: Peroxisome Proliferator-Activated Receptor gamma (PPARγ) transactivation assays were used to identify putative obesogens. Solid-phase extraction (SPE) was used to sub-fractionate the water-accommodated fraction generated by mixing COREXIT, cell culture media and DWH oil (CWAF). Liquid chromatography/mass spectrometry (LC-MS) was used to identify components of fractionated CWAF. PPAR response element (PPRE) activity was measured in PPRE-luciferase transgenic mice. Ligand binding assays were used to quantitate ligand affinity. Murine 3T3-L1 preadipocytes were used to assess adipogenic induction. 꿨□η

Results: Serum-free conditions greatly enhanced the sensitivity of PPARγ transactivation assays. CWAF and COREXIT had significant dose-dependent PPARγ transactivation activities. From SPE, the 50:50 water:ethanol volume fraction of CWAF contained this activity, and LC-MS indicated that major components of COREXIT contribute to PPARγ transactivation in the CWAF. Molecular modeling predicted several components of COREXIT might be PPARγ ligands. We classified dioctyl sodium sulfosuccinate (DOSS), a major component of COREXIT, as a probable obesogen by PPARγ transactivation assays, PPAR-driven luciferase induction *in*

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vivo, PPARγ binding assays (affinity comparable to pioglitazone and arachidonic acid) and *in vitro* murine adipocyte differentiation. 꿹□η

Conclusions: We conclude that DOSS is a putative obesogen worthy of further study, including epidemiological and clinical investigations into laxative prescriptions consisting of DOSS. 꿹□η

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Introduction

The *Deepwater Horizon* (DWH) oil spill, which began 20 April 2010, resulted in the release of over 200 million gallons of MC252 (Mississippi Canyon block 252) crude oil into the Gulf of Mexico. Approximately 2 million gallons of dispersant was used to emulsify the oil into the water column, with the aim of aiding in oil biodegradation and preventing the oil from reaching fragile nearshore habitats (Kujawinski et al. 2011). The dispersant applied by aerial spray and at the wellhead oil source was primarily COREXIT 9500 (EC9500, EC9500A and EC9500B) and secondarily COREXIT 9527 (Nalco Environmental Solutions). Dispersant has been shown to increase the bioavailability of oil components, such as polycyclic aromatic hydrocarbons (PAHs) to fishes (Ramachandran et al. 2004). While many studies in a variety of animal models have focused on the toxicity of crude oil, dispersed oil, or dispersant alone (Almeda et al. 2013; Hemmer et al. 2011; Rico-Martinez et al. 2013), long-term sub-lethal studies are limited.

Both oil and dispersant are implicated as potential endocrine and metabolic disruptors. Crude oil is linked to reproductive effects in male rats (Adedara et al. 2014), and dispersants have been shown to be estrogenic in an *in vitro* transactivation assay using a human liver hepatoma cell line (Judson et al. 2010). Also, maternal exposure to PAHs (major components of oil) in ambient air during pregnancy was associated with a higher prevalence of obesity at 5 and 7 years of age among participants in a New York City birth cohort (Rundle et al. 2012). Given the massive quantity of oil released and the unprecedented use of dispersant during the DWH oil spill, it is important to understand potential impacts to human health through direct and indirect exposures including those resulting from relief efforts and seafood consumption, respectively.

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Obesity is a major health problem that contributes to a variety of diseases, including type II diabetes, hypertension and cancer (Calle 2007; Ogden et al. 2006). Although traditionally attributed solely to an imbalance in energy intake versus expenditure, recent evidence implicates environmental agents known as 'obesogens' as potential contributors to the obesity epidemic, especially in children (Grun and Blumberg 2006). The mechanism of action of obesogens is not completely understood, but any chemical that affects food intake, energy expenditure, lipid metabolism, or adipocyte (fat cell differentiation) could potentially act as an obesogen. The master regulator of adipocyte differentiation, the nuclear receptor PPARγ (Janesick and Blumberg 2011) is a prime target on which obesogens act. Obesogens include diethylstilbestrol (Newbold et al. 2005), bisphenol A (Sommet et al. 2009), various phthalates and their metabolites (Stahlhut et al. 2007), fungicides and insecticides such as triflumizole (Li et al. 2012), hydrocarbons (Tracey et al. 2011) and the marine anti-fouling agent tributyltin (Kirchner et al. 2010). It is therefore relevant to determine if novel obesogens exist in oil or dispersants.

We investigated the obesogenic potential of COREXIT 9500 dispersed MC252 crude oil and identified the major COREXIT component, dioctyl sodium sulfosuccinate (DOSS), as a likely obesogen. In addition to it being a major component of the dispersant COREXIT, DOSS is widely used in pharmaceuticals and personal care products (DHHS 2014; EWG 2015b).

Materials and Methods

Transfection and PPARγ reporter gene assays

For PPARγ transactivation assays, HEK293T/17 cells (ATCC CRL-11268) were maintained in DMEM/F12 (Gibco by Life Technologies) containing 10% fetal bovine serum (ThermoScientific), 2 mM glutamax, 100 μM nonessential amino acids and antibiotic/antimycotic. Cells were transfected with Lipofectamine 2000 according to the

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manufacturer's protocol (Invitrogen by Life Technologies) and plated in 96 -well dishes at a density of 20,000 cells per well. Each well of cells was transfected with 16 ng PPARγ-Gal4 (fusion protein of the yeast GAL4 DNA-binding domain [amino acids 1-147] and the mouse PPARγ ligand-binding domain [a.a. 163-475]; kindly provided by B. Blumberg; UC Irvine), 80 ng UASx4 TK-luc (contains four copies of the GAL4 Upstream Activating Sequence and the herpes virus thymidine kinase promoter [-105/+51] driving firefly luciferase) and 4 ng of pRL vector (encoding Renilla luciferase to control for transfection efficiency). The next day triplicate wells of cells were treated as described. Cell lysates were harvested after 18 hr of treatment and the Dual-Luciferase Reporter Assay System (Promega) and a Veritas Microplate Luminometer (Turner Biosystems) were used to measure firefly and Renilla luminescence according to the manufacturers' recommendations. For assays using human PPARγ, PPARα and PPARβ/δ plasmids were kindly provided by Dr. Barbara Abbott, EPA and are described in (Bility et al. 2004). The GAL4-RXRα plasmid was kindly provided by Dr. Bruce Blumberg, UC Irvine (Grun and Blumberg, 2006).

Preparation of oil water accommodated fractions

To distinguish between PPARγ activity originating from the dispersant COREXIT 9500 (Nalco Environmental Solutions, LLC) versus MC252 oil (AECOM), a suite of water accommodated fractions was prepared using alternative oils and solvents. All water accommodated fraction mixtures were prepared by vigorously stirring the components overnight followed by 12 hr of gravity separation and aqueous phase collection. CWAF (COREXIT Water Accommodated Fraction) is COREXIT 9500, MC252 oil and DMEM/F12 cell culture media mixed 1:20:200 (ratios by volume). WAF is MC252 oil and DMEM/F12 mixed 1:10. C_MWAF (COREXIT Mazola corn oil Water Accommodated Fraction) is COREXIT, Mazola corn oil and

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DMEM/F12 mixed 1:20:200. COREXIT only mixtures are COREXIT and DMEM/F12 mixed 1:200. DWAF (Dimethyl sulfoxide Water Accommodated Fraction) is DMSO, MC252 oil and DMEM/F12 mixed 2:20:200.

Solid-Phase Extraction

Fractionation of CWAF was performed to determine if compounds from COREXIT or oil were responsible for the observed PPARγ activity. Bond Elut 3 mL silica solid phase columns (Agilent Technologies) and vacuum manifold chambers were employed to fractionate CWAF. Four fractions bearing differential polarities and hydrophobicities were collected in the following order: 50:50 water:ethanol, methanol, dichloromethane and hexanes. For every 75 μL of CWAF loaded into the column, 100 μL of water was used to pull the sample through the column, and 2 mL of solvent was used to collect each fraction. Before downstream applications solvents were removed by vaporization using a Savant ISS110 SpeedVac Concentrator (Thermo Scientific) and resuspended in 10 μL DMSO/ 500 μL of fraction.

Chemical analysis of CWAF sub-fractions

Composition of the CWAF ethanol:water extractable SPE fraction was determined using a heated (50°C) Kinetex liquid chromatography (LC) C-18 column (100 mm x 2.1 mm, 1.7 mm; Phenomenex) on an Agilent 1100 LC with autosampler. The mobile phases were (A) milli-Q water with 1.0 M ammonium acetate (pH 6.5, Fisher Scientific) and 0.1% formic acid:water (volume fraction, 98%, ACS grade, EMD Millipore) and (B) 1:1 (v/v) isopropanol (IPA):acetonitrile (ACN) (volume fraction, Scientific) with 1.0 M ammonium acetate (pH 6.5) and 0.1% formic acid:IPA/ACN (volume fraction). The components of CWAF (5 mL injection) were separated using a flow rate of 200 mL/min that started at 40 % solvent A (for 5 min) and

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changed to 20 % A (0 min to 5 min), to 0 % A (5 min to 19 min), back to 40 % A (19 min to 20 min), and equilibrated at 40 % A for 5 min. Separated components were detected using an AB Sciex API 4000 triple quadrupole mass spectrometer (equipped with a TurboV electrospray ionization source) operating with Analyst software (v. 1.5.2). Full scan (FS) mass spectrometric (MS) experiments (scanning m/z 200 to 1200) were performed in both positive and negative polarity mode to identify potential target masses in the ethanol/water fraction. The FS parameters (positive/negative) were scan rate (2 s), entrance potential (10/-10 V), declustering potential (75/-75 V), curtain gas (20), gas 1 (20), gas 2 (20), ion spray voltage (5000/-4500 V), source temperature (500 °C) and ihe on. To further characterize the target masses, product ion scans (MS/MS) were collected (collisionally activated dissociation (CAD), collision energy (30 eV), cell exit potential (15 V)). Upon identification of commonalities in the fragmentation of the target masses, precursor ion scans (PISs) of m/z 307.3, 309.3 and 311.3 (corresponding to fragments of ethyl linoleate, ethyl oleate and ethyl stearate, respectively) were employed to highlight analyte classes that exhibited specific in-source fatty acid fragments commonly associated with Polysorbate (Tween) materials (Hvattum et al. 2012). Noting the recently reported ingredients of Corexit (EPA), tentative identification of two dominant components of the CWAF ethanol/water extract, Polysorbate 80 (Tween 80) and DOSS, was made by comparing the acquired mass spectrometric data (MS, MS/MS and PIS) to previously published reports (Chen et al. 2002; Hvattum et al. 2012; Mathew et al. 2012; Ramirez et al. 2013; Zhang et al. 2012).

To confirm the presence of TWEEN 80, the sub-fraction was analyzed in positive full scan mode, revealed several unique mass profiles with mass differences (between adjacent ions) of 22 and 44 amu, reported to be $[M+NH_4]^+$ and $[M+2NH_4]^{2+}$ ions of polysorbate species (Zhang et al. 2012). Product ion scans (PISs) showed that the m/z 309.3 ion was the most frequent fragment for the

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target masses. Previous reports attributed the m/z 309 fragment ion to an in-source loss of specific fatty acid esters (ethyl oleate, for m/z 309.3) characteristic of polysorbate species (Hvattum et al. 2012), or more recently to a strong presence of oleate-related species in polysorbate 80 (Tween 80) (Zhang et al. 2012). PIS scan of m/z 309.3 demonstrated several mass spectral profiles relating to sorbitan monooleates (specifically 16 – 27 polyoxyethylene units, as shown in inset A; Supplemental Material, Figure S2), isosorbide monooleates, and sorbitan dioleates, indicating the presence of Tween 80. The other highly abundant component of the CWAF ethanol/water sub-fraction was dioctyl sodium sulfosuccinate (DOSS). Initial investigation of the extract in negative full scan mode revealed an ion at m/z 421. A total ion chromatogram performed in negative FS mode is shown in Supplemental Material, Figure S2 (bottom panel) with the peak at 2.45 min largely representing the [M – H]$^-$ ion of DOSS. To confirm the presence of DOSS, a PIS of m/z 421.1 was performed and the resultant fragmentation profile is shown in inset B of Supplemental Material, Figure S2. Based on previous reports, which indicate the presence of fragment ions m/z 81 and m/z 227 (Mathew et al. 2012; Ramirez et al. 2013), it was confirmed that DOSS was abundantly present in the 50:50 ethanol:water sub-fraction.

Molecular modeling of COREXIT components binding to the PPARγ ligand-binding domain

Molecular modeling was assessed using MOE (Molecular Operating Environment; Chemical Computing Group, Inc.) Software. Two PDB (Protein Data Bank) crystal structures, 4EMA and 2HFP, comprising the human PPARγ ligand binding domain bound to different ligands were compared. Using MOE's superposition function, no significant differences were found in the active site of PPARγ (RMSD < 2Å). Because 4EMA contained our positive control Rosiglitazone (Rosi) it was chosen as the model. Ten compounds, including some metabolites,

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were docked to PPARγ. Molecular parameters were set for maximum energy minimization and Amber12 liquid state. Five compounds that comprise COREXIT, a negative control (17β-estradiol) and a positive control (Rosi) were assessed and virtually synthesized based on liquid state parameters at pH 7.4. The run was set to 30 different poses, with an area for 30 refinements if necessary. After parameters were set, a continuous run of all compounds were docked, and descriptors of binding data were given in ascending order related to E score. The E score gives binding efficiency in terms of energy state, with lower E scores indicating higher affinity. Compounds that had the capability to be cleaved by esterases were assessed with and without the fatty acid chains.

In vivo bioluminescence imaging

The "repTOP PPRE-Luc" mouse model (PPRE-luciferase mouse), containing a PPAR response element – luciferase reporter transgene (El-Jamal et al. 2015) was used for *in vivo* bioluminescence imaging. C57BL/6J mice (originally obtained from Charles River Laboratories) were bred in the animal facilities at MUSC. All mice were treated humanely and with regard to alleviation of suffering. Mice were housed up to five per cage in ventilated air racks with ad libitum access to water and irradiated rodent chow (Harlan 2018). Temperature was maintained between 21-23C, humidity maintained 40 %, and a 12 hr light:dark cycle. Five groups of three male mice (littermates aged 5-6 weeks) were injected i.p. at 9:00 a.m. in the animal housing facility with saline, 10 mg/kg Rosi (Rosiglitazone; Cayman Chemical) or 50 mg/kg DOSS (Dioctyl sodium sulfosuccinate; Sigma Aldrich). Five hours later mice were anesthetized with 2.5% isofluorane (Sigma Aldrich) in air and injected i.p. with 150 mg/kg luciferin potassium salt (Goldbio). An IVIS 200 bioluminescence imaging system and Living image 4.3.1 software were used to quantify bioluminescence according to the manufacturer's

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instructions (Caliper Life Sciences). Specifically, mice were placed in the instrument and received 2% isofluorane in air through nosecones to maintain sedation during image acquisition. PPRE – driven bioluminescence of live mice was quantified using images acquired 10 min after luciferin injection with 1 min exposures. While mice were still sedated they were sacrificed by cervical dislocation, livers were dissected and washed in PBS, homogenized in lysis buffer and luciferase activity was determined in liver homogenates using the Luciferase Reporter Assay System and a Veritas microplate luminometer. All animal procedures were approved by the Institutional Animal Care & Use Committee, MUSC (Animal Welfare Assurance #A3428-01).

TR-FRET PPARγ Competitive Binding Assay

Competitive Time-Resolved Fluorescence Resonance Energy Transfer (TR-FRET) (Toth et al. 2012) binding assays were used to determine the affinity of DOSS for PPARγ (SelectScreen Service, Life Technologies). For these assays the donor fluorophore (Terbium) on the receptor causes energy transfer to the acceptor fluorophore (Fluormone Green) on the bound ligand resulting in emission at 520 nM. With increasing doses of ligand (e.g. DOSS) there is increasing displacement of receptor-bound Fluormone Green tagged positive control ligand and, hence, less signal. Known concentrations of test and control ligands allow fluorescent emission ratio to be used to quantitate binding affinity. Terbium is excited with a 340 nm filter and emits multiple peaks, the first of which (485 nm – 505 nm) overlaps with the maximum excitation peak of Fluormone Green. To measure energy transfer to Fluormone Green without interference from Terbium, a 520/25 nm filter is used with a 100 μsec delay and 200 μsec integration.

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Adipogenic differentiation assays

For triacylglycerol staining assays to quantify adipogenic differentiation, 3T3-L1 preadipocyte cells (Zenbio) were plated in 48-well plates at a density of 10,000 cells per well in Preadipocyte Growth Medium (PGM; DMEM/F12 supplemented as described above) and grown until confluence. Two days post-confluence the media was changed to minimal induction media (MIM; PGM supplemented with 62.5 nM dexamethasone, 0.125 mM IBMX and 1.25 ng/mL insulin) and either different concentrations of DOSS (10, 30, 25 or 50 ppm) or 1 μM Rosi. After 72 hr of induction, the media was switched to PGM containing 1 μg/mL insulin. Cells were allowed to differentiate for three more days (6 days total) and fixed with 4% paraformaldehyde. Triacylglycerol staining with AdipoRed (Lonza) and nuclear counter-staining with NucBlue (Hoechst; Invitrogen) was conducted according to the manufacturers recommendations. Adipogenesis was quantified by mean relative fluorescent units of 42 fields per well (10X magnification) with five replicates used for each treatment using a HERMES high content screening scanner (ViScan, IDEA Bio-Medical Ltd.). Hoechst fluorescence was determined using excitation 390/18 nm and emission 440/40 nm (light intensity: 50%, exposure: 30 ms, gain: 30%), and AdipoRed was quantified using excitation 485/20 nm and emission 525/30 nm (light intensity: 90%, exposure 58 ms, gain: 30%).

mRNA Expression via quantitative PCR

3T3-L1 cells were treated with test ligands as described above. After 72 hours of exposure to MIM supplemented with varying concentrations of DOSS or Rosiglitazone, three wells of treatment were pooled from each of two experiments for mRNA expression analyses. RNA was isolated using the RNeasy Kit (Qiagen), following the manufacturer's instructions. Gene expression was assessed in triplicate using 25 ng of RNA per qPCR reaction and the iTaq

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Universal SYBR Green One-Step Kit following the manufacturer's instructions (BioRad). Results were normalized to the housekeeping gene HPRT. Data are expressed as a fold change compared to the MIM only control. Primer sequences for the queried genes can be found in Supplemental Table S1.

Statistical analysis

All data analyses were performed using GraphPad Prism software (GraphPad Software Inc.). After confirmation of normality and equal variance (using Brown-Forsythe and Bartlett tests), one-way ANOVA followed by Dunnett's Multiple Comparisons post hoc tests were performed. P-values < 0.05 were deemed significantly different.

Results

PPARγ ligand binding assay optimization

We optimized a rapid, sensitive, specific and robust system for detecting PPARγ transactivation activity in MC252 oil and COREXIT dispersant. Considering that COREXIT is a mixture of solvents and surfactants that might compromise membrane integrity and also that components of fetal bovine serum may have PPARγ agonist activity that would obscure testing, we determined if a PPARγ ligand binding domain–GAL4–UAS luciferase system (Forman et al. 1995) could be conducted with cells under serum-free (SF) conditions. HEK293T/17 cells were transfected with plasmids encoding a yeast GAL4 DNA-binding domain – mouse PPARγ ligand binding domain fusion protein, a yeast UAS (GAL4 Upstream Activator Sequence) driving firefly luciferase, and a constitutively active Renilla luciferase transfection efficiency control. The PPARγ agonist rosiglitazone (Rosi) confirmed the accuracy of the system for detecting

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PPARγ transactivation activity. As shown in Figure 1, treatment of transfected cells with 0, 10 nM, or 100 nM Rosi for 4 h, 8 hr or 18 hr resulted in time- and dose-dependent increases in luciferase activity in both serum-containing (10% FBS) and SF conditions. Notably, the response to Rosi under SF culture conditions was more pronounced than serum-containing cultures at all time points (Fig. 1A-C). Conversely, treatment for 18 hr under SF conditions with 17β-estradiol (E2) or all-trans-retinoic acid (RA) did not increase luciferase activity, whereas Rosi treatment induced marked luciferase activity (Fig. 1D). These data demonstrate the sensitivity and specificity of the PPARγ ligand binding domain–GAL4–UAS luciferase system. SF conditions and 18 hr treatments were chosen for subsequent experiments aimed at identifying components of oil and COREXIT bearing PPARγ transactivation activity.

PPARγ Transactivation

To distinguish between PPARγ activity originating from dispersant versus MC252 oil several mixtures of MC252 oil, with and without COREXIT, were prepared and analyzed for PPARγ transactivation activity, including: CWAF, WAF, C_MWAF and COREXIT only (see Methods). Dose-dependent PPARγ activation was detected in CWAF, C_MWAF and COREXIT dilutions but not in WAF (Figure 2). The CWAF and C_MWAF fractions comprise the aqueous fraction of the original mixtures of oil and dispersant and a portion of the amphipathic compounds present in the original mixtures are expected to partition to the organic phase. Also, the dose-dependent PPARγ activation by COREXIT alone (no organic phase) substantially outstripped those of CWAF and C_MWAF, these results suggest that components of COREXIT were responsible for the activity detected. To further investigate if oil might have contributed to PPARγ activation by the fractions an alternate solvent DMSO was used to prepare DWAF

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(DMSO Water Accommodated Fraction), which lacks COREXIT. Although twice the amount of DMSO was used to prepare DWAF than COREXIT in CWAF and in C_MWAF, no PPARγ activation was observed in any DWAF dilutions tested (Supplemental Material, Figure S1) further implicating a COREXIT ingredient and not a component of oil.

CWAF fractionation and Analysis

Solid phase extraction (SPE) was employed to separate CWAF into fractions based on polarity and hydrophobicity; CWAF was fractionated into 50:50 water:ethanol, methanol, DCM and hexane soluble fractions. The PPARγ transactivation system demonstrated substantial PPARγ transactivation activity in the 50:50 water:ethanol fraction whereas no activity was detected in the methanol, DCM and hexane fractions (Figure 3). The compounds present in the CWAF water:ethanol fraction were identified using LC-MS and LC-MS/MS as described in Materials and Methods. Analysis of the fraction in positive full scan mode resulted in over 200 unique target masses. Tween 80 (Polysorbate 80) was concluded to be a highly abundant component of this fraction based on manual inspection and product ion scan profiles (Supplemental Materials, Figure S2, Top). After investigation of the extract in negative full scan mode, DOSS was determined to be another highly abundant component of the CWAF water:ethanol fraction (Supplemental Materials, Figure S2, Bottom). Mass spectrometry analyses of the transactivation positive fraction argued that relatively hydrophilic components of COREXIT and not MC252 oil were responsible for the observed PPARγ transactivation activity.

Modeling of COREXIT components binding to PPARγ

Molecular modeling was employed to predict which COREXIT components might bind to PPARγ. Span 80, Tween 80 and DOSS were predicted to bind to the PPAR γ ligand-binding

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domain as shown by their low E scores whereas propylene glycol and 2-butoxyethanol were not (Supplemental Materials, Figure S3A). Span 80 and Tween 80 have an ester bond that could be cleaved by cellular esterases and, once cleaved, neither cleavage products is predicted to bind tightly (Supplemental Materials, Figure S3A). For DOSS docking, the basic lysine 367 residue has a strong hydrogen bond with a sulfonyl oxygen (Supplemental Materials, Figure S3B). The α-carbon adjacent to the sulfonyl group of DOSS shows potential for strong donation to a hydrogen of Methionine 364. PPARγ has multiple basic residues that allow pairing with the acidic sulfhydryl group of DOSS, potentially allowing hydrogen bonding between the ligand and receptor. Tween 80, along with other compounds that exhibit low E scores, either have too large a fatty acid group to effectively fit into the binding site of PPARγ or have a charge that is too basic, resulting in higher binding scores (Supplemental Materials, Figure S3A).

PPARγ transactivation activity of COREXIT components

Collectively, the results above implicate a COREXIT component(s) in the PPARγ transactivation observed in the CWAF prepared from MC252 oil. Mass spectrometry indicates that Tween 80 and DOSS are present in the 50:50 water:ethanol fraction of CWAF which exhibits activity in the transactivation assay, and molecular modeling predicts that Span 80, Tween 80 and DOSS can bind to the PPARγ ligand binding domain. Because molecular modeling is speculative, these compounds were tested for PPARγ activity. Span 80 did not demonstrate PPARγ transactivation activity even at concentrations much higher than effective COREXIT alone dilutions (Supplemental Materials, Figure S4A). Tween 80 had weak activity that was much too low to account for the activity observed in CWAF and COREXIT (Supplemental Materials, Figure S4B). Furthermore, a mixture of petroleum distillate (ICP ;

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CAS 64742-47-8) and propylene glycol (PG), other major components of COREXIT, did not demonstrate PPARγ transactivation activity (Supplemental Materials, Figure S4C). In contrast, a simplified version of COREXIT containing only ICP, PG and DOSS demonstrated robust PPARγ transactivation (Supplemental Materials, Figure S4D). DOSS alone elicited dose-dependent increases in PPARγ – driven luciferase expression in the low ppm range (Figure 4). Thus, DOSS has PPARγ transactivation activity whereas Span 80, ICP and PG do not. Since COREXIT 9500 is approximately 10% DOSS (Kujawinski et al. 2011), it is likely that the PPARγ agonist activity observed following treatment with CWAF, C_4WAF or COREXIT alone is due to DOSS.

DOSS PPARγ agonist activity in PPRE-luciferase Transgenic Mice

To validate the PPARγ agonist activity of DOSS, PPAR response element (PPRE) luciferase reporter mice were used as an *in vivo* model. Male littermates age 5-6 wks were injected with Rosi (positive control), saline (negative control) or DOSS. Imaging from live mice 5 hr post-treatment revealed marked increases in bioluminesence for both Rosi and DOSS treatments and suggested that liver tissue was the main source of the differential luciferase expression, with some expression in the skin of Rosi- and DOSS- treated mice (Figure 5A). To confirm differential PPRE activity in Rosi- and DOSS-treated hepatocytes, liver was dissected and homogenized immediately following imaging and humane sacrifice. As shown, treatment of PPRE–luciferase mice with 10 mg/kg Rosi increased liver luciferase activity ~2 -fold whereas treatment with 50 mg/kg DOSS elicited a ~4-fold increase (Fig ure 5C), demonstrating that DOSS is capable of activating PPAR–driven gene expression in mice. Although PPARα, a major metabolic regulator, is the predominant PPAR isoform in the liver, PPARγ is also

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expressed in hepatocytes. PPRE activation in the liver opened the possibility that DOSS may activate other PPAR isoforms or RXRα. Transactivation assays using the human LBDs (ligand binding domain) indicated that 4 ppm DOSS activated PPARγ ~3 fold, while activation of PPARα was only ~1.2 fold and non-detectable for the human RXRα LBD (Supplemental Materials, Figure S5A, B, D). Of note, DOSS activated PPARβ/δ ~8 fold at 4 ppm, which is under further investigation (Supplemental Materials, Figure S5C).

TR-FRET assays of DOSS affinity for PPARγ

The structure of DOSS is shown in Figure 6A and predicted PPARγ receptor binding shown in Supplemental Materials, Figure S3B. TR-FRET assays were utilized to measure the affinity of DOSS for PPARγ. As shown in Figure 6B, DOSS binds to the human PPARγ ligand-binding domain with a K_D of 1500 nM. This is a binding affinity comparable to the pharmaceutical PPARγ agonist pioglitazone (K_D = 1310 nM) and the endogenous ligand arachidonic acid (K_D = 1340 nM), as determined in the same assay (Singh et al. 2008).

Adipocyte differentiation in vitro

To functionally test the obesogenic potential of DOSS, murine 3T3-L1 preadipocytes were exposed to low-level adipocyte differentiation inducers with and without DOSS and adipogenesis quantified by determining triacylglycerol content (Figure 7A, B). Cells were treated with minimal induction media (MIM) with and without DOSS or 1 μM Rosi (positive control). Triacylglycerol accumulation was quantified using AdipoRed staining (green) normalized to cell number (Hoechst nuclear counter-staining). Dose-dependent increases in adipogenesis were observed with DOSS treatment, with significant differences observed at 25 and 50 ppm DOSS (Figure 7A, B). In addition, mRNA expression of the preadipocyte marker Pref-1/Dlk1 decreased,

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while mRNA expression of the adipocyte marker fatty acid binding protein (Fabp4) increased dose-dependently following 72 h DOSS treatment (Supplemental Materials, Figure S6). These results demonstrate that DOSS promotes adipocyte differentiation *in vitro*.

Discussion

Increases in general health and longevity over the past century are tributes to our knowledge of the scientific basis of good health. These impressive and hard-won gains are now threatened by an obesity epidemic (Stewart et al. 2009). Poor nutrition and lifestyle are well established drivers of obesity. Additional contributors might include 'obesogens,' compounds that alter metabolism and fat cell production, as indicated by cell culture and animal model studies (Grun and Blumberg 2006; Janesick and Blumberg 2011). Maternal-fetal obesogen exposure studies in animal models suggest that they might impact multiple lifelong health issues (Daftary and Taylor 2006; Janesick and Blumberg 2011; Suzuki et al. 2007) and might impact obesity in future generations (Li et al. 2012; Tracey et al. 2013). Still, sound evidence of direct effects in humans remains to be determined; it is unclear whether environmental obesogens, singly or in combination act through known metabolic and/or adipogenic mechanisms (e.g. via PPARγ) to cause clinically significant outcomes in humans, such as obesity, type II diabetes, insulin resistance syndrome and polycystic ovary syndrome. Obesogens that are most prevalent in the environment, including those in widely used dispersants, consumables and personal care products would be a good focus of such attention.

Here we have identified a novel likely obesogen, dioctyl sodium sulfosuccinate (DOSS), as evidenced by PPARγ transactivation activity in a transfected cell line, activation of PPRE in transgenic reporter mice, and induction of adipogenesis in preadipocytes *in vitro*. DOSS affinity

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to human PPARγ receptor was also shown to be comparable to the pharmaceutical pioglitazone and an endogenous ligand arachidonic acid. In addition to DOSS being a principle component of COREXIT oil dispersant used during DWH remediation, DOSS is also used in many consumer goods including: laxatives, household cleaning products, deodorants, hair coloring, and nail polishes (DHHS 2014; EWG 2015b). That DOSS is "Generally Recognized As Safe" and a common additive in flavored drinks, support the notion of its widespread use and the likelihood of long-term exposures (EWG 2015a; FDA 1998). Significantly, DOSS itself (Colace) is prescribed as a laxative for pregnant women, in which there is a 38% prevalence of constipation, the treatment with which could possibly impact fetal development (Jewell and Young 2001). Also, fetuses and neonates can be at greater risk to food-borne contaminants and therefore groups studying seafood contaminant levels suggest that the US FDA revise the levels of concern for these compounds for pregnant women and children (Rotkin-Ellman et al 2012). It should be noted that while environmentally relevant DOSS exposures are not yet known, oral laxative use in pregnant women of up to 500 mg/day (83.5 kg average term pregnancy) would be expected to be within an order of magnitude of the dose of DOSS used in our initial mouse studies, which resulted in significant PPRE activity *in vivo* (Fig. 5). Clearly, *in vivo* oral or topical dosing studies in animals at doses that are environmentally relevant are warranted to fully substantiate and understand the direct and long term impacts of such sub-toxic level exposures of this likely obesogen (Buhnsante et al 2014).

Conclusion

The results of this study indicate that the major COREXIT dispersant component DOSS is a potential obesogen. This work indicates that DOSS might be a compound that negatively impacts health and that further investigation is warranted. The subsequent identification of

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metabolites and biomarkers of DOSS exposure and biological consequences of exposure will aid in assessing its contribution to obesity and related health concerns.

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Figure Legends

Figure 1. PPARγ transactivation activity in a GAL4-UAS system using serum-free conditions. HEK293T/17 cells were transfected and exposed to the PPARγ agonist Rosi under serum-containing (10% FBS) and serum-free (SF) conditions in triplicate and luciferase activities were measured following exposure for: A) 4 h, B) 8 hr and C) 18 h. Data in "A" – "C" are normalized to the 10% FBS control within each time point. As shown, assay sensitivity is greatly enhanced under SF conditions. D) HEK293T/17 cells were transfected and exposed to estrogen (E2) all-trans-retinoic acid (RA) or Rosi under SF conditions and luciferase activities were measured, demonstrating ligand-specific responsiveness of the system. Data in "D" are normalized to the untreated control. RLU (Relative Light Units); data are expressed as Mean ± SD; n = 3 per group (* $p < 0.05$ versus control).

Figure 2. PPARγ transactivation by COREXIT. Dilutions of mixtures were prepared, HEK293T/17 cells transfected and exposed in triplicate for 18 h, and luciferase activities were measured. A) CWAF, B) WAF, C) C_MWAF (A – C are presented as final concentrations volume fractions), D) COREXIT (diluted in cell culture media to the concentrations indicated volume fractions). Dose-dependent ligand binding activities were detected in CWAF, C_MWAF and COREXIT dilutions but not in WAF dilutions. Data are expressed as Mean ± SD; n = 3 per group (* $p < 0.05$ versus control).

Figure 3. PPARγ transactivation by the 50/50 ethanol:water CWAF volume fraction. CWAF mixtures were fractionated using solid phase extraction methods and four solvent types to identify fractions containing PPARγ ligand binding activity. PPARγ activity was observed only in the 50:50 ethanol:water volume fraction but not for methanol, DCM or hexane fractions. Data are expressed as Mean ± SD; n = 3 per group (* $p < 0.05$ versus no treatment control).

Figure 4., PPARγ transactivation by DOSS. Dilutions of mixtures were prepared, HEK293T/17 cells were transfected and exposed in triplicate for 18 h, and luciferase activities were measured. Final DOSS concentrations (volume fractions) are indicated. Data are expressed as Mean ± SD; n = 3 per group (* $p < 0.05$ versus vehicle control).

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Figure 5. PPRE activity in response to DOSS in PPRE-luc mice. A) Representative images of mice treated with 10 mg/kg Rosi, vehicle control or 50 mg/kg DOSS (left to right). B) Luciferase activity of live mice as in "A." C) Luciferase assay of liver tissue from mice as in "A." Data are expressed as Mean ± SD; n = 5 per group (* $p < 0.05$ versus vehicle control).

Figure 6. TR-FRET analysis of DOSS binding to PPARγ. A) Molecular structure of DOSS. B) Competitive TR-FRET analysis of DOSS binding to the human PPARγ LBD (apparent K_D = 1380 nM).

Figure 7. Adipogenesis following DOSS exposure *in vitro*. 3T3-L1 cells were grown to confluence over 72 hr in PGM (preadipocyte growth media). Cells were either maintained in PGM or treated with MIM (Minimal Induction Media) alone or supplemented with 10, 20, 25 or 50 ppm DOSS or 1μM Rosi for an additional 3 days prior to analysis. A) AdipoRed quantification of lipid accumulation as described in Methods. Data are expressed as Mean ± SD; n = 5 per group (* $p < 0.05$ vs. MIM control). B) Representative images of lipid accumulation of cells treated as in "A" (Scale bar = 50 microns).

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Figure 1

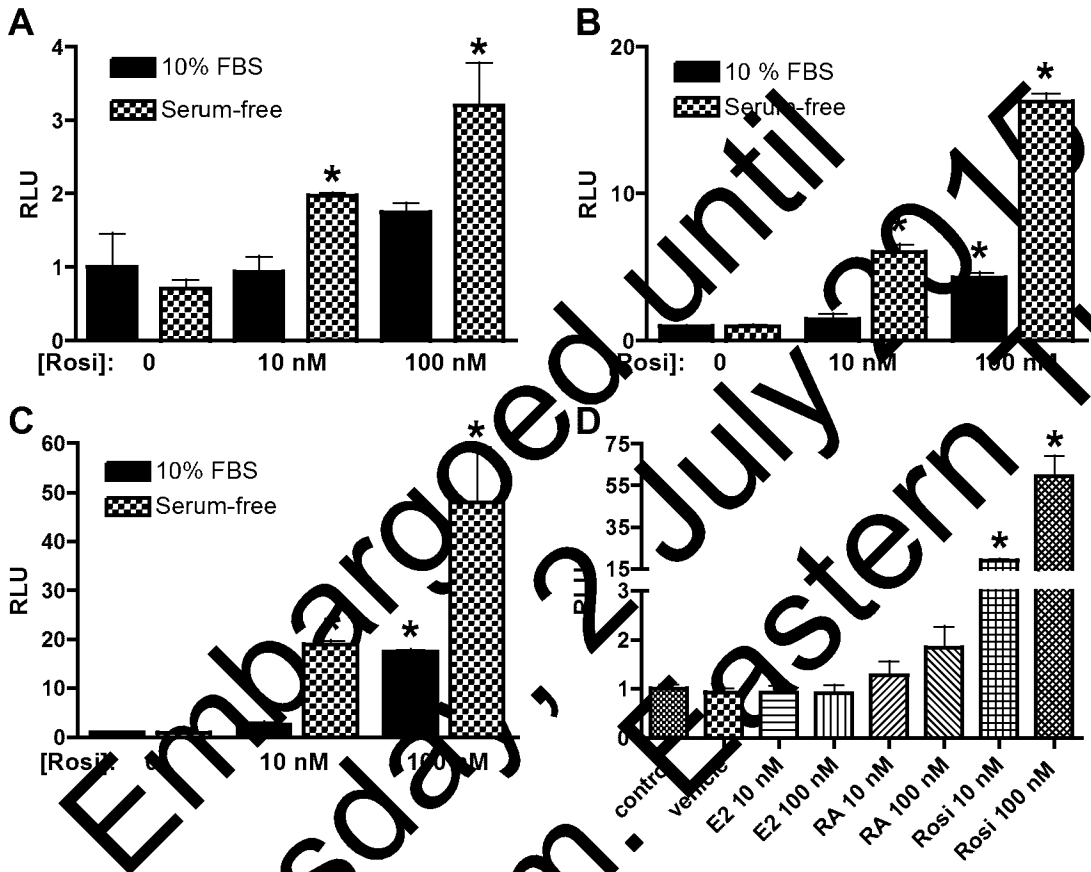

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Figure 2

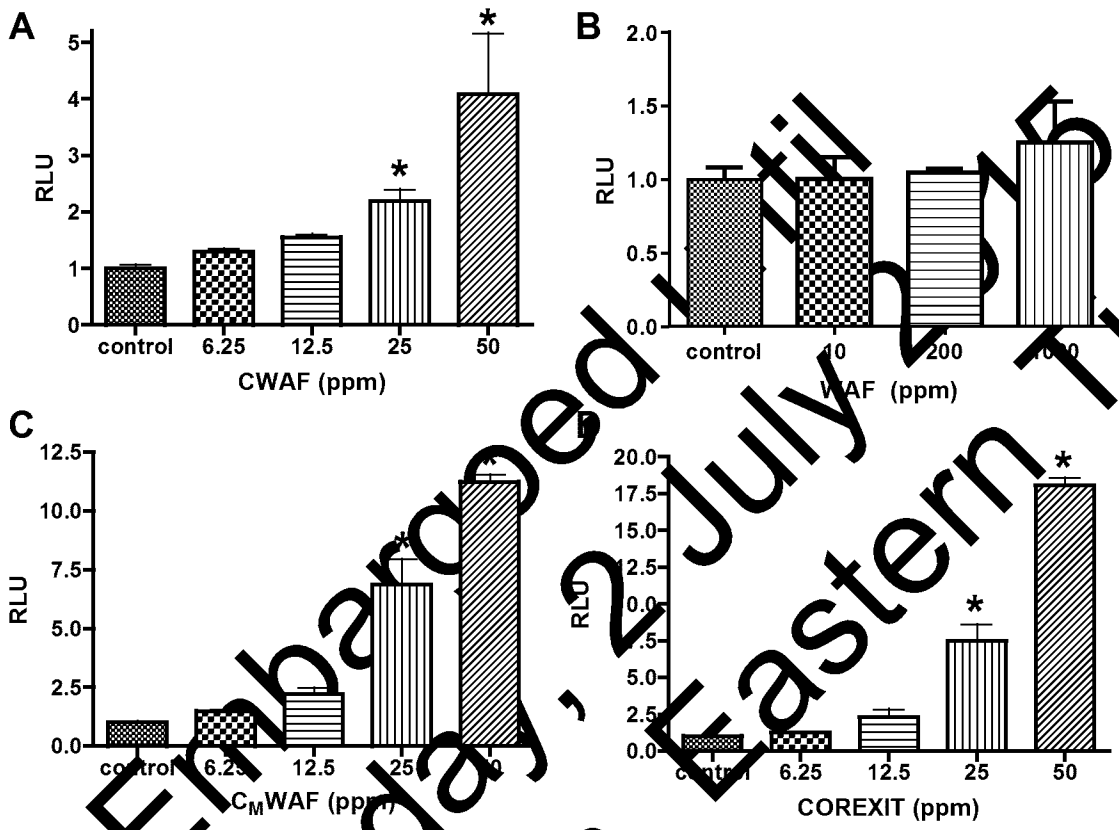

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Figure 3

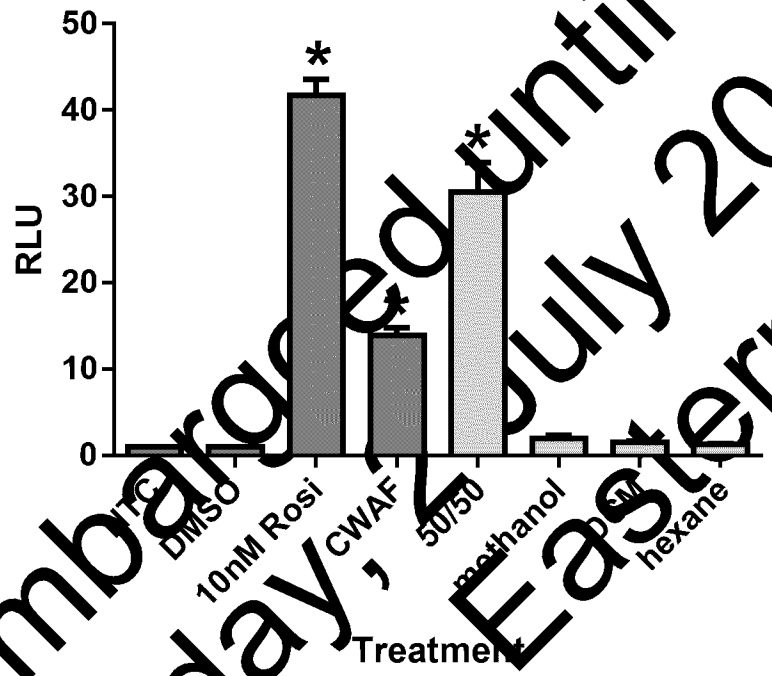

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Figure 4

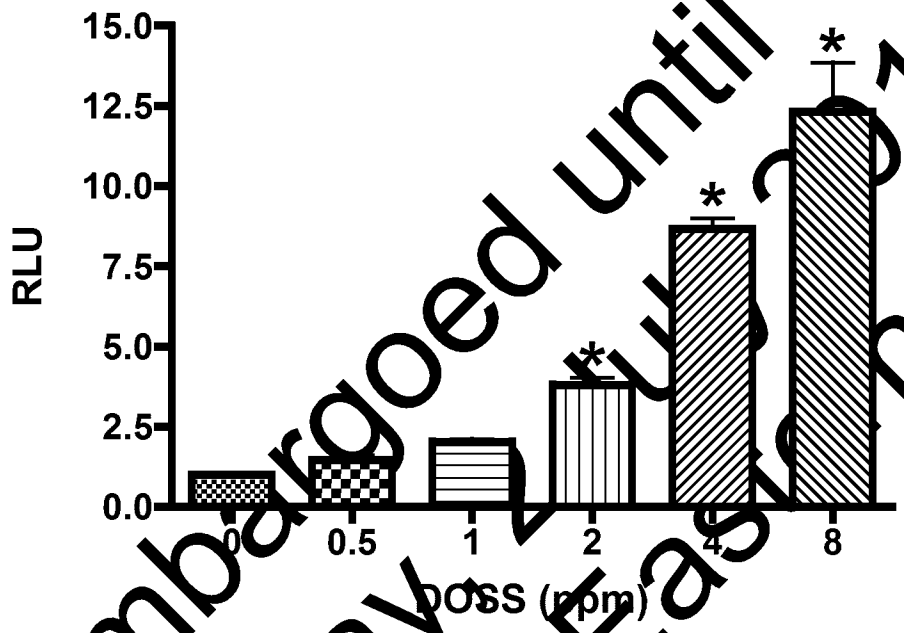

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Figure 5

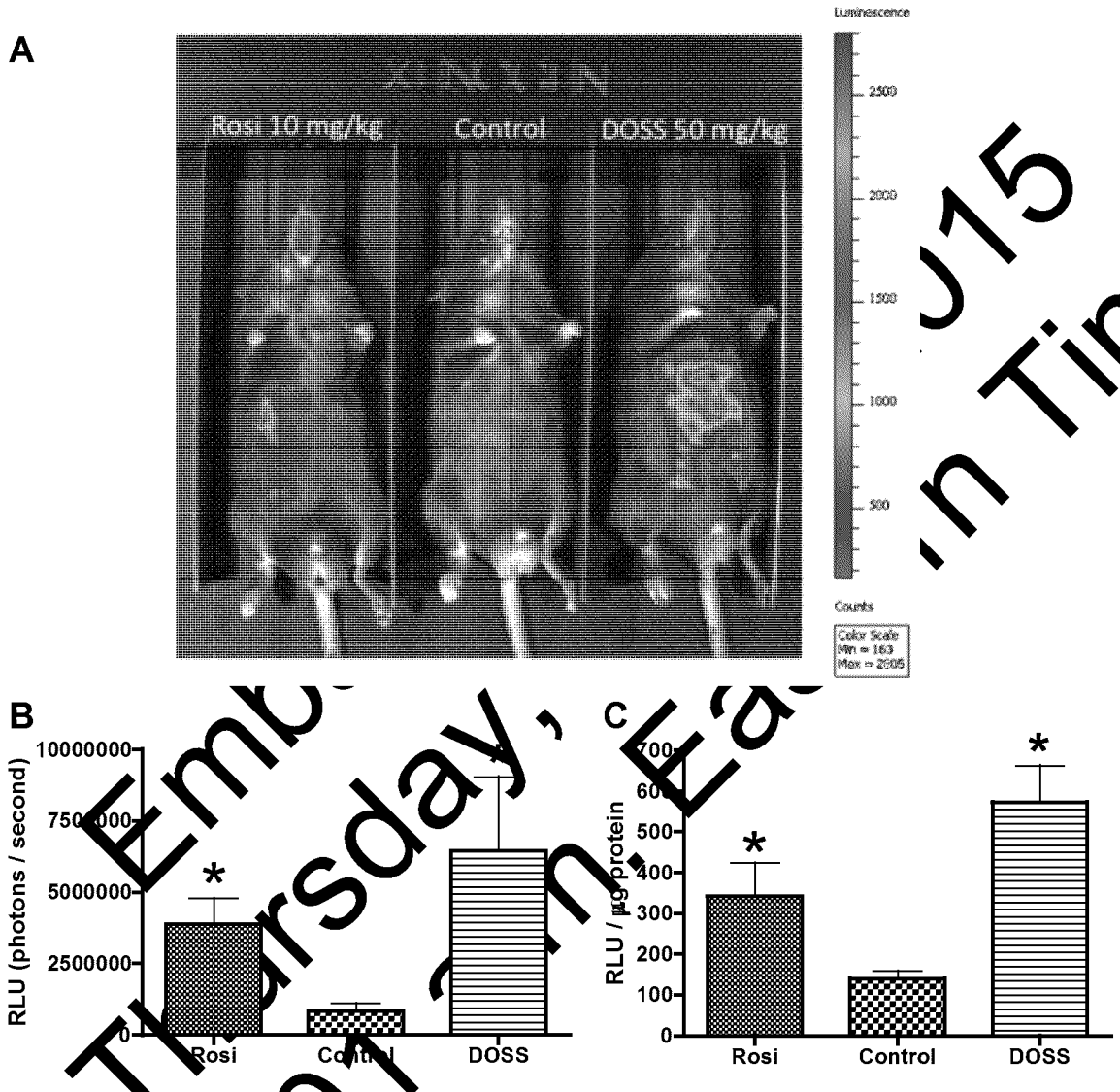

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Figure 6

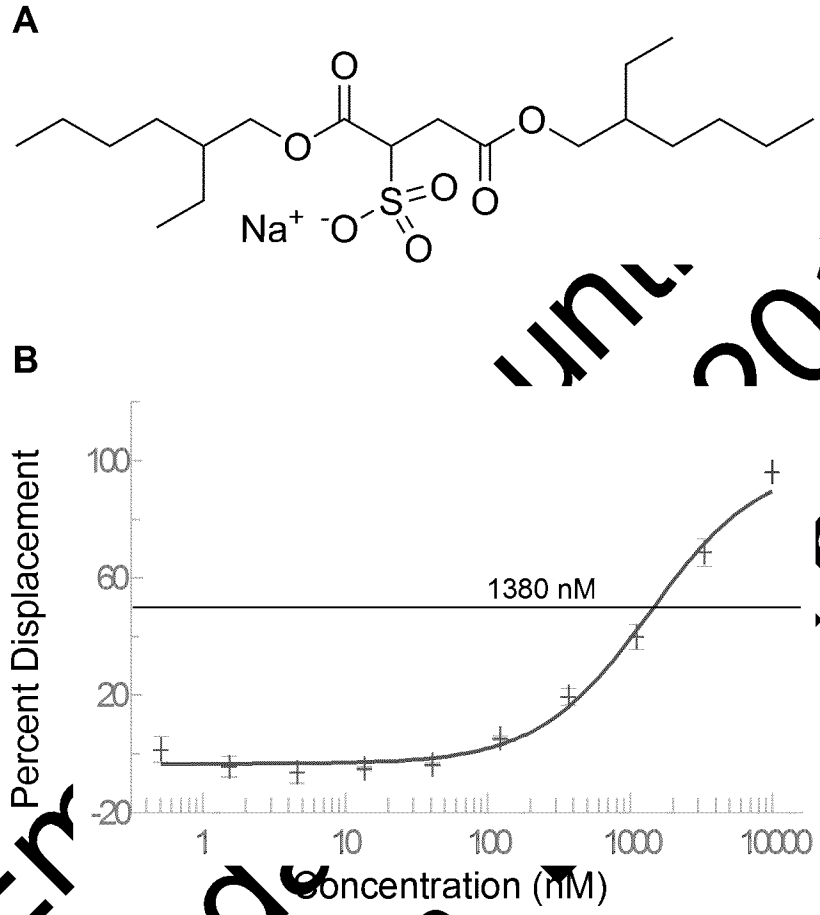

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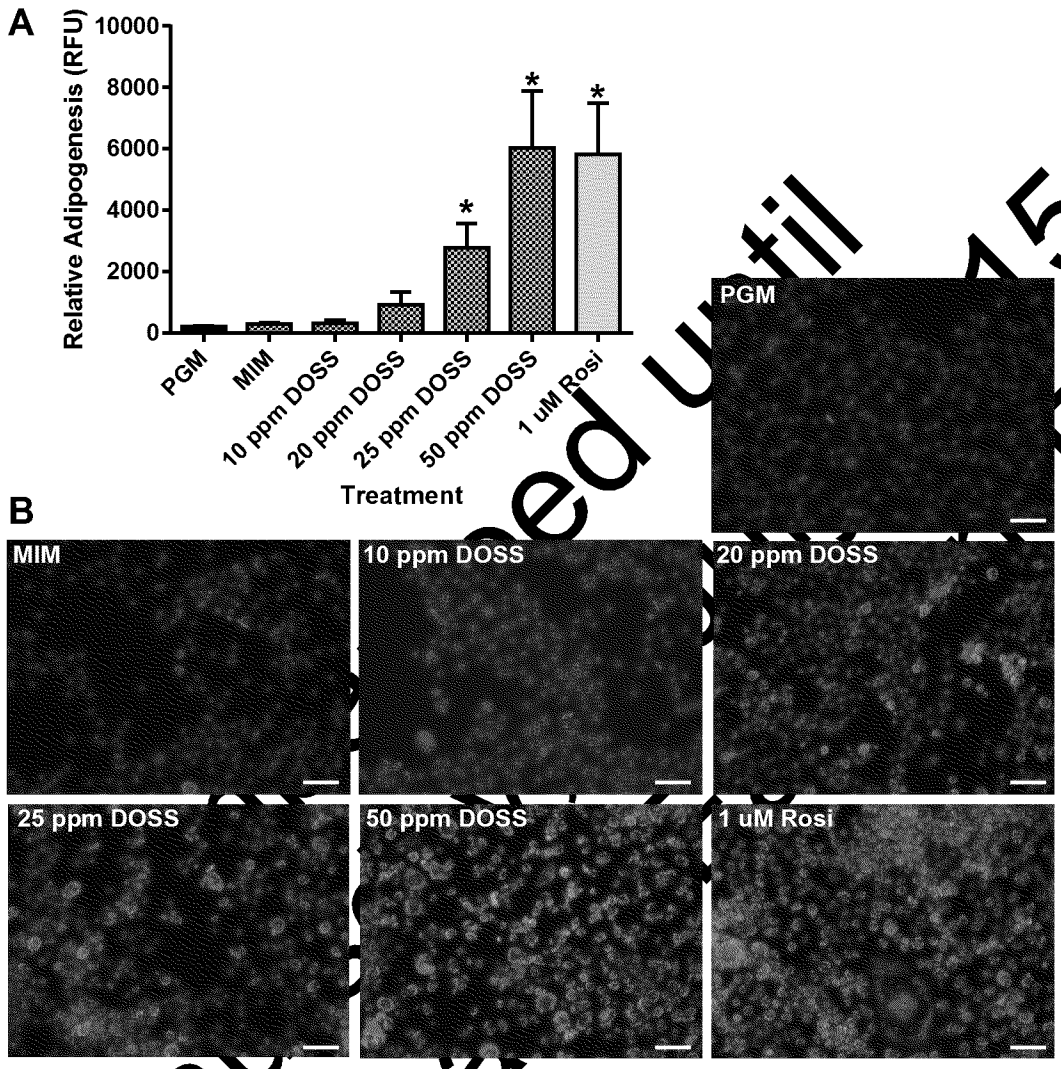
Figure 7



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To: Leigh DeHaven[DeHaven.Leigh@epa.gov]
From: Matthiessen, Craig
Sent: Thur 4/23/2015 6:13:10 PM
Subject: FW: API and NOIA Comments on EPA Subpart J Proposed Rule
API and NOIA Comments on EPA Subpart J Proposed Rule with PNG Attachment 04.22.15.pdf

FYI

From: Emily Hague [mailto:Hague@api.org]
Sent: Wednesday, April 22, 2015 6:08 PM
To: Matthiessen, Craig; Wilson, Gregory; Principe, Vanessa
Cc: Raymond Bradley
Subject: API and NOIA Comments on EPA Subpart J Proposed Rule

Hello Craig, Greg and Vanessa –

API and NOIA submitted the attached comments on the EPA Subpart J Proposed Rule this afternoon through Regulations.gov. Attached is our letter for your reference. We also plan to provide this letter by mail to Mathy Stanislaus.

Thank you for this opportunity to comment,

Emily

Emily Kennedy Hague

Senior Policy Advisor, Upstream & Industry Operations

American Petroleum Institute

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Washington, DC 20005

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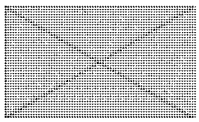

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April 22, 2015

U.S. Environmental Protection Agency
EPA Docket Center (EPA/DC)
Docket ID No. EPA–HQ–OPA–2006–0090
1200 Pennsylvania Avenue NW 20460

Submitted via electronic submission to http://www.regulations.gov **and by mail**

Dear Dr. Gregory Wilson,

On January 22, 2015, the U.S. Environmental Protection Agency (EPA or the Agency) issued a Proposed Rule to amend Subpart J of the National Oil and Hazardous Substances Contingency Plan that governs the use of dispersants, other chemical and biological agents, and other spill mitigating substances when responding to oil discharges into the waters of the United States. 80 Fed. Reg. 3380 (January 22, 2015). Comments are due by April 22, 2015. The following comments to the docket are provided by the American Petroleum Institute (API) and the National Ocean Industries Association (NOIA) (collectively, "we") on behalf of our member companies based on review of the above-cited Proposed Rule.

API is a national trade association that represents over 625 members involved in all aspects of the oil and natural gas industry, including the exploration and production of both onshore and offshore Federal resources. The U.S. oil and natural gas industry supports 9.8 million U.S. jobs and 8 percent of the U.S. economy, delivering tens of millions per day in revenue to our government. API members provide most of the nation's energy and are backed by a growing grassroots movement of more than 25 million Americans.

NOIA, founded in 1972, represents more than 270 companies among all segments of the offshore industry with an interest in the exploration and production of both traditional and renewable energy resources on the nation's outer continental shelf (OCS). NOIA's mission is to secure reliable access and a fair regulatory and economic environment for the companies that develop the nation's valuable offshore energy resources in an environmentally responsible manner.

API, NOIA, and our respective members recognize the important mission of the EPA in protecting human health and the environment and share in this mission. More than most industries, the oil and natural gas industry understands the nature of risk and places at the center of its concern comprehensive planning for and effective management of risks in order to safeguard human well-being and protect environmental resources. To this end, woven into every operational endeavor are release prevention measures, preparedness methods and plans for rapid, effective response should an incident resulting in a release occur. Developed alongside regulatory agencies, operators submit to and follow a distinct set of response principles which protect shared values. The framework by which these principles are employed and tradeoffs are made in order to protect these shared values is called Net Environmental Benefit Analysis (NEBA). NEBA is a process used by the response community for making the best choices to minimize impacts of oil releases on people and the environment. NEBA aids in protecting people and the environment, and is the matrix through which every decision is made in a response event. In the offshore context, oil dispersing agents are a primary tool in the NEBA process and the response toolkit, as they

are a principal tool used for protecting human health and defending environmentally sensitive areas. When a release occurs, judgment and response speed are critical. In an offshore setting, dispersants are essential in creating a safe environment and are a key ingredient in marshaling an effective, swift response.

API, NOIA, and our respective members understand that through this Proposed Rule, EPA's goal is to develop a regulation which protects people and preserves natural resources. We too wish to accomplish the same goal, based upon sound scientific research and grounded in real-world, outside-the-laboratory scenarios and taking into account incident-specific risk. While the original intent of the dispersant rule was simply to provide for a schedule of dispersants and other chemicals that may be used in carrying out the National Contingency Plan (NCP), the Proposed Rule would essentially expand its purpose to an operational rulemaking which would significantly alter operational procedures.

In summary, the Proposed Rule, if implemented, would be substantially problematic for all stakeholders, including the response community, which is required to carry out an effective spill response. The Proposed Rule would also be problematic for the Federal and state ag ency community interests, as well as the public with regard to increasing environmental and community impacts. Although the Agency indicates that it seeks to "*encourage the development of safer and more effective spill mitigating products, and would bette r target the use of these products to reduce the risks to human health and the environment*" and "*ensure that On-Scene Coordinators (OSCs), Regional Response Teams (RRTs), and Area Committees have sufficient information to support agent preauthorization or authorization of use decisions*," API, NOIA, and our respective members submit that the Proposed Rule falls short of these objectives and in many cases would have the opposite effect . For example, and at the center of our concern, is the proposed dispersed oil toxicity test and its threshold which could result in the elimination of many dispersants and potential future dispersant s. E ven if the dispersants themselves were completely non-toxic, the proposed dispersed oil toxicity test and associated pass/fail threshold could prevent all dispersants from being listed and available for use in a spill response . The Proposed Rule covers activities broader than mere scheduling criteria for dispersants. The added complexity resulting from the Proposed Rule in auth orization, monitoring and product listing, in addition to unfounded and overly corrective assumptions about dispersant effects described in the Proposed Rule, will not assist the Unified Command during an oil spill . Instead, it will likely complicate and limit its ability to respond in the most effective manner to ensure the health and safety of people and minimize environmental and community impacts. Also, prohibiting the application of dispersants during an oil spill response or delaying their use will significantly increase the economic and environmental damage of oil spills.

API and NOIA encourage the Agency to review the comments contained herein , incorporate the corresponding recommendations in a supplemental proposed rule, and provide the public and other Federal government and state stakeholder agencies with an opportunity to provide another round of comments be fore implementing a final rule. We also recommend that EPA initiat e a Negotiated Rulemaking under the Negotiated Rulemaking Act of 1990 to establish a negotiating committee under the Federal Advisory Committee Act to develop draft regulatory text on a consensus basis for adoption and implementation as a proposed supplemental proposed rule by EPA. A balanced negotiating committee made up of response experts – from the Federal Agencies who oversee oil spill response and from industry and relevant third-party experts – would add value to further Proposed Rule revisions and ensure that Subpart J is aligned with the latest scientific consensus on, and avoid an artificial bias against, the use of dispersants. As an example, Negotiated Rulemaking was successfully used to implement vessel and facility response planning requirements under the Oil Pollution Act of 1990. At a minimum, we believe that E PA should facilitate a discussion between the response experts before finalizing the Proposed Rule.

We first provide general comments followed by detailed comments on a section -by-section basis for EPA's consideration below.

GENERAL COMMENTS

Industry Shares EPA's Goal Of Establishing Sound Dispersants Policy Grounded In Science and Executable in Real-World Spill Scenarios

In every operation, the goal of industry is to never have an oil spill, and it invests extensive time and effort to prevent spills from occurring. Industry and government have a shared interest in a unified, coordinated, and proactive approach that allows us to protect our common values. These values include the health and safety of our citizens, sensitive ecosystems, the local business community and economy, and the vitality and sustainability of tourism and other key community industries, such as fishing.

To achieve a well-managed response and the protection of our common values, the primary guiding principle is to stop the source of a spill as quickly as possible with the goals of ensuring the health and safety of people and minimizing environmental and community impacts. In many spill circumstances, dispersants play a critical role in achieving these goals, perhaps most importantly by reducing risks associated with Volatile Organic Compounds (VOCs) in the immediate vicinity of the spill that could be both a human health and safety issue, and should continue to be a response option promptly available to the Unified Command. The Proposed Rule could jeopardize the protection of the common values by potentially precluding even completely non-toxic dispersants from being listed due to the proposed dispersed oil toxicity tests and associated pass/fail thresholds. Scientific studies have shown that approximately 97.5% of the TPH constituents in dispersed oil toxicity tests come from the oil (not the dispersant), so the proposed laboratory tests will measure the toxicity of oil (not the dispersant).[1] If the standardized oils (i.e., ANS and IFO-120) required to be used in the proposed test have toxicity values (LC50) in water accommodated fractions (WAF) less than 10 ppm, then no dispersant, no matter its individual toxicity, will meet the threshold values for listing.

Moreover, the creation of arbitrary thresholds for passing such tests, especially when EPA has shown that modern dispersants are of low toxicity, is not supportable and it is not clear whether any dispersant will be approved for the NCP Product Schedule when both toxicity and effectiveness tests are required. Specifically, setting an acute toxicity threshold of dispersants plus oil at an LC50 of 10 ppm has a high probability of eliminating an effective dispersant from the list, i.e., any dispersant that passes the baffled flask effectiveness test. We know from previous testing by industry that many (or even most) crude oils by themselves have LC50's below 10 ppm. Of more relevance is the use of toxicity results to assist in a NEBA-based discussion of the relative merit of using a particular dispersant in favor of another. Similarly, the attempt to link lab test results to decisions relating to pre-authorization and use is misplaced since laboratory tests are useful in understanding differences between products, not their real world performance.

The Proposed Rule indicates that the Agency " *does not state or imply* " that one response option is endorsed over another which is a practice shared by industry. However, the preponderance of additional requirements for dispersant u se will likely have the unintended consequence of prohibiting, or delaying the approval of, dispersant use in a timely manner regardless of whether they may be the best, or only, response option. Further, the language contained in the preamble suggests that the Agency considers dispersants as a last priority, rather than giving them equal consideration with all other appropriate response options. Additionally, API and NOIA are concerned that the Proposed Rule may cause chemical

[1] Scientific reasoning that the dispersant only contributes ~2.5% of the TPH toxicity is based on the following. In a 1:20 disp ersant-to-oil ratio (DOR), the dispersant proportion is 5%. The solvent component of modern day dispersants is roughly half, which mean s the overall TPH contribution from the dispersant is ~2.5%. As a result, the toxicity is dominated by the oil constituents.

manufacturers to either disco ntinue the production of effective, commercially -available products or discontinue research into the development of the next generation of dispersants.

A Net Environmental Benefit Analysis Process Ensures Response Choices that Minimize the Impacts of Oil Spills on People and the Environment

Any changes to the rule must take into account the Net Environmental Benefit Analysis (NEBA)[2] process. When a spill occurs, the OSC must make time-critical choices about which response options to implement immediately and effectively to manage the potential impacts of the spill. The NEBA process helps the OSC select choices that minimize the impacts of the spill on people and the environment. NEBA is a consensus-based planning tool that is used to bring natural resource trustees, regulators and stakeholders together to address resource-management decision-making needs for an oil spill response. It provides a structured, scientific method to evaluate the likely net reduction, or possible increase, in environmental and socio-economic impacts resulting from the implementation candidate response options as compared to the natural recovery or "do nothing" alternative. An assessment of the trade-offs associated with each option is then conducted taking into consideration the potential impacts to sensitive environmental resources and local community values. The NEBA process determines which response option or combination of options can best reduce the overall impact of spilled oil to common values and promote the fastest overall ecosystem recovery. Of particular note, the NEBA process considers the potential effects to a wide range of concerns, ranging from likely environmental effects (i.e., deep marine to terrestrial, etc.) to possible economic consequences. When initially considering the potential outcomes, no individual area receives a greater priority over another. Instead, all are weighed from an equal footing and only after evaluating all the likely effects is a determination made regarding the response option that offers that greatest environmental benefit. In so doing, decision-makers ensure that an unbiased process is used, with input from relevant stakeholders, to determine the best course of action. This process has been adopted all over the world to identify response methods that will yield the greatest benefit with the least impact.[3]

The NEBA process can be used in both oil spill preparedness planning and response. In the United States, a formal NEBA process is conducted during the planning phase at the Area Committee and Regional Response Team (RRT) levels with input from state and Federal participants to determine the benefits and limitations from using each response technology within their individual areas of responsibility. In most offshore regions of the U.S., this is accomplished in the form of the Consensus-Based Ecological Risk Assessments (CERA) process (NEBA equivalent) used by the U.S. Coast Guard (USCG)[4] and supported by the National Oceanic and Atmospheric Administration (NOAA), EPA, other Federal and state agencies, and academia. More than twenty workshops were held in various locations around the continental U.S., Caribbean, and Alaska from 1995 to 2011 to compare the benefits and risks of various response options when considering resource trade-off decisions. All of the workshops resulted in final publications (available from USCG) that were delivered to the Area Committees and RRTs to assist with response planning. One example of how this CERA/NEBA process was used to inform dispersant use decision-making is summarized in several papers authored by regulators in the state of California.[5] The applicability of the CERA/NEBA process as a tool for facilitating dispersant decision-making during spill response and planning was also evaluated by NOAA and published in a 2008 paper.[6]

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[2] NEBA is similar to the Consensus Ecological Risk Assessment (CERA) process developed by the U.S. Coast Guard in the mid -1990s.

[3] See, *Incident management system for the oil and gas industry: good practice guidelines for incident management and emergency response personnel*, IPIECA, August 2014, http://www.ipieca.org/publication/incident-management-system-oil-and-gas-industry-good-practice-guidelines-incident-manage.

[4] Aurand, D., Walko, L., & Pond, R. (2000). *Developing consensus ecological risk assessments: Environmental protection in oil spill response planning*. Washington, D.C.: U.S. Coast Guard.

[5] Addassi, Y. N., & Faurot-Daniels, E. (2005). California oil spill dispersant plan -Achievement through cooperation. *Proceedings of the 2005 International Oil Spill Conference, 2005* (1), 433 -437. doi:10.7901/2169 -3358-2005-1-433; Addassi, Y. N., Sowby, M.,

In 2014, the practice of incorporating a NEBA review during Source Control drills in the Gulf of Mexico was implemented by RRT VI during several large scale spill response exercises,[7] which has fostered good cooperation between the agencies to focus on the goal of minimizing shoreline community and ecosystem impacts by selecting response options that can maximize the effective treatment of oil offshore. NEBA discussions during both of these recent spill drills resulted in the concurrence of the RRT to authorize dispersants (both aerially and subsea) to treat the offshore oil slick.

Government decision-makers and/or the Responsible Party can conduct a rapid NEBA during actual spill responses to compare and rank the strengths and weaknesses of different response options for the incident-specific conditions. Lessons learned following a spill are incorporated into future policies and plans. Ecological recovery studies of the 1996 *Sea Empress* spill in the UK demonstrate the benefit of dispersant application along the coastline to prevent persistent oil from stranding in shoreline habits.[8] A more recent publication examined the recovery rates for a tropical ecosystem during a controlled study of dispersed versus untreated shoreline oil slicks and concluded that better recovery occurred in the areas where dispersant was used.[9]

Regrettably, the Proposed Rule lacks a NEBA perspective. It incorrectly focuses on intrinsic, hazard-based criteria for substance listing and ignores the more appropriate risk-based trade-off decision process responders must consider during an oil spill response. It does not recognize that dispersants are only applied when regulators and response decision-makers deem them necessary to prevent more significant and harmful consequences. The Proposed Rule favors protecting pelagic and benthic species while putting critical habitats, such as the ocean's surface and near-surface zones, as well as sensitive shorelines, at greater risk to environmental damage. Modeling results presented at the 2005 International Oil Spill Conference concluded that:

> *"…the results of the modeling support the contention that there are more opportunities to save wildlife, shorelines, and sensitive habitats along the shore with dispersant use than there are risks of impacting water column biota. If the areas that would be impacted by surface oil are those where wildlife are concentrated, as they typically are near shore, and the water column impacts resulting from dispersant use would be offshore where water column biota are lower in abundance, the trade-off is much more heavily weighted toward dispersant use before oil comes near the shoreline. In fact, for medium or smaller spills, or even larger spills where sensitive species and life stages are not present, the impact of dispersant use on water column biota could be negligible."*[10]

Parker-Hall, H., & Robberson, B. (2005). Establishment of dispersant use zones in the state of California: A consensus approach for marine waters 3 –200 nautical miles from shore. Proceedings of the 2005 International Oil Spill Conference, 2005(1), 187 -191. doi:10.7901/2169-3358-2005-1-187.

[6] Mearns, A., & Evans, M. (2008). Evaluating the consensus ecological risk assessment workshop as a tool for facilitating decision - making during spill response and planning. *Proceedings of the 2008 International Oil Spill Conference Proceedi ngs, 2008*(1), 739-741. doi:10.7901/2169-3358-2008-1-739

[7] Freeport McMoran Source Control drill (April 30-May 1, 2014) and BP Source Control drill (Nov 5-6, 2014)

[8] Lunel, T., Rusin, J., Bailey, N., Halliwell, C., & Davies, L. (1997). The net environmental benefit of a successful dispersant operation at the Sea Empress incident. *Proceedings of the 1997 International Oil Spill Conference, 1997* (1), 185 -194. doi:10.7901/2169-3358-1997-1-185

[9] Baca, B., Rosch, E., DeMicco, E. D., & Schuler, P. A. (2014). TROPIC S: 30 -year follow -up and analysis of mangroves, invertebrates, and hydrocarbons. *Proceedings of the 2014 International Oil Spill Conference, 2014* (1), 1734 -1748. doi:10.7901/2169-3358-2014.1.1734

[10] French McCay, et al., Modeling Fates and Impacts of Hypothetical Oil Spills in Delaware, Florida, Texas, California, and Alaska Waters, Varying Response Options Including Use of Dispersants. International Oil Spill Conference Proceedings: May 2005, Vol. 2005, No. 1 pp. 735-740. Also available at http://ioscproceedings.org/doi/pdf/10.7901/2169-3358-2005-1-735.

For oil spills where dispersant use is contemplated, a typical NEBA will predict the potential impacts to aquatic organisms from an increased exposure to dispersed oil droplets. Dispersant use is typically restricted to water depths greater than 10 to 20 meters so that dilution will minimize exposure or impacts to the benthic community. Studies have shown the dispersed oil concentrations are rapidly diluted within the large volume of receiving water from a high of a few hundred parts per million to a few parts per million within a few hours. Consequently, exposure to the toxic effects of the dispersed oil will be of short duration and limited to those aquatic organisms that inhabit near surface waters. The NEBA will also estimate the reduction of impacts to waterfowl, shoreline ecosystems and coastal communities resulting from the reduction in, or elimination of, the quantity of floating oil. The trade-offs of a short term increase in exposure of selected aquatic organisms to dispersed oil versus an increase in oil impacting coastal environments and communities must be evaluated and take into account local community values to determine if dispersant use is warranted.

Given the challenges of implementing other response options, a decision not to have dispersants available to responders could result in oil stranding on shorelines where it may persist for an extended time. Effectively dispersed oil will biodegrade rapidly so that the majority of the oil will persist for a much shorter period of time. Reducing the persistence of the oil in the environment is critical to reducing the overall impacts.[11] This is not to say that water column organisms are less intrinsically important than surface or shoreline species but using NEBA can and does provide a critical framework for deciding what is best for the overall ecosystem. Important considerations to understand in assessing this tradeoff include:[12]

- The impacts to the water column are mitigated by dilution – that is the potentially toxic levels of dispersed oil are limited in duration and physical coverage/extent and effected populations (e.g., plankton) tend to be ones that recover quickly.
- Oil effectively dispersed in the water column will generally biodegrade after a few days or weeks while oil stranded in near shore and shoreline areas can persist for years.
- Near shore and shoreline areas are the nursery grounds for many species, even those that live offshore as adults, so protecting the near shore areas also protects organism that live as adults offshore.
- The bio density of near shore areas (swamps and marshes) is far greater than the bio density in pelagic waters offshore.
- Dispersants also protect surface dwelling organisms offshore, i.e., marine mammals, birds, and turtles, through removal of floating oil.
- Slicks on the water surface are far more likely to impact fish eggs and larva that tend to float at or near the water surface than quickly removing oil from the surface with dispersants.
- In certain geographies, slicks can impact mangroves and other shoreline vegetation that can subsequently die off and result in shoreline erosion that increases sediments in the near shore water column and potentially affects corals and other species.

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[11] Hazen, et al., Deep-Sea Oil Plume Enriches Indigenous Oil-Degrading Bacteria, Science, 330 (2010), pp. 204-208.

[12] (a) French McCay, D., and Graham, E. Quantifying Tradeoffs – Net Environmental Benefits of Dispersant Use. International Oil Spill Conference Proceedings: May 2014, Vol. 2014, No. 1, pp. 762-775.
(b) McManus, M.A., Woodson, C.B. Plankton Distribution and Ocean Dispersal. The Journal of Experimental Biology, 215 (2012), pp. 1008-1016.
(c) DeMicco et al., Net Environmental Benefit Analysis (NEBA) of Dispersed Oil on Nearshore Tropical Ecosystems: TROPICS – The 25th Year Research Visit, International Oil Spill Conference Proceedings, May 2011, Vol. 2011-282.
(d) Varela et al., The Effect of the "Prestige" Oil Spill on the Plankton of the N -NW Spanish Coast. Marine Pollution Bulletin 53 (2006), pp. 272-296.
(e) Addassi, et al., Establishment of Dispersant Use Zones in the State of California: A Consensus Approach for Marine Waters 3-200 Nautical Miles from Shore. International Oil Spill Conference Proceedings: May 2005, Vol. 2015, No. 1, pp. 187-191.

The Agency should consider the NEBA process and how and why dispersants are used before making changes to the Subpart J Regulations.

The Proposed Rule has the Practical Effect of Treating Dispersants as Toxic and either Prohibiting or Discouraging the Use of this Critical Response Tool

Dispersants are an essential tool in the responder's toolkit. They are products used in oil spill response to dilute the oil in the water column to enhance natural microbial degradation, a process where microorganisms remove oil from the environment.[13] All marine environments contain naturally occurring microbes that feed on and break down crude oil. Dispersants aid the microbial degradation by forming tiny oil droplets, typically less than the size of a period on this page (<100 microns), thus increasing the oil's surface area and making it more available for the petroleum-degrading microorganisms to consume.[14]

All oil spill response options have their place in the response toolkit because of the extreme variability of spill conditions. Dispersants become a critical response tool for larger spills far from shore; spills more distant from stockpiles of recovery and containment equipment; when weather and ocean conditions preclude the use of other options; or when weather conditions are predicted to become more severe because they can be rapidly applied by aircraft or subsea (at a high encounter rate) when wind and wave conditions prevent other vessel-based recovery options.

The Proposed Rule focuses on the potential risks of dispersants without recognizing the benefits and core purpose of dispersants, which is to rapidly dilute the spilled oil and enhance removal of the oil from the environment through microbial degradation, resulting in reduced VOCs and shoreline impacts. Ultimately, the purpose of dispersants is to reduce the overall toxicity and persistence of oil in the environment.

We believe that research showing that dispersants do not enhance the biodegradation of oil from the environmental is based on studies that used unrealistically high concentrations of dispersed oil. Prince and Butler only recently developed a biodegradation test method that compares dispersed oil biodegradation to biodegradation of a surface slick at representatively low concentrations (i.e., 2.5 ppm).[15] This research unambiguously shows the enhanced biodegradation of dispersed oil over allowing an oil slick to remain on the surface. Most prior dispersed oil biodegradation studies used oil concentrations that were two or more orders of magnitude too high.[16]

Dispersants have proven to be an effective way to respond to an oil spill, most notably in those situations that prohibit, or otherwise limit, the effectiveness of other response measures. We submit that all response options should be contemplated based on their individual, or combined, ability to respond to

[13] American Society for Microbiology (ASM). (2011). *FAQ: Microbes & oil spills.* Retrieved from http://academy.asm.org/images/stories/documents/Microbes_and_Oil_Spills.pdf; Personna, Y., Boufadel, M., & Zhang, S. (2014). Biodegradation of dispersed Endicott oil in controlled experiments. Proceedings of the 2014 International Oil Spill Conference, 2014(1), 1126-1140. doi:10.7901/2169-3358-2014.1.1126; McFarlin, K., Leigh, M., & Perkins, R. (2014). Biodegradation of oil and dispersed oil by arctic marine microorganisms. Proceedings of the 2014 International Oil Spill Conference, 2014(1), 300-317. doi:10.7901/2169-3358-2014-1-300317.1.

[14] Hazen, T. C., Dubinsky, E. A., DeSantis, T. Z., Andersen, G. L., Piceno, Y. M., Singh, N., Jansson, J. K., Probst, A., Borglin, S. E., Fortney, J. L., Stringfellow, W. T., Bill, M., Conrad, M. E., Tom, L. M., Chavarria, K. L., Alusi, T. R., Lamendella, R., Joyner, D. C., Spier, C., Baelum, J., Auer, M., Zemla, M. L., Chakraborty, R., Sonnenthal, E. L., D'haeseleer, P., Holman, H. N., Osman, S., Lu, Z., Van Nostrand, J. D., Deng, Y., Zhou, J., & Mason, O. U. (2010). Deep-sea oil plume enriches indigenous oil-degrading bacteria. *Science*, *330*, 204-208. doi:10.1126/science.1195979

[15] Prince, R.C. and Butler, J.D. A protocol for assessing the effectiveness of oil spill dispersants in stimulating the biodegradation of oil. Environ Sci Pollut Res Int. 2014 Aug;21(16):9506-10. doi: 10.1007/s11356-013-2053-7. Epub 2013 Aug 13.

[16] Lee, K., Nedwed T., Prince R.C., Palandro D., Lab tests on the biodegradation of chemically dispersed oil should consider the rapid dilution that occurs at sea. Mar Pollut Bull. 2013 Aug 15;73(1):314-8. doi: 10.1016/j.marpolbul.2013.06.005. Epub 2013 Jun 27.

discharged oil, either on or below the water's surface, in a manner that causes the lowest negative effect on the environment and promotes the most rapid recovery of the affected ecosystem.

Laboratory Dispersant Efficacy Tests do not Predict How Well Dispersants Will Work in the Wide Range of Real World Spill Conditions

Although laboratory dispersant effectiveness testing can be used as a comparative screening tool for different dispersants under laboratory conditions, the Proposed Rule appears to suggest these results will be representative of actual effectiveness when applied to oil spills on open water. However, these results do not translate to the wide range of field conditions, oil types and weathering degrees in real world oil spills. Specifically, the static conditions in a lab, where researchers conduct experiments with known quantities of oil and dispersant, cannot be replicated at sea. Although the amount of dispersant that is to be applied is calculated based on a desired initial dispersant-to-oil ratio, the quantity and characteristics of oil during a real spill is an estimate, making any definitive, quantitative effectiveness estimation problematic. Localized determinations of the relative effect of surface dispersant application may be evaluated qualitatively using visual cues or semi-quantitatively using ultraviolet fluorometry, which is sufficient for operational effectiveness assessments. Additionally, much of the detailed spill monitoring specified by the Agency in the Proposed Rule has no bearing on dispersant effectiveness monitoring and cannot be conducted in a time-frame that will support day-to-day, near real-time operational decision-making.

We suggest the language in the Proposed Rule be modified to clarify the laboratory efficacy testing is for comparative purposes only and that the pass/fail criteria be established at a level that will only eliminate the least effective dispersants from being listed. Some dispersants that only exhibit average effectiveness in the laboratory tests may be very effective in certain situations in the field and the Response Community needs to maintain as many options as possible to select the most appropriate response option for a given set of conditions and circumstances.

Dispersant Toxicity Tests do not Accurately Simulate Real World Exposures.

API and NOIA acknowledge that there may be benefits to a so-called "gate-keeper" toxicity test with dispersant alone to ensure that any dispersants that might contain highly toxic components would not be accepted for listing on the Product Schedule. However, it is unclear what rationale was used for the dispersed oil toxicity tests stated in the Proposed Rule.

The relevant factors in dispersed oil toxicity include the concentration of dispersed oil, or oil compounds, in the water and the duration of exposure. The fundamental basis of aquatic toxicity testing is to create a set of concentrations and expose the animals for a duration where observable effects can be measured. As a result, laboratory exposures are useful for data collection and generating toxicity curves; however these conditions are not representative of the real world where the natural processes of rapid dilution and biodegradation act on the dispersed oil to dramatically reduce the exposure conditions [17]. Using acute 48- or 96-hour LC_{50} toxicity tests with dispersed oil mixtures (to calculate LC_{50} values) is considerably different from the likely exposure regime experienced by marine organisms in the open sea following an oil spill. For this reason, the Chemical Response to Oil Spills: Ecological Effects Research Forum (CROSERF)[18] was assembled to develop new dispersed oil toxicity testing protocols that account for rapid dilution. Academia, regulators and industry funded a ten year program through CROSERF to

[17] Lee, K., Nedwed, T., & Prince, R. (2011). Lab tests on the biodegradation rates of chemically dispersed oil must consider natural dilution. *Proceedings of the 2011 International Oil Spill Conference, 2011* (1), 245. doi:10.7901/2169-3358-2011-1-245
[18] Aurand, D., & Coelho, G. (2005). *Cooperative aquatic toxicity testing of dispersed oil and the chemical response to oil spills: Ecological effects research forum (CROSERF)*. Ecosystem Management & Associates, Inc., Technical Report 07-03. Lusby, MD.

develop new testing methods that are more aligned with real -world field c onditions. This data is now available via the NOAA Dtox database.[19]

Results from dispersed oil monitoring during the Deepwater Horizon (DWH) spill is clear evidence of the rapid dilution occurring after surface dispersant application [20] and subsea dispersant injection .[21] Further evidence of the rapid dilution of dispersed oil in the field is found in the analytical results from several field trials conducted in the North Sea to characterize the fate and transport of dispersants applied to an open ocean oil slick. These field experiments and the subsequent chemical characterization condu cted in 1994,[22] 1995,[23] and 1996[24] showed a rapid (within one hour) dilution of dispersed oil concentrations following dispersant application. This same effect was observed during the DWH response following surface dispersant application.[25] Since the proposed EPA dispersed oil testing does not take into account dilution, it is more likely that reported toxicity values at a rtificially high laboratory concentrations, not representative of real -world dilution exposures, will lead to misinterpretation of these tes t results and possibly preclude the use of dispersants altogether.

We strongly suggest that the laboratory toxicity test be limited to dispersants only to screen out the more toxic products and that toxicity testing for dispersed oil be explicitly elimin ated from the Rule. It is very likely that all dispersants will be unable to pass the dispersed oil toxicity test as existing oil toxicity data indicates the test oils alone will be unable to pass the test.

In the context of NEBA (and its forebear, th e Consensus Ecological Risk Assessment, or CERA), scientists understand and accept that marine organisms may experience localized, transient toxic effects from exposure to dispersed oil, but these local effects are offset by the benefit of dispersant use i n preventing or minimizing oil drifting ashore and causing severe and long -term harm to more sensitive coastal resources and communities . While knowledge of the potential for toxic effects to marine organisms is useful for conducting a NEBA, it cannot be t he sole indicator that dictates the use of dispersants. All resources -at-risk as well as coastal communities must be considered in the response option decision-making process, with the emphasis on coordinating a response that will result in the least overall impacts while promoting the most rapid overall recovery of the affected ecosystem.

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[19] Bejarano, A., Chu, V., Dahlin, J., & Farr, J. (2 014). Development and application of dtox: A quantitative database of the toxicity of dispersants and chemically dispersed oil. *Proceedings of the 2014 International Oil Spill Conference* , *2014*(1), 733 -746. doi:10.7901/2169-3358-2014.1.733

[20] Operational Science Advisory Team (OSAT 1). (2010). *Summary report for sub-sea and sub-surface oil and dispersant detection: Sampling and monitoring. Unified Area Command, New Orleans*. Retrieved from: http://www.dep.state.fl.us/deepwaterhorizon/files2/osat_report_17dec.pdf .

[21] Coelho, G., Aurand, D., Essex, L., Parkin, A., & Robinson, L. (2012). *Monitoring subsurface dispersant injection during the MC252 incident, volume 1*. Lusby, MD, USA: Ecosystem Management & Associates, Inc.

[22] AEA Technology. (1994). *International calibration of laboratory dispersant test methods against sea trials* . Oxfordshire, UK: AEA Technology.

[23] AEA Technology. (1995). *International calibration of laboratory di spersant test methods against sea trials. Field trial report. July 1995 sea trials*. Oxfordshire, UK: AEA Technology ; Jones, M., & Petch, S. (1995). A report on the analysis of hydrocarbons in sea waters and associated samples from trial oil spills off east ern England, July 1995. Newcastle upon Tyne, UK: University of Newcastle upon Tyne.

[24] Strøm-Kristiansen, T., Hokstad, J. N., Lewis, A., & Brandvik, P. J. (1997). *NOFO 1996 oil on water exercise – analysis of sample material. SINTEF Data report number STF66 A97050*. Trondheim, Norway: SINTEF ; Coelho, G. M., Aurand, D. V., Petch, G.S., & Jones, D.M. (1998). Toxicity bioassays on dispersed oil in the North Sea: June 1996 field trials. Ecosystem Management & Associates, Inc., Report 96-02. Purcellville, VA: Ecosystem Management & Associates, Inc.

[25] Huber, C. A., Steen, A., & Parscal, B. (2014). Does wave height matter for effective surface dispersant application? *Proceedings of the 2014 International Oil Spill Conference, 2014* (1), 747-761. doi: 10.7901/2169-3358-2014.1.747

During an Oil Spill, Operational Monitoring Should Focus on How the Selected Response Options Mitigate the Effects of the Oil on the Environment

Following an oil spill, the primary emphasis of operational response monitoring should be directed toward the response effort and the effect that those efforts have on reducing the net negative environmental consequences. The Agency proposes the requirement to "*monitor agent use in the environment*." API and NOIA submit that operational monitoring should not be focused on monitoring the agent (i.e., dispersant) use, but rather on monitoring the overall changes to the characteristics, transport, and fate of the oil within the ecosystem. We also submit the Agency should acknowledge that the primary issue in a spill scenario is oil in the environment (not dispersants in the environment) and that operational monitoring efforts should concentrate on evaluating how well the response option (or options) mitigates the negative effects of the oil on sensitive environmental resources.

EPA proposes monitoring that will provide a comprehensive assessment of the environment. However, the monitoring actions required in the Proposed Rule go beyond those required to inform operational decision-making and cross into the realm of Natural Resource Damage Assessment (NRDA) monitoring. One reason for this is that NRDA monitoring requires days to years before opinions on damages are made. Operational decisions require real or near-real time data. Damage assessment monitoring should not fall under the purview of spill response decision-making, and any monitoring of response options should be done solely to ensure the effectiveness of that response technique.

The Proposed Rule includes additional surface dispersant effectiveness monitoring requirements beyond those established in current practices, with no justification of how this additional monitoring burden will enhance operational response decision-making. Further, the additional requirements do not differentiate between surface and subsurface use of dispersants. As a result, the Proposed Rule would apply an unnecessary set of requirements in the event of surface dispersant usage in lieu of those monitoring techniques outlined in the USCG *et al., Special Monitoring of Applied Response Technologies* (SMART) protocols.[26] Additionally, the monitoring regime outlined in the Proposed Rule deviates substantially from that recommended by the National Response Team (NRT) in its *Environmental Monitoring for Atypical Dispersant Operations: Including Guidance for Subsea Application and Prolonged Surface Application,*[27] which also advocates the adaptation of the SMART monitoring regimen. These additional monitoring requirements, if adopted, may divert valuable resources away from the response effort, potentially prolonging the spill event. They may also preclude the use of dispersants in many cases if required to be in place as a condition of authorization, as it can take many days to assemble the equipment, vessels, and scientific experts.

During a subsea dispersant application, the Agency proposes an exhaustive set of environmental monitoring parameters that include *in situ* oil droplet size distribution analysis, *in situ* fluorometry, fluorescence signatures, dissolved oxygen, total petroleum hydrocarbons, carbon dioxide, methane, heavy metals, turbidity, water temperature, pH, and conductivity. As stated previously, we concurs with monitoring that supports effective, operational decision-making, but argues that most of these parameters will not provide any information on the effectiveness of the subsea dispersant application, will unnecessarily require additional scientific resources and will delay the reporting of key operational monitoring parameters. Spill response effectiveness monitoring should be based on simple, rapid assessments that can provide near real-time information on the progress of the response. For this reason, we believe that any mandated operational monitoring should be both incident-specific and designed to integrate into the other operational activities taking place. As such, the Responsible Party

[26] These protocols were jointly developed by the U.S. Coast Guard, National Oceanic and Atmospheric Administration, U.S. Environmental Protection Agency, Centers for Disease Control and Prevention, and Minerals Management Service.
[27] See http://www.nrt.org/production/nrt/nrtweb.nsf/AllAttachmentsByTitle/SA-1086NRT_Atypical_Dispersant_Guidance_Final_5-30-2013.pdf/$File/NRT_Atypical_Dispersant_Guidance_Final_5-30-2013.pdf?OpenElement

shares in the responsibility with the OSC in determining what monitoring needs to be done in ac cordance with the region -specific pre -approval and planning process. Comprehensive, detailed environmental monitoring is not an appropriate topic for this Proposed Rule.

The Agency's Economic Review Fails to Recognize Significant Costs of the Proposed Rule.

The Regulatory Impact Analysis (RIA) conducted by the Agency does not estimate all of the potential policy scenarios, and the economic impacts of those policies, that are issued in the Proposed Rule. Therefore, the RIA neglects to provide the public with a full description of the proposal's impact. Additionally, EPA did not provide any quantified social benefits that could result from implementation of any part of the Proposed Rule. An independent assessment [28] of the proposal (see Attachment A) has found that including the impacts of the requirements neglected by the Agency in the RIA would increase the cost of the proposal three times. In addition to underestimating compliance costs and administration costs for both industry and the federal governmen t, the RIA supporting the proposal fails to calculate the costs associated with the immediate market imbalances that could occur if products are removed from the market, either temporarily or permanently.

Beyond the market imbalance, removal of dispersants from the toolbox could result in additional clean-up costs that are not considered in the RIA. As noted in Attachment A, "To the degree this rulemaking reduces chemical and biological agent availability and innovation, the nation will have less tools av ailable to fight oil spill damage." A possible outcome of this limitation "is that future oil spill damages would be more severe than they would be if the rule did not occur." EPA did not quantify the costs associated with the possibility that the rule w ould limit the ability of the Response Community to keep oil from reaching shorelines or damaging ecosystems to a greater extent than if dispersants were readily available. We believe additional costs could extend to costs associated with environmental cla ims, increased response costs due to the need for shoreline cleanup, and other costs of environmental damages to sensitive shorelines, birds, and lost economic and recreational opportunities. In fact, EPA confuses the social benefits of avoiding an oil spill or having an appropriate response to a spill with the social costs of a spill, such as lost tourism revenue and other environmental damages. Furthermore, the Agency underestimated the costs to small businesses, which resulted in the false conclusion t hat small businesses would not be materially affected by the proposed ruling. Using realistic estimates, the attached third-party report finds that 43 percent of the firms identified by the Agency would face compliance costs in excess of three percent of a nnual sales and risk of closure. The Agency should amend the methodology and deficiencies found in the RIA, as discussed here and in the attached report.

We explicitly incorporate the comments and recommendations addressing the RIA provided by the independent assessment (see Attachment A).

The Proposed Rule Conflicts with Current Facility and Vessel Oil Spill Response Plans

Effective September 30, 2009, facility and tank vessel plan holders were required to update their response plans to include planning for responding to discharges using dispersants under a USCG rulemaking. Specifically, dispersant equipment is required in areas where it has been pre-determined that dispersants would be a viable oil spill mitigation technique and pre-authorizations have been established. Previously, with regard to dispersants for facilities located in areas with pre-authorization, a mechanical recovery equipment credit for up to 25% could be obtained for certain persistent oils.

[28] The independent assessment was prepared by the Policy Navigation Group (PNG), which consists of a diverse team of senior policy analysts with experience at Office of Management and Budget in the White House, managers, economists, engineers, lawyers and skilled researchers, with particular expertise in both private and public sector environmental management strategies including benefit-cost analysis and life-cycle assessments. See http://www.policynavigation.com/index.php?page=bios for more information about PNG.

However, since 2009 facilities handling certain persistent oils in areas with pre-authorization must ensure, through contract or other approved means, the availability of dispersant response resources and the commencement of dispersant-application operations within 7 hours of the decision by the OSC to use dispersants. Dispersant response resources must include: (1) sufficient volumes of dispersants to meet specified regulatory requirements, (2) dispersant application platforms and systems sufficient to meet planning standards, and (3) trained personnel.

Similarly, vessels transporting certain persistent oils in areas where dispersants are pre-authorized have been since 2009 required, through contract or other approved means, to have dispersant-related response resources meeting dispersant planning standards, including appropriately trained dispersant-application personnel. The dispersant resources must include the identification of each primary dispersant staging site used by each dispersant-application platform and the corresponding distance to the associated stockpile. Similar requirements were adopted for non-tank vessels in 2013.

There are also aerial tracking requirements under the current response plan requirements, and there are now pre-authorization zones for the use of dispersants outlined in the applicable Area Contingency Plan throughout the nation for every state except for Alaska and Connecticut whereby the OSC has the authority to expedite the authorization for the use of dispersants. Although there are no specific dispersants requirements under Bureau of Safety and Environmental Enforcement's (BSEE) response plan requirements for offshore facilities, it is clear based on experience with the *Deepwater Horizon* that dispersants are a key response tool that must be available on an expedited basis to respond both to a spill on the surface of the water and subsea in case of a blowout.

The Proposed Rule, however, appears to directly conflict with Coast Guard response plan requirements and raises a host of questions related to the continued validity of facility and vessel response plans. It is unlikely that any dispersants will pass both the efficacy and toxicity tests required by the Proposed Rule as a precursor to being listed on the NCP Product Schedule. For example, the EPA proposal may have the practical effect of virtually eliminating the entire stockpile of available dispersants nationwide that will be able to be listed on the NCP Product Schedule following full implementation of the Proposed Rule. In addition, it could have the practical effect of eliminating the usefulness of preauthorization zones. This could result in invalidating response plans.

Furthermore, the Proposed Rule, if implemented , would require significant additional requirements for information needed an d monitoring required before dispersants use approval is granted , which may prevent a plan holder from being able to deploy dispersants in the desired/required amount of time. For some spills it may mean that dispersants cannot be used at all due to limit ed window of opportunity. Thus, the Proposed Rule raises significant issues related to USCG and BSEE facility and vessel oil spill response plan compliance and could result in unnecessary and increased environmental damage and corresponding spill claims a s a result of increased damages. In this regard, we note that although the President delegated to EPA the responsibility for the amendment of the NCP, the Proposed Rule may extend beyond the limits of EPA's authority under that delegation or the applicabl e law. Furthermore, amendments to the NCP must be coordinated with members of the NRT , including the USCG and other relevant agencies, prior to publication for notice and comment. 40 C.F.R. § 300.2. It appears this coordination may not have been accompl ished sufficiently to avoid the conflicts discussed above. Accordingly, we recommend that EPA further coordinate with the USCG and BSEE to ensure that the Proposed Rule does not adversely affect USCG and BSEE response planning procedures and requirements.

<u>Agency Review of Public Comments</u>

Due to the significance of this rulemaking to the industry and to other Federal government agency stakeholders involved with spill response, it is critical the Agency provide adequate time for these other

agencies to review and provide feedback on comments submitted by the public for EPA's benefit and consideration. Accordingly, we strongly urge the Agency to seek and consider comments from the other relevant Federal government agencies on the public's comments befor e it decides on how to handle all input received in response to the Proposed Rule.

Availability of EPA Testing Data

It has come to the attention of API and NOIA that the Agency may have testing data related to dispersants that may not have been released to the public. If that is the case then the Agency should make that data publicly available as soon as possible in some form of a supplemental notice to this Proposed Rule. Supplemental comments should then be requested to ensure that the public has an opportunity to provide additional informed comments for EPA's consideration before finalizing the Proposed Rule.

DETAILED COMMENTS ON THE PROPOSED AMENDMENTS TO 40 CFR PARTS 110 AND 300

Our specific section -by-section comments on the Proposed Rule are presented as follows . These comments conform to the organization of the Proposed Rule on a section-by-section basis.

I. § Section 300.5 Definitions

A. *The definition of burning agents should not include ignition devices*.

Burning Agents. The proposed defi nition reads: " *Burning agents are additives that improve the combustibility of the materials to which they are applied through physical or chemical means* ." In the preamble (80 Fed. Reg. 3385) an example is given of a helitorch system, stating that the mate rials in the helitorch would be considered burning agents. Additionally, the Agency is seeking comment on whether it should add ignition devices to the definition of burning agent.

The proposed defin ition seems to combine burning agents (materials that actually change the combustibility of the material they are added to) and ignition agents (materials used to start combustion, as is the case with the helitorch). This confuses the question around including ignition devices within the definition of burning agents which, if happens, could lead to administrative pauses in requesting a test burn, or any burn during an emergency phase of a response.

Igniters are used to initially heat a small portion of the oil to release vapors that can be ignited. The initi al process of ignition is not the same as improving overall combustibility of an oil. For example, when starting a campfire, a match does not change the combustibility of the wood; it simply provides the energy to start the combustion process. Similarly, a n in-situ burn ignition system provides energy to heat and vaporize some of the oil so that it can start to combust. For this reason, we submit that ignition devices (both ignition liquids and equipment) should not be included in the definition of a burning agent.

We recommend the Agency adopt the following definitions:

> *Burning agents are additives that change the combustibility of the materials to which they are applied through physical or chemical means prior to ignition.*
>
> *Ignition agents are additives that ignite, or initiate combustion of the materials to which they are applied.*

B. *EPA's definition of dispersants does not fully define dispersants.*

Dispersants. The EPA proposed definition of dispersants in 300.5 should be expanded to include an explanation of why the production of smaller droplets is important. The following language should be added to the end of the proposed definition: *"The formation of small droplets is intended to allow the oil to be rapidly diluted in open ocean environments t o non -harmful concentrations and to promote rapid biodegradation of the oil by naturally occurring microbes."*

C. *Oil-mineral aggregate ("OMAs") are not sorbents*

Sorbents. API and NOIA offer several comments on the definition of sorbents in 300.5, as follows:

- We support the addition of clay as an example of an inorganic/mineral compound, especial ly since commercial products made from clay are currently on the market.
- The Agency expresses concern that sorbents made from particulate matter may be used as sinking agents. Many inorganic/mineral compounds that are quite dense are commonly used on terrestrial spills on roads, pavements and other hard surfaces. The rule should not limit their use for these situations.
- Very fine clays (like those used in OMAs), wh ile still nominally denser than water, will still suspend in the water column because the particle sizes are very small. The rule needs to acknowledge that OMA's are not sinking agents. If the Agency is concerned that inorganic/mineral sorbents are being u sed as sinking agents, then their use should be explicitly prohibited for use as a sinking agent. Uses for other purposes should be allowed.
- EPA should not limit how sorbents in particulate form are used. The use of OMA technologies is not to sorb oil but to promote dispersion and biodegradation. The purpose of the technique is not the same as for sorbents and should not be regulated as such. OMA technologies should be excluded in the definition of sorbents and should have separate testing/authorization requirements.
- While most sorbents are collected and recovered from the environment, some natural organic sorbents are spread over oil on habitats where the oil cannot be easily removed. The sorbent ties up the oil to reduce further migration and to limit the exposure to flora and fauna. The Agency should not discourage this application as it is sometimes considered a "best practice" for certain oiled habitats. As such, the Agency should either remove the phrase, "generally collected and recovered…" or add lang uage to indicate that loose, organic sorbents used in wetlands may not be recovered.

D. *Saltwater should be defined in the Proposed Rule*

Saltwater. In column 2, 80 Fed. Reg. 3389, of the preamble and subsequent sections the term "saltwater" is used. It is recommended that saltwater be defined in the definitions in 300.5 since the Proposed Rule states that dispersants are only allowed in saltwater environments. There is no definition of saltwater offered in the proposal. Dispersants have been shown to work a t salinity much lower than the typical 35 ppt ocean concentrations and effectiveness at salinity as low as 14 ppt has been reported. A definition where dispersants can be used needs to be provided, taking into consideration the data on dispersant performance in brackish or estuarine environments.

II. <u>Section § 300.910 Authorization for Agent Use</u>

A. *The Unified Command (UC) determines the best use of response assets on a daily basis.*

EPA should not establish a policy or rule that mechanical recovery is always the priority choice of countermeasures to use in a response. In the preamble for this section (column 1, 80 Fed. Reg. 3387), the Agency makes the following statement:

> *"During the DWH response, a priority countermeasures scheme was established to first use mechanical recovery via skimming/booming or in-situ burning followed by subsea dispersant and lastly surface dispersant use."*

This may have been the conceptual prioritization from the perspective of EPA, but in reality dispersants played a much larger role and it was the responsibility of the UC to determine the best use of response assets on a daily basis to account for weather conditions, VOC suppression, oil slick locations, response equipment availability, etc. Every spill is different and specific references to a single spill event can indirectly and inappropriately be perceived as a recommended practice and should be avoided. In any spill scenario, all response tools must be used to their maximum effect. The Agency's unprecedented use of "Directives" during the DWH incident severely limited the use of dispersants and circumvented the NEBA decision-making process allowing significantly more oil reaching the water's surface and, subsequently, the shoreline. This resulted in additional environmental impacts with no documented benefits to the marine ecosystem.

The Agency should reconsider this statement and prioritization as it puts unneeded complexity into the response decision-making process and inappropriately prioritizes mechanical recovery over other response options. The effectiveness of mechanical recovery can be limited in large, offshore spills as a result of typical environmental conditions, such as wave action/height or wind conditions as well as the extensive surface area that must be covered. Further, the Agency's artificial prioritization of this technique over other viable response options is contrary to the NEBA concept to determine the best blend of response options (with no pre-determined or pre-existing bias) to achieve the best overall protection and recovery for the ecosystem.

B. *Decision-making plans are also important to response decision-making.*

Later in the same paragraph referenced above, the Agency makes the following statement:

> *"The Agency believes that preauthorization or expedited decision making plans are critical elements of contingency planning activities."*

We strongly agree that preauthorization and expedited decision-making are important.

C. *Proposed changes involving preauthorization planning will increase the workload of all Regional Response Teams (RRTs) and Area Committees (AC) and restrict their flexibility.*

EPA should not restrict RRT or OSC activities related to preauthorization plans in areas where preauthorization is desirable and applicable. At the end of the same paragraph (column 2, 80 Fed. Reg. 3387), the Agency makes the following statement:

> *"The Agency believes these proposed revisions to the authorization of use provisions will assist OSCs, RRTs, and ACs in their advanced planning activities as they consider response methods that result in the greatest environmental protection."*

We agree with the intent to assist the OSCs and RRTs. However, the added complexity resulting from the Proposed Rule in authorization, monitoring and product listing, in addition to the overly conservative assumptions about dispersant effects described in the Proposed Rule, will not assist these entities.

Instead, it complicates and limits their ability to respond. The Agency must provide specific examples to show how this rule assists responders, particularly in relation to the OSC duties of making timely operational decisions, especially those decisions based on using the concept of NEBA to guide a response.

The existing rule states that the RRTs and Area Committees should evaluate the desirability of using various agents as part of their planning processes and state that "*RCPs and ACPs shall, as appropriate, include applicable preauthorization plans....*" Under the current rule, most RRTs did, in fact, create preauthorization plans, and those plans did include appropriate oceanographic and geographic limits. In practice, only Region VI used those plans to mitigate oil spills, and the Region VI OSCs, RRTs, and Area Committees became very familiar with their use. Policies and practices for the use of the RRT VI preauthorization plan were created by the appropriate member agencies without regulatory requirements and evolved to account for changes in information technology.

The proposed language states, "*RRTs and Area Committees shall address in a preauthorization plan…*" This becomes a mandate for all RRTs and Area Committees, including those areas that may have little interest or need for such plans. In fact, some RRTs and Area Committees do not even have water bodies where dispersants could be used. Most of the factors that are required to be considered by the Proposed Rule are already addressed in preauthorization plans (e.g., water depth, distance from shorelines). Some factors, however, such as the requirement that "*preauthorization plans must specify limits for the quantities and the duration of use,*" for agents are new and have the effect of limiting the application and effectiveness of the pre authorization plans. This requirement would suggest that RRTs must know in advance the size of the potential releases, the resources at risk and what strategies are available to protect them, the dispersability of the oil, and the optimum dispersant-to-oil application rate. The OSC's flexibility and the effectiveness of the response method are limited and not assisted by such requirements, and EPA has not justified that the proposed requirement is necessary in relation to existing requirements.

The existing rule also states that "*preauthorization plans may address factors such as ...*" However, the Proposed Rule states "*Preauthorization plans should document…*" and adds requirements for consideration of factors such as "inventory" and "manufacturing capability of available agents." Again, this requires additional effort on the part of RRTs and Area Committees, where such work is already typically being done by industry as part of their planning processes.

The net effect of most of the changes involving preauthorization planning is an increase in the workload of all RRTs and Area Committees while restricting their flexibility in areas where preauthorization is desirable and applicable.

III. Section § 300.910(a) Use of Agents Identified on the Schedule on Oil Discharges Addressed by a Preauthorization Plan

A. *Adding more entities complicates the planning process.*

Section § 300.910(a) states that the RRTs and Area Committees shall address preauthorization plans. API and NOIA do not see any valid reason to add more entities to the planning process. In the preamble to this section, the Agency makes the following statement (column 1, 80 Fed. Reg. 3388):

> *"Therefore, the Agency is proposing to include RRTs as another planning entity with responsibility for developing preauthorization plans, and is requesting comment on this change, and on the advantages or disadvantages of keeping the development of these plans at the AC level."*

We believes that while the RRTs may provide more practical experience to the planning effort, the potential benefit would be overshadowed by the added complexity and bureaucracy. Unle ss the Agency can provide a sound rationale, we recommend against including the RRTs in the development of preauthorization plans.

B. *Area Committees should identify shoreline habitats that can benefit from the appropriate use of dispersants.*

In this same section of the preamble (column 3, 80 Fed. Reg. 3388), the Agency makes the following statement:

> *"The RRT's and ACs should identify the affected biological resources and their habitats likely to be negatively impacted, as well as those that are expected to benefit."*

API and NOIA support the requirement that A rea Committees should identify shoreline habitats that can benefit from the appropriate use of dispersants or other response methods. This will advance the use of the NEBA concept. Note that many of these resources are already identified in Area Contingency Plans.

C. *Preauthorization plans should provide the OSC sufficient authority to use chemical or biological response agents.*

In this same section of the preamble (column 1, 80 Fed. Reg. 3389), the Age ncy makes the following statement:

> *"The Agency is clarifying that if the preauthorization plan is approved in advance for chemical or biological agent use under specified discharge circumstances, then the OSC may authorize the use of the agents on the Sc hedule for their intended purpose without the incident specific concurrences and consultations described in paragraphs (b) of this section unless otherwise directed by the Administrator in accordance with current concurrence authority."*

We believe that the preauthorization plan should provide the OSC sufficient authority to use chemical or biological response agents. Since the Agency will have already been involved in the preauthorization plan approval, additional Administrator concurrence is unnecessary and would unduly complicate the response.

D. *RRTs and A rea Committees should be required to address and document their review and conclusions on whether or not the use of chemical or biological agents is appropriate.*

The Proposed Rule reads that:

> *"RRTs and Area Committees shall address in a preauthorization plan, as part of their planning activities, whether the use of chemical and biological agents listed on the Schedule on certain oil discharges is appropriate."*

This appears to compel RRTs and A rea Committees to document when and why such agents are appropriate, but does not require documentation or the rationale if they are not deemed appropriate, leaving the option open for RRTs and A rea Committees to simply not address prea uthorization for use of such agents. RRTs and A rea Committees should be required to address and document their review and conclusions on whether or not the use of chemical or biological agents is appropriate. API and NOIA suggest modifying the proposed language to read:

RRTs and A rea Committees shall address in a preauthorization plan, as part of their planning activities, whether or not the use of chemical and biological agents listed on the Schedule on certain oil discharges is appropriate and document the rationale for whether or not the use of an agent is considered appropriate.

IV. Section § 300.910(a)(1) Preauthorization Plan Development

A. *Dispersant use should not be limited by the preauthorization plan.*

EPA should not unnecessarily limit the use of dispersants through new req uirements in developing preauthorization plans. In this section (column 3 , 80 Fed. Reg. 3422), the Agency makes the following statement:

> *"For discharge situations identified where such agents may be used, the preauthorization plan must specify limits for the quantities and the duration of use* (Ed. emphasis added), *and use parameters for water depth, distance to shoreline, and proximity to populated areas."*

We assume that this provision in the Proposed Rule is a direct response to recommendation C5 on pag e 270 of the January 2011 report *Deep Water: the Gulf Oil Disaster and the Future of Offshore Drilling* by the National Commission on the BP *Deepwater Horizon* Oil Spill and Offshore Drilling. However, in the four years since the publication of this report, there have been numerous scientific, peer -reviewed environmental and health publications that have examined the dispersant use during DWH.[29] Subsequent laboratory toxicological studies of dispersed oil in the water column after dispersant application showed that there was no detectable harm to the species tested. Key findings from this research program included the following:

- Following surface dispersant applications, the dispersed oil c oncentrations in the water column return within 3 hours to background l evels due to vertical and horizontal dilution into surrounding ocean waters;

[29] Atlas, R. M., & Hazen, T. C. (2011). Oil biodegradation and bioremediation: A tale of the two wo rst spill in U.S. history. *Environmental Science & Technology, 45* (16), 6709-6715. doi:10.1021/es2013227; Chakraborty, R., Borglin, S. E., Dubinsky, E. A., Anderson, G. L., & Hazen, T. C. (2012). Microbial response to the MC -252 oil and Corexit 9500 in the Gulf of Mexico. Frontiers in Microbiology, Ecotoxicology and Bioremediation, 3, 357 -367. doi:10.3389/fmicb.2012.00357; Lubchenco, J. (2010, December 29). Oil spill clarifies road map for sea turtle recovery. The Miami Herald. Retrieved from http://www.nmfs.noaa.gov/mediacenter/docs/2011/mar/oil_spill_clarifies_road_map_for_sea_turtle_recovery.pdf ; Louisiana Department of Wildlife and F isheries. (2010, July). Oyster stock assessment report of the public oyster areas in Louisiana. Oyster Data Report Series No. 16. Retrieved from https://www.wlf.louisiana.gov/sites/default/files/pdf/page_fishing/32695 -Oyster%20Program/2010-oyster-stock-assessment-report.pdf; Operational Science Advisory Team. (2010). Summary report for sub-sea and sub -surface oil and dispersant detection: Sampling and monitoring. Retrieved from http://www.restorethegulf.gov/sites/default/files/documents/pdf/OSAT_Report_FINAL_1 7DEC.pdf; Operational Science Advisory Team. (2011). Summary report for sub -sea and sub -surface oil and dispersant detection: ecotoxicity addendum. Retrieved from http://www.restorethegulf.gov/sites/default/files/u306/FINAL%20OSAT%20Ecotox%20Addendum.pdf ; Shea, D. (2014, August 15). In re oil spill by the oil rig "Deepwater Horizon" in the Gulf of Mexico, on April 20, 2010. Expert report of Dr. Damia n Shea. New Orleans, LA: United States District Court, Eastern District of Louisiana. Retrieved from http://mdl2179trialdocs.com/releases/release20150120070000/TREX -013444.pdf; Soniat, T. M., King, S. M., Tarr, M. A., & Thorne, M. A. (2011). Chemical and physiological measures of oysters (Crassostrea virginica) from oil -exposed sites in Louisiana. Journal of Shellfish Research, 30(3), 713 -717. doi:10.2983/035.030.03 11; and U.S. Food and Drug Administration. (2010, October 29). NOAA and FDA announce chemical test for dispersant in Gulf seafood. Retrieved from http://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/2010/ucm231653.htm.

- The surface dispersants were applied over an operating area of 18,000 sq. mi., as a result, surface dispersant application rarely occurred in the exact same location, which further enhanced dilution of dispersed oil in the Gulf; and
- The mixing of relatively small volumes of dispersed oil into the very large, well -mixed Gulf of Mexico resulted in very short exposure durations of animals

These studies, conducted during and after the DWH aerial dispersant operations, indicate that there is no need to specify limits for the quantities and the duration of use of dispersants in a preauthorization plan. We believe the Section 300.910(a)(1) proposed requirement that specifies limits for the quantities and duration of use should be deleted from the Proposed Rule.

If the Agency wants to determine whether and how to limit dispersant use, we propose a joint EPA/industry study of existing research results to provide scientific credibility to any limitations that are established. Without scientific justification, artificially -set limitations on dispersant use would threaten the intent of using NEBA to support response decision -making and would limit the OSC's ability to make the best overall decision concerning the actual scenario and the environment.

To be clear, API and NOIA believe the amount of dispersant used should be based on the outflow of oil and the dispersant-to-oil ratio (DOR) that is effective in dispersing the plume. It is under stood that after a specified time period (e.g., 48 hours), the OSC will request RRT concurrence for continued dispersant use (except when there is a threat to human life and health) wherein concerns over quantities and duration can be evaluated.

We believe that the proposed preauthorization requirement to provide distance to shoreline and proximity to populated areas is not justified as the RRTs/Area Committees have already set these requirements in existing preauthorization plans as appropriate . Each RRT has developed preauthorization maps which clearly depict minimum distances from shore and minimum water depths. In addition to these already established distance and depth limitations, during an actual response, dispersant responders work with the RRT, OSC, and Responsible Party to set standard requirements and operating procedures for aerial spray safety setbacks of 1,000 ft. or more from vessels, platforms, response personnel, and sensitive marine life. Because these practices are already in place, there is no need to specifically regulate new parameters. For these reasons, API and NOIA believe the parameters for distance to shoreline and proximity to populated areas should be deleted.

We suggest that the Agency confer with other Federal agencies involv ed in oil spill planning and response and revise the language in the Proposed Rule to specify that preauthorization should rely on the concepts of CERA/NEBA as the foundation for pl ans and response decisions, not on artificially set limits on dispersant volumes. The USCG has conducted more than a dozen CERAs to help inform the decision-making process, but the Proposed Rule appears to contradict the CERA/NEBA tenets that were previously used to define preauthorization zones.

B. *EPA should work with other agenc ies to implement changes to preauthorization plans.*

Finally, since the Proposed Rule suggests that the Agency is adjusting the natural resource trustee concurrence requiremen t for preauthorization plans, we believe strongly that the Agency must demonstrate how it will work with other agencies to implement these proposed changes into the existing RRT preauthorization process and should specify a time interval for the relevant agencies to complete this integration (e.g., 1-year).

C. *The USCG and Bureau of Sa fety and Environmental Enforcement (BSEE) already regulate logistical aspects of dispersant use.*

There is no reason for the Agency to regulate logistical matters related to dispersant usage because they are already regulated by other agencies. In Section § 300.910(a)(1), the Agency makes the following statement:

> *"...and logistical factors including inventory, storage locations and manufacturing capability of available agents, availability of equipment needed for agent use, availability of adequately trained operators, and means to monitor agent use in the environment."*

There have been many advances in regulations and spill response planning in the past decad e. The regulations should acknowledge that there are now requirements in 33 CFR Parts 154 and 155 that have established a surface dispersant capability throughout the U.S. to apply up to 55,000 gallons (daily) of dispersant out to 50 nm offshore. These new regulations resulted in the development of 44 strategically located dispersant stockpile bases. Fur ther, these regulations require training and exercising of equipment and personnel. Given existing compliance with 33 CFR Parts 154 and 155, preauthorization plans do not have to restate all of these assets but should be able to refer to this regulated cap ability. With current U.S. stockpiles containing close to 1 million gallons of dispersant and international stockpiles containing over 1.5 million gallons (as established via the Global Dispersant Stockpile), the requirement to assess dispersant manufacturing capability during the initial response is unnecessary.

We recommend that the Agency revise this section of the regulation to not require specific information on stockpiles, spray equipment, personnel, training or manufacturing and acknowledge that the USCG and the BSEE are regulating these aspects of spill response.

V. <u>Section § 300.910(a)(2) – Preauthorization Plan Approval</u>

A. *The proposed language for w hen a withdrawal of concurrence invalidates a Preauthorization Plan is unclear.*

EPA needs to clarify when withdrawal of concurrence invalidates a preauthorization plan. In the preamble to this section (column 2, 80 Fed. Reg. 3389), the Agency states:

> *"The Agency is proposing specific procedures for concurrence withdrawals, allowing agencies to do so if they believe the preauthorization plan no longer addressed or reflects existing situations if it were to be implemented. While an agency with concurrence authority may not decide to withdraw concurrence from an approved preauthorization plan, there are curr ently no set procedures to promptly address those situations. The proposal would require the RRT and the ACs to address the withdrawal of approval of the preauthorization plan within 30 days of the withdrawal, allowing an opportunity to address the concerns."*

However, the Proposed Rule language is not clear regarding how the withdrawal process operates. While the proposed 30-day period for the RRT to address withdrawal is a positive step as it provides structure and guidance to the process, it is unclear w hen withdrawal of conc urrence would render the preauthorization plan invalid. API and NOIA believe this only makes sense if there is no active or ongoing response. Agencies should not withdraw their concurrence from an existing plan during a response as this could make responding in a timely fashion difficult, if not impossible. This could potentially allow an agency to invalidate a plan at the time of a s pill forcing a delay in the use of dispersants at the most critical time of the response. Note that the States of Alaska and Florida have withdrawn their approval for

preauthorization in state waters, which was done effectively without any additional regul atory requirements.

Clarifying the language to allow for preauthorization plans to remain in place dur ing the 30-day period in which RRTs and A rea Committees address the withdrawal would prevent disruption to response activities. This would maintain the validity and usefulness of preplanning and preauthorization, while allowing for agencies to withdraw con currence based on changing conditions, reducing the possibility of the withdrawal based on political or media influence. This 30 -day review period should also be subject to public comment.

We also note that currently Subpart J does not include the USCG representative to the RRT as a government agency required to approve preauthorization plans. It is important to inc lude one of the key stakeholders, the USCG, in the approval of preauthorization plans.

Accordingly, API and NOIA suggest modifying the proposed language as follows:

> *(2) Preauthorization Plan Approval. The EPA representative to the RRT, USCG RRT representative for the coastal a nd ocean zones where the USCG OSC would have primary authority and responsibility for operational decisions, the Department of Commerce and the Department of the Interior natural resource trustees and, as appropriate, the state RRT representatives shall review and either approve, approve with modification, or disapprove the preauthorization plans developed by the RRT and/or the Area Committees. Withdrawal of concurrence means the preauthorization plan becomes invalid and the authorization of use for chemical or biological agents must be performed according to paragraph (b) of this section. For an agency to withdraw concurren ce, the agency must first notify the RRTs and Area Committees. The RRTs and Area Committees shall review and address the withdrawal within 30 days of the date of notification, during which time the notification of withdrawal will be subject to public comment. The Preauthorization Plan will remain in effect while the RRTs and Area Committees review the withdrawal. If the agency withdrawing its concurrence remains unsatisfied after the 30 -day review period, then the Preauthorization Plan becomes invalid at th e conclusion of the 30 -day review period, and the authorization of use for chemical or biological agents must be performed according to paragraph (b) of this section.*

VI. Section § 300.910(a)(3) – Preauthorization Plans Reviews

A. *The re-approval process for pr eauthorization plans is too frequent and the timing and process for review and revision is unclear.*

Currently there are no requirements for the review of preauthorization plans. Revised Section 300.918(a)(3) requires preauthorization plan review, and revision as needed at the following times:

> *at least every 5 years; after a major discharge or a Spill of National Significance (SONS); to address revisions of the Schedule; to reflect new listings of threatened and/or endangered species; and to address any o ther change that may impact the conditions under which the use of chemical and biological agents is preauthorized.*

The preamble explains that "other changes" may include a new or revised worst case discharge estimate, and that this review requirement is "intended to ensure that preauthorization plans are actively maintained and updated to reflect revisions to the Schedule." (80 Fed. Reg. 3389). If the Agency decides to move forward with a re view requirement, API and NOIA recommend that the Agency clarify (1) what defines a

"major discharge"; (2) what process should be followed for re-approval; and (3) what effect a change in the preauthorization would have on existing FRPs and VRPs, which are also updated on a 5 -year cycle. We believe the review of preauthorization plans every 10 years or, at the discretion of the RRT/ Area Committee after a SONS (per [a] and [b] in the statement) , is sufficient and that the "major discharge" language should be removed . The Agency should also strike the requirement for review upon new threatened and/or endangered species listings and "to address any other change" since this type of planning on a "less than five year basis" overly -burdens the RRTs. Also, the Agency should clarify what the re-approval process would entail and establish a framework for how long review and approval should take. In addition, the USCG representative to the applicable RRT should also be included in this process. This, along with the remaining review triggers, would still allow for robust, current preauthorization plans, while maintaining stability of existing, potentially affected FRPs and VRPs.

We suggest modifying the proposed language as follows:

> *(3) Preauthorization Plans Reviews. The RRT and/or the Area Committees must review, and revise as needed, pursuant to paragraph (a)(1) of this section, preauthorization plans at least every 10 years; or at the discretion of the RRT and/or Area Committee after a Spill of National Significance (SONS); to address revisions of the Schedule; to reflect new listings of threatened and/or endangered species; and to address any other change that may impact the conditions under which the use of chemical and biological agents is preauthorized. The designated EPA RRT representative, the USCG RRT representative for the coastal and oceans zones where the USCG OSC would have primary authority and responsibility for operational decisions, the Department of Commerce and the Department of the Interior natural resource trustees, and the RRT representative from the state(s) with jurisdiction over the waters of the area to which a preauthorization plan applies shall review and either approve, approve with modification, or disapprove any revisions to the preauthorization plans.*

VII. Section § 300.910(b) Use of Agents Identified on the Schedule on Oil Discharges Not Addressed by a Preauthorization Plan

A. *A reasonable consultation time of 48 hours should be established for natural resource trustees if the Agency concludes that the current "if Practicable" standards should be changed*

In this section in the Proposed Rule (column 1 , 80 Fed. Reg. 3423), the Agency has removed the words *"when practicable"* with respect to consultation with the Department of Commerce (DOC) and the Department of the Interior (DOI) natural resource trustees for the following reasons discussed in the preamble:

> *"The requirement for consultation with the DOC and DOI natural resource trustees is also maintained. However, the language is amended by removing 'when practicable' with respect to consultation with the DOC and DOI natural resource trustees. The Agency believes that the case-by-case decision making should include consultations with natural resource trustees since these discharge situations may present unique challenges when selecting a response option that involves chemical or biological agents. While the Agency recognizes the time -critical nature of decision making during a response, advances in communication technology with increased capabilities to communicate quickly."*

(column 1, 80 Fed. Reg. 3390) API and NOIA believe that while technical advances in communication (e.g., cell phones) have improved since the last Subpart J revision, it does not guarantee an immediate or timely response by the required individuals. And the current system has worked well for years. Thus,

continued flexibility in the approval process (i.e., "when practicable") is still warranted to ensure the timeliest and best possible response . If the Agency concludes that the current " when practicable" language needs tightening up it could establish a reasonable consultation time of 36 hours. Spill response decision-making requires timely decision-making. Natural resource trustees already have an independent process to assess possible damages outside of the response effort (via Natur al Resources Damage Assessments [NRDA]). The phrase could be revised to state, "*...when practicable within a 36-hour timeframe*".

B. *The change in th e term "navigable waters threatened " will set up additional barriers to dispersant use and unduly limit actions by the OSC.*

In the same paragraph (column 1, 80 Fed. Reg. 3390), the Agency makes the following statement:

> *"The Agency is also proposing to revise the term 'navigable waters threatened' to 'waters and adjoining shorelines threatened' to be consistent with the provisions in paragraph (a) of this section."*

We are concerned that this change will set up additional barriers to dispersant use and unduly limit actions by the OSC.

C. *Early dispersant use decision-making should focus on documenting that a NEBA justification exists to support dispersant application.*

The Proposed Rule would unnecessarily establish new requirements f or an OSC to document the parameters used to authorize dispersants. This is discussed in the same section (column 2, 80 Fed. Reg. 3423), as follows:

> *"...the OSC must consider and document the parameters for the use of agents including the quantities to be used, the duration of use, the depth of water, the distance to shoreline and proximity to populated areas, and should address factors suc h as environmentally sensitive resources or restricted areas that might be impacted, agent inventory and storage locations, agent manufacturing capability, availability of equipment needed for agent use, availability of adequately trained operators and appropriate means to monitor agent use in the environment."*

Because dispersants have a limited window of opportunity to be used on spills, it is important to decide quickly on their use. Decisions by the OSC should not be delayed to complete information that is not needed. Many of the proposed items for the OSC to document (e.g., stockpiles, personnel, spray assets) are already specified and required in the applicable response plan requirements of 33 CFR Parts 154 and 155. Given the current stockpile availability in the U.S. and in the Global Dispersant Stockpile, dispersant availability will not be a concern for weeks or months. As suc h, we believe that the immediate actions by the OSC should include a review of the pre -authorization plan(s) and a rapid , incident-specific NEBA to support the selection of response options that may include dispersant application as a means to lessen or eliminate impacts to sensitive shoreline resources or to pr otect worker health and safety. In addition, we recommend that the Pr oposed Rule require referencing the USCG -classified dispersant OSRO or other OSRO for many of the items requested.

VIII. <u>Section § 300.910(c) Burning Agents</u>

A. *Ignition devices for in-situ burning are not burning agents.*

Under the current rule an OSC may author ize use of a burning agent on a case -by-case basis after concurrence of the EPA representative to the RRT, the state RRT representative and in consultation with the DOC and DOI natural resource trustees, when practicable. The Agency proposes to authorize the OSC to approve the use of a burning agent without the approval or consultation with other agencies to facilitate expedited use in recognition of their increasing importance in response to spills and that small quantities of burning agents are used and are quickly consumed by the resulting fire. API and NOIA agree and commend the Agency for this proposal. Further, we agree that ignition devices should be excluded from the definition of burning agents.

We believe that chemical herder agents are includ ed within the scope of the term burning agents. In the preamble to this section (column 3, 80 Fed. Reg. 3390), the Agency makes the following statement:

> *"Further, because of the nature of burning agents and the proposed revisions to the authorization of use for these products, the Agency continues to believe it is not necessary to require product submissions for burning agents."*

We believe this statement also applies to chemical herder agents. Please clarify if this is correct.

IX. Section § 300.910(d) Exception

A. *EPA needs to clarify the phrases "protection of human life" and "near inhabited areas."*

In this section in the Proposed Rule (column 2 , 80 Fed. Reg. 3423), the Agency makes reference to "the protection of human life ." We believe it is unclear whet her "*protection of human life* " is inclusive of the protection of worker health and safety. The Agency should amend this section to clearly include the protection of oil spill response worker safety within this concept. This same section also references spi lls "*near inhabited areas.* " This language is confusing since spills where dispersant use serves an environmental benefit will rarely (if ever) be near inhabited areas.

B. *A time limit on protecting human health is inappropriate.*

We believe the establishmen t of a 48 h our limit to the OSC's use of authority to use agents to protect human health is inappropriate. There should never be a limit to the OSC's ability to make decisions that are aimed at protec ting human health or human life, and the exception shoul d be permissible until the threat to human health has subsided. The current rule adequately allows for the OSC to approve use of dispersants in such cases and EPA has not justified that the proposed requirement is necessary or provides any benefit to existing requirements.

X. Section § 300.910(e) Prohibited Agents

A. *Banning nonylphenol (NP) and nonylphenol ethoxylates (NPE) is not necessary for dispersants.*

API and NOIA submit that NP and NPE components should not be banne d. In the preamble to this section (column 2, 80 Fed. Reg. 3391), the Agency makes the following statement:

> *"The Agency is also proposing to add a prohibition from listing on the Schedule and from authorizing use of any chemical or biological agents that contain n onylphenol (NP) or nonylphenol ethoxylates (NPEs) as components."*

While we appreciate the Agency's concern about NP and NPE components, an outright prohibition seems inconsistent with the practice of allowing NP and NPE ingredients in a variety of widely-used cleaning products in the U.S. After use, these products are routinely flushed and transported into wastewater discharges on a daily basis. Spill response dispersant use is extremely infrequent and only occurs when a significant threat to shoreline or near shore resources is present. Banning these components in oil spill dispersants while allowing their wide spread use in other commercial products seems contradictory and prejudicial. API and NOIA requests that the Agency explain why NP/NPE is banned in dispersant products, but not in many more commonly manufactured products.

B. *Endocrine disruption testing has little relevance and is not necessary.*

We submit that endocrine disruption testing should not be added. In the same section (column 1, 80 Fed. Reg. 3392), the Agency states:

> *"Because validated testing methods are still being developed the agency is not proposing any test requirements with respect to endocrine disruption for products to be listed on the Schedule."*

We believe that adding any such testing provides little relevance in the context of oil spill response decisions and that testing efforts are better directed at the use of standardized toxicity tests with aquatic organisms using endpoints of population relevance (i.e., mysid and *Menidia* tests proposed).

C. *Mechanical response clean-up methods have greater limitations in offshore conditions than dispersants.*

Mechanical response clean-up methods have many limitations. In the same section (column 2, 80 Fed. Reg. 3392), the Agency makes the following statement:

> *"There are chemical and biological agent alternatives to sinking agents and to agents containing NP or NPE; <u>as well as mechanical methods</u>* (Ed. emphasis added) *for responding to oil discharges, including those situations that pose extreme threats or are time critical."*

We believe the Agency must realize the limitations that mechanical response methods have in offshore conditions. Weather conditions will preclude booming and skimming operations in sea states above six feet wave height, and even in ideal sea state conditions, responding to offshore spills historically has resulted in 5-10% of spilled oil recovered by mechanical recovery methods. For this reason, it is critical that responders have reasonable access to chemical response methods, because of the substantially higher encounter rates (80% or more) that can be achieved by treating the spilled oil with dispersants.

XI. <u>Section § 300.910(f) Storage and Use of Agents</u>

A. *No additional requirements should be put in place for product shelf life.*

Currently, the manufacturer is required to provide information on recommended conditions of storage and use for each product at the time an application for listing a product under Subpart J is submitted to the Agency. With regard to shelf life, the Agency is requesting comments on whether more information should be submitted on issues related to shelf life. Specifically, in the preamble to this section (column 1, 80 Fed. Reg. 3393), the Agency makes the following statement:

> *"To alleviate concerns that applications are submitted that establish an extended or indefinite shelf life for a product, the Agency is requesting comments on whether any*

> *additional data or information requirements should be included for the product listing determinations specific to a product's shelf li fe, or whether alternative approaches, such as limiting the shelf life for product categories to a given timeframe, should be considered."*

API and NOIA believe that no additional requirements should be put in place for product shelf life and thus it shoul d not change the current practice of having the manufacturer provide information on recommended conditions of storage and use for each product. Ensuring product efficacy (regardless of age) is the only relevant end-point. For example, research has shown that properly maintained stockpiles of Corexit 9500 have remained effective for 25 years. Given that periodic effectiveness testing is proposed, there is no justification for also mandating a shelf life that could potentially result in costly replacement of stockpiles that remain viable and effective.

If the Rule dictates a dispersant shelf -life, this could caus e an undue financial burden. We believe that suppliers may set low shelf-lives to protect themselves from liability or to promote future recurring s ales, even though there are well-documented studies indicating that properly stored dispersant stockpiles have maintained their effectiveness for decades. A 2008 study by Clark, *et al.*,[30] evaluated U.S. stockpiles of Corexit 9527 and concluded that batches of this dispersant have remained viable for spill response for over 30 years. Establishing shelf -lives for products makes sense if periodic testing is not specified. However, since the Proposed Rule specifies re -testing of the dispersant stockpiles, there is no justification for also requiring a shelf -life. We submit that the requirement for a shelf -life should be removed from the Proposed Rule and that the Agency should instead provide more clarity on product re - testing for efficacy. Specifically, the requ irement to conduct periodic 5 -year tests of effectiveness and toxicity is unclear. The sampling requirement has not been delineated in the Proposed Rule, which could be interpreted, in the extreme case, that every single dispersant container would have to be re-sampled and tested to remain in an "approved" status.

The Rule should clearly state that representative samples of batches/lots are tested for efficacy and that the testing interval take into account the aforementioned studies that demonstrated tha t dispersant stockpiles maintain effectiveness for decades. Further, we submit that there is no scientific justification for re-testing toxicity.

B. *Central dispersant stockpiles are typically maintained by OSROs, not by Responsible Parties or product manufacturers.*

Under the Proposed Rule the OSC would only be able to authorize use if the Responsible Party certifies that the products have been stored under the conditions provided by the submitter. In this section in the Proposed Rule (column 2-3, 80 Fed. Reg. 3423), the Agency makes the following statement:

> *"The OSC may authorize for use only products that are certified by the Responsible Party to have been stored under the conditions provided by the submitter under 300.915(a)(6) and whose date of use does not exceed the expiration date listed on the container's label at the time of the incident. The Responsible Party must provide the OSC product documentation, developed in consultation with the submitter of the product to the Schedule, prior to OSC authori zation of product use affirming it has maintained its integrity, including no changes in its composition, efficacy, and toxicity."*

[30] Clark, J., Becker, K., & Lessard, R. (2008). Maintaining dispersant stockpiles and assessing their quality. *Proceedings of the 2008 International Oil Spill Conference, 2008*(1), 695-698. doi:10.7901/2169-3358-2008-1-695

The Agency needs to recognize that central dispersant stockpiles are typically maintained by OSROs and are stored mainly in 200 to 300 gallon totes so that they can be transported by truck or air to the site of a spill. In most spill situations, the dispersant stockpile will not be in the control of the Responsible Party or the submitter of the product (i.e., the original manufacturer) at the onset of a spill. As a result, there is no way for these two entities to make a certification for a product that was not in its direct control just prior to the spill. API and NOIA suggest modifying the language to clarify that Responsible Parties must only demonstrate compliance with Section 300.915(a)(6) for inventory/product they control.

C. *Certification of storage conditions should not be required for authorization of use.*

Section § 300.910(f) states that the OSC may authorize for use only products that have been stored under the conditions specified by the manufacturer including the maximum, minimum and optimum temperatures as well as humidity and other relevant conditions. This proposed regulation could require dispersants to be stored in climate controlled buildings with continuous temperature and humidity monitoring. We do not support this proposed requirement.

D. *API and NOIA opposes any re-testing requirements during a spill response.*

The intent of this section is difficult to discern but it appears that the certification requirement appears to essentially requires complete retesting of the product (at the time of the spill) for the Responsible Party to certify such a statement. It appears that the Agency has included this language with the specific intent to delay the dispersant authorization process by requiring complete re-testing at the time of a spill incident. We strongly oppose any re-testing requirements during a spill response. Any product testing should be conducted at a specified, planned interval, not during an emergency response. During a response, the Responsible Party should not have to certify the dispersants that will be applied, since that is the purpose of the NCP Product List. The only requirement should be for the Responsible Party to show the OSC, if requested, the original manufacturer's verification (Certification of Analysis) that the product meets specifications for dispersants with an age of less than the period for retesting recommended by the manufacturer. For older dispersants the Responsible Party should, if requested, show the efficacy re-test data for the stockpile. The test required should only be for effectiveness as it is a reliable indicator that the composition has remained the same. We propose that this language is changed to read: *"The OSC, to authorize the use of dispersants, may request that the Responsible Party provide test data of the dispersant stockpile showing it is effective."* We also suggest modifying the language so that it applies only for product manufactured or produced after the date of final rule publication.

E. *Re-testing requirements must permit flexibility in test results over time.*

This same section specifies re-testing and re-labelling requirements. This section does not specify the criteria for re-testing results and needs to specify permissible levels of deviation from past testing results. We point out that efficacy and toxicity testing have inherent variability. Two testing runs of the same product, in the same laboratory, in the same week can yield varied results, so any re-testing requirements must permit flexibility in test results over time. We suggest an allowable 10% variance in effectiveness test results, based on manufacturer and scientific experts' opinion on effectiveness testing. As previously stated, we do not believe there is any scientific justification to re-test for toxicity since efficacy results will confirm if the composition of the dispersant has changed. We suggest clarifying language so that it is clear product testing is only required if it is not stored under requirements provided by submitter, or it has expired.

F. *The assignment of an arbitrary 5-year life to products is biased and creates unwarranted expense due to recurrent testing.*

Finally, the assignment of an arbitrary 5-year life to products without regard to prior research on product viability over time, or on manufacturer input on product re-testing, is biased and creates unwarranted expense due to recurrent testing. Proposing 'no change' in composition, efficacy, and toxicity seems unreasonable and could result in significant costs of replacing usable dispersant stockpiles. Additionally, dispersant manufacturers typically advise that container seals not be broken and the material not be exposed to air, which would be necessary to test existing stocks, which may or may not have an expiration date printed on the label under current regulation.

Studies exist that show Corexit products maintain effectiveness for 25 years. We believe that any re-certification term should be based on existing scientific and manufacturer data. There should also be an allowance for some change/degradation of product over time, aligned to international practice. For example, the United Kingdom Marine Management Organisation allows a loss of efficacy to 75% of the original minimum level. Further, there is no scientific rationale to require any form of toxicity re-testing of a dispersant that was previously tested. Manufacturers will have the best insight regarding when product recertification should be needed. In addition, the Responsible Party should never be required to re-label products they did not produce, with the possible exception of adding a re-test date for product efficacy.

XII. Section § 300.910(g) Supplemental Testing, Monitoring, and Information

A. *API believes the standard efficacy and toxicity tests already required are more than adequate for regional use.*

We do not believe there is a need for additional testing than is currently required under the NCP. In the preamble to this section (column 2, 80 Fed. Reg. 3393), the Agency makes the following statement:

> *"The proposal removes 'in addition to the test methods specified in 300.915 and described in appendix C to part 300.' While RRT's may want to use the efficacy and toxicity testing protocols specified in Appendix C of the NCP for comparative purposes, the proposed revisions clearly establish the RRT's authority to require tests using parameters beyond those specified in Appendix C. Furthermore, there may be supplementary toxicity and efficacy testing information based on recognized standard testing methods already available that RRTs may want to consider when addressing site, area, or ecosystem specific concerns."*

We believe the standard efficacy and toxicity tests already required are more than adequate for regional use. We suggest the Agency consult the NOAA Dtox database. A review of that database suggests that the sensitivities of all tested species are in the known range and that additional tests simply reinforce the existing species sensitivity distribution curves. Regional data are unlikely to fundamentally change overall NEBA considerations for dispersant use. Any regionally required laboratory efficacy tests during a response will not be as relevant as a pilot test in the field and will only delay the dispersant authorization process approval beyond the window during which dispersants could be applied (thereby precluding their use in some situations where they may have provided a net environmental benefit). This proposal allows RRTs to request a broad range of additional data on a product, a situation that creates the potential for confusing and costly testing and is unlikely to add further information of value to oil spill response decision-making.

B. *Additional monitoring during a response is unreasonable.*

Section § 300.910(g) provides the RRT with the authority to request that the OSC require the Responsible Party to conduct additional monitoring associated with use of a product. We submit it is unreasonable to require additional monitoring during a response except in exceptional circumstances. In the preamble (column 2, 80 Fed. Reg. 3393), the Agency makes the following statement:

> *"For example, the RRT may want to monitor the exposure of marine mammals to oil constituents, including the dispersed oil, or to monitor toxicity in the water column using biological assays."*

We believe such monitoring during a response is unreasonable and should only be undertaken if (a) there is some critical question associated with the spill response that has not been answered with the testing already in place; and (b) there is sufficient time to arrange for proper and scientifically defensible protocols to be established. Given that tests associated with such monitoring are likely to be complex and require considerable time to prepare, implement, and interpret, it appears that the tests would not inform operational decision-making during the response, but rather would develop data for NRDA. As previously stated, operational monitoring and NRDA are two different things and this Proposed Rule should not specify NRDA monitoring. Additionally, the "biological assays" that are referenced in the Proposed Rule are impractical given the nature of offshore spills where dilution is significant, water movement is constant, and synoptic sampling of small quantities of organisms from dynamic water masses is not representative of any chronic or resident conditions.

API and NOIA suggest revising the language as follows:

> *(g) Supplemental Testing, Monitoring and Information. The RRT may require supplementary toxicity and efficacy testing, or available data or information that addresses site, area, or ecosystem specific concerns relative to the use of a product for both planning and authorization of use. During a discharge incident, the RRT may request that the OSC require a Responsible Party to conduct additional monitoring associated with the use of a product to the extent necessary for conducting response operations. Such additional monitoring data may include supplemental sampling and testing to ensure safety of response personnel, to assess acute environmental impacts or otherwise aid the OSC and/or the RRT in operational decisions.*

XIII. Section § 300.910(h) Recovery of Agents from the Environment

A. *The OSC has the authority to use the NEBA process to make decisions on recovery of agents from the environment.*

In the preamble to this section, the Agency is requesting comments on new language that would require the Responsible Party, under OSC oversight, to remove specified products/agents from the environment after use. While the Proposed Rule hints at NEBA, it does not reference it specifically when suggesting that some situations (e.g., safety of personnel or greater harm to the environment) might preclude the removal of these agents. That would seem to contradict the main change in this section (h) while not providing any framework (e.g., NEBA) in which to make a determination for precluding the removal. The language is also potentially redundant as the OSC is already obligated to consider safety and additional adverse environmental impacts (i.e., via NEBA) as part of the normal decision-making process. Essentially, it is already an underlying tenet of the response process. Additionally, in some cases recovering 100 percent of these agents after application is not practical or even feasible regardless of the diligence of the Responsible Party

We suggest revising the proposed language to make it clear that the OSC has the authority to use the NEBA process to make these decisions:

> *(h) Recovery of Agents from the Environment. Depending on factors such as the safety of response personnel and harm to the environment (including consideration of Net Environmental Benefit Analysis [NEBA]), and as directed by the OSC, the Responsible*

Party shall, following application, endeavor to adequately contain, collect, store and dispose of the agents that are intended to be recovered from the environment.

XIV. Section § 300.910(i) Reporting of Agent Use

A. *The Agency should not adopt a prescriptive time period for reporting of agent use.*

The Agency is requesting comments on the appropriateness of requiring the OSC to provide the RRT additional reporting information " *within 30 days of completion of agent use* ." This runs counter to the adaptive decision-making that might be required during a discharge event where such agents are used.

Based on the pre authorization testing that is being proposed and, more importantly, the variability of discharge situations, we recommend that the Agency not adopt a prescriptive time period and rather provide the relevant RRT(s) discretion to determine the appropriate time period for reporting agent use. A strong justification for this approach is that during prolonged discharges, a fixed 30 -day reporting period might constrain the response personnel and interfere with higher priority resource allocations. Furthermore, the OSC would typically request this information as part of the daily briefing.

API and NOIA suggest removing the 30-day window for reporting and modifying the proposed language as follows.

> *(i) Reporting of Agent Use. Unless already included in the OSC report required under § 300.165 of this part, the authorizing OSC shall provide the RRT the following information on chemical and biological agents used in response to an oil discharge: product name, quantity and concentration used, duration of use, and locations.*

XV. Section § 300.913 Monitoring the Use of Dispersants

A. *The appropriate use of spill mitigating products will reduce the overall impact of the spill and protect the health and safety of response personnel.*

The Agency makes the following two related statements to explain the goal of the NCP Product Schedule (column 3, 80 Fed. Reg. 3393; column 3, 80 Fed. Reg. 3402; respectively):

> "*The goal of establishing a Schedule under the NCP is to protect the environment from possible damage related to spill mitigating products used in response to oil discharges.*"
>
> *"Emergency response personnel need to know whether a dispersant or any other type of chemical or biological agent on the Schedule could have negative environmental impacts relative to the oil before decisions are made about its use in a particular oil discharge situation. Consequently, it is essential to consider comparative information about the efficacy and the toxicity of these products.*"

Possible damage related to spill mitigating products used in response to oil discharges is considered, but not the possible damage that could be caused by the oil itself without the use of spill mitigating products. The main threat to response personnel, communities, and the ecosystem comes from the oil, not from the spill mitigating products. The concept of CERA/NEBA accepts that some effects might be caused by the response (including the use of spill mitigating products), but also recognizes the greater benefit of reducing the overall impact of the spill that can be achieved by using them. The Agency needs to acknowledge the importance of NEBA in justifying the use of dispersants.

We believe that the focus on the potential for negative environmental impacts that could be caused by a dispersant ignores the essential point that dispersants are used to mitigate (minimize) the negative human health and environmental impacts that could be caused by the oil. The main threat to the ecosystem comes from the oil itself, not from the dispersant. The wording of the preamble to a final rule needs to:

- reflect the ultimate aim of dispersant use;
- clarify that the toxicity of dispersed oil comes from the oil (not the dispersant); and
- acknowledge and emphasize the importance of using a NEBA process in dispersant use decision-making.

We request that the Agency consider including the following two paragraphs (or equivalent language) in the preamble to the final rule to briefly explain dispersant use and the importance of NEBA in making dispersant use decisions.

> *"Dispersant Use and Net Environmental Benefit Analysis (NEBA)*
> *The aim of dispersant use is to protect response personnel from VOC exposure and to prevent oil from drifting ashore and potentially causing severe and long-term damage to coastal resources and communities, by dispersing the oil into the water column where it will be diluted rapidly to very low concentrations and the majority of the oil will subsequently be biodegraded. This common aim of dispersant use is the same, whether it is applied to oil on the sea surface or directly at the outflow source in the case of a subsea release. The potential risk of dispersant use is that, by dispersing the oil into the water column, there is an increased potential for toxic effects to be caused to marine organisms. The severity of the toxic effects that could be caused is related to the exposure of the marine organisms to the dispersed oil (or the partly water-soluble oil compounds) and exposure is a function of concentration of the oil in the water and the duration for which such exposure persists.*
>
> *The issue of the environmental trade-offs caused by dispersant use is addressed by Net Environmental Benefit Analysis (NEBA). NEBA is a process used to make choices about oil spill response techniques to be used to minimize the potential impacts of the oil on people and the environment. NEBA takes into account the likely effectiveness and feasibility of conducting alternative response techniques under the prevailing conditions. The main principle of NEBA is that an oil spill response technique (or combination of techniques) that is used should be that which minimizes potential impacts of the oil on the environment to the greatest extent and promotes the most rapid recovery and restoration of the affected area. In many cases of dispersant use, the potential risks to the offshore marine ecosystem are very low because dispersed oil concentrations are low and persist only briefly. There is benefit in using dispersants in offshore environments to prevent damage to coastal communities and sensitive near-shore resources where persistent stranded oil can cause longer-term environmental problems."*

The Proposed Rule also appears to focus more on the environmental effects during the response rather than the health and safety of response personnel. The Agency should make it clear that one of the primary objectives of characterizing the efficacy and understanding transport is to protect the health and safety of response personnel. That critical aspect is not mentioned in this section.

B. *The OSC should determine where, when, and how monitoring resources should be deployed.*

EPA should clarify the meaning of the phrase *"upon initiation and for the duration of subsurface dispersant use."* Later in this section of the preamble (column 2, 80 Fed. Reg. 3394), the Agency states the following:

> *"The proposal requires the responsible party to implement monitoring for any subsurface dispersant use in response to an oil discharge upon initiation and for the duration of subsurface dispersant use."*

The phrase *"upon initiation and for the duration of subsurface dispersant use"* can be misconstrued to mean that all monitoring required by the Proposed Rule must be performed at all times, when in fact the monitoring timing and operational parameters should be established by the OSC. Every response is unique, and it should be left to the OSC to determine where, when and how monitoring resources should be deployed to provide the best near real-time operational monitoring on the progress of the response.

C. *The Proposed Rule should be restructured to separate surface dispersant application monitoring from subsea dispersant injection monitoring.*

EPA should distinguish between surface and subsea dispersant application monitoring. In the first paragraph of this section in the Proposed Rule (column 1, 80 Fed. Reg. 3424), the Agency states:

> *"As directed by the OSC, the Responsible Party must monitor any subsurface use of dispersant in response to an oil discharge, surface use of a dispersant in response to oil discharges of more than 100,000 US gallons occurring within 24 hours, and surface use of dispersant for more than 96 hours in response to an oil discharge, and submit a Quality Assurance Project Plan for approval to the OSC covering the collection of all environmental data".*

We believe it is significant that monitoring is to be required *"as directed by the OSC."* It should be made clear that the OSC has discretion to authorize initial use of dispersants during a time-limited efficacy testing phase while evaluating the need for and extent of additional adaptive monitoring actions. The OSC is in the best position to determine when and what operational spill response monitoring is to occur. Experience has shown that the use of phased monitoring approaches, consistent with the USCG *et al.*'s *Special Monitoring of Applied Response Technologies* (SMART) protocols, is appropriate, and they are most responsive to changes in site-specific conditions and information requirements. While the requirement for the Quality Assurance Project Plan (QAPP) is constructive in helping to maintain effective data integrity and management, the rule should provide the OSC with discretion in how detailed the document needs to be to meet this requirement. This would provide the relevant incident decision-makers with practical information that can be consistently acquired, analyzed, and understood.

The Proposed Rule seems to inappropriately replace the currently used 3-tier SMART protocols for monitoring surface dispersant use with the more exhaustive monitoring approach proposed for subsea dispersant use. The USCG Strike Teams already have the responsibility for monitoring surface dispersant operations and possess the trained personnel and equipment to conduct these activities. Many RRTs require the immediate activation of USCG Strike Team monitoring for all dispersant operations, regardless of size or location. We believe it is beneficial to have the government perform the surface monitoring to enhance credibility with the public that the operations are being conducted correctly and are working as intended. If this practice is going to change, the Agency should explain why it is circumventing an established, well-vetted process performed by the USCG Strike Teams. The information in the Proposed Rule creates confusion between existing responsibilities of the USCG Strike Teams and those of the Responsible Party. We request that this confusion be reconciled between the Agency and the USCG, as the Responsible Party should not be required to provide duplicate monitoring for surface dispersant operations.

For these reason s, we believe this section of the Proposed Rule should be restru ctured to separate surface dispersant application monitoring from subsea dispersant injection monitoring. API and NOIA offer the following relevant points:

- The section on surface dispersant application monitoring should specify that it will be implemented with existing SMART protocols using USCG resources.
- The section describing subsea dispersant injection monitoring should specify it will be performed by the Responsible Party.
- In both cases, the Proposed Rule should clearly state that the mobilization o f monitoring capabilities will not delay initial dispersant applications. Monitoring requirements should not impede the use of chemical agents during a response and should be implemented as appropriate resources become available during the response.
- The c riteria of greater than 100,000 gallons or duration of 96 hours for the spill should be replaced with a single criterion that " *any enhanced monitoring beyond SMART shall commence within seven days.* " Our rationale for a deployment schedule of seven days for any enhanced monitoring (whether subsea or surface dispersant monitoring) ensures that scientifically - defensible monitoring can be performed, by ensuring:
  - The best scientific experts can be assembled and mobilized to the spill;
  - Once on scene, the science team can design a monitoring plan that can be integrated safely into ongoing response operations, and be worked into the Simultaneous Operations (SIMOPs) schedule;
  - The team can tailor a general monitoring strategy into a specific mission plan for the monitoring vessel that is available (there is no way to know what research vessel may be available, and each vessel will have unique characteristics for equipment deployment);
  - Available monitoring vessel(s) can be identified, mobilized to port, and properly out fitted with the scientific equipment needed to implement the mission plan;
  - An appropriate sampling strategy can be developed and approved for the specific incident, taking into account ongoing response activities that may impede access to sampling sites; and,
  - Appropriate safety considerations for the monitoring vessel, dispersant application or injection platforms, and rapidly-assembled teams can be properly reviewed.

D. *Effectiveness determination is not currently scientifically feasible.*

The language in this section of the Proposed Rule appears to indicate the Agency believes that comprehensive monitoring will permit the dispersant effectiveness at sea to be quantitatively determined. This requirement for effectiveness determination is not currently scien tifically feasible. Also, use of the word "*comprehensive*" should be avoided as it is subjective. Instead, it should be replaced with "*adaptive*" which indicates that a decision could be revisited as the d ischarge situation changes. We recommend replacing all instances of the word " *comprehensive monitoring*" with "*adaptive monitoring*" throughout the proposed section. The following language could be used:

> *The agency believes that an adaptive monitoring program which includes objective science and ocean transp ort modeling in certain discharge situations is necessary to determine the overall effectiveness of the dispersants and should transcend the initial dispersant application to include the extent, character, and transport of the dispersant and dispersed oil in the water column.*

With respect to <u>surface dispersant use monitoring</u>, we offer the following comments:

- Experience at the DWH and other incidents has shown that no currently available remote sensing technique, including airborne visible/infrared spectro meter (AVIRIS) and other multi- and hyper-spectral equipment, is capable of accurately quantifying the total amount of oil on the sea surface. It is also not possible to accurately determine the total amount of dispersed oil in the water column at any time because water sampling or ultra violet fluorometry (UVF) transects cannot be made at sufficient resolution in space (i.e., distance and depth) and cannot be made at sufficient resolution in time (i.e., simultaneously at all points in the water under an oi l slick). Localized measurements by UVF made before and after dispersant spraying can reveal the relative effect of dispersant use, but is not quantitative . A sharp increase in dispersed oil concentrations in the water, after dispersant use, is a good indi cation that the dispersant is working, but such measurements cannot produce an aggregate estimate of disper sant effectiveness. As such, we believe that the Agency should remove any requirement for quantitative reporting of efficacy, since it is not technically possible.
- A QAPP should not be required for surface dispersant operations. QAPP for approval by the OSC covers the collection of all environmental data to ensure and maximize its quality, objectivity, utility, and integrity. All these requirements wil l result in the need to generate a very large document that needs to be reviewed, verified and approved by OSC. This will lead to delays in dispersants decision-making, while adding little value to the goals of the response. A more useful approach may incl ude a daily Quality Control review of the SMART data to determine if the surface dispersant applications were effective that day, to support decisions for possible dispersant use the next day. A Quality Control form was developed during DWH for this purpos e. we believe the QAPP requirement should be deleted for surface dispersant operations and replaced with a simplified Quality Control form for SMART data.

With respect to <u>subsea dispersant injection monitoring</u>, we provide the following comments:

- The Age ncy does not address methods for visual determination of subsea dispersant effectiveness. During DWH, visual monitoring of the subsea dispersant injection was conducted in two ways to provide valuable, near real -time information to help inform response dec isions. These included:
  - Aerial observations of surfacing oil quantity and appearance (provided from observation aircraft overflights); and
  - Subsea observations of changes in plume appearance at the injection site (provided from ROV imagery).

  This form of monitoring for subsea dispersant injection should be recognized as an important step for initially evaluating the operation while more "enhanced scientific monitoring capabilities" are being assembled.
- API has developed subsea monitoring guidance (API Techn ical Report 1152 , *Industry Recommended Subsea Dispersant Monitoring Plan – Version 1.0*) and recommends the Agency consider this as the basis for their approach for operational monitoring. This guidance is publicly available at http://www.oilspillprevention.org/~/media/oil-spill-prevention/spillprevention/r-and-d/dispersants/api-1152-industry-recommended-subsea-dis.pdf.

XVI. Section § 300.913(a) Documenting and Monitoring the Oil Discharged and Dispersants Used Requirements

A. *The Responsible Party should not be required to document information at the beginning of a response that has already been determin ed in planning and preparedness activities.*

The current regulations found in 33 CFR Parts 154 and 155 require OSROs that use dispersants to maintain a certain level of spray assets, dispersant stockpile quantities, and logistical capabilities to

deliver stockpiles to staging bases, and to provide information on the application dosages they can apply. Since this is regulated elsewhere, reporting of these elements should not be required in the Proposed Rule and should therefore be deleted.

The Responsible Party should not be required to provide the *"rationale for dispersant product choice(s) including the results of any efficacy and toxicity tests specific to area or site conditions."* If the dispersant product is on the Product Schedule (which means that eff icacy and toxicity data have already been provided to the government), then it is, by definition, a viable option for the response.

Providing *"hourly application rates"* does not apply to aerial and vessel application since dosages are prepared in gallons per acre application and are based on the spray assets' application speed an d spray system swath width. We suggest that this statement be modified to read: *"hourly application rates (in the case of subsea dispersant injection)."*

The phrase " *recommended di spersant-to-oil ratio (DOR)* " should be modified to " *recommended <u>initial</u> dispersant-to-oil ratio (DOR).* " Every spill is different, and the DOR should be adjusted as additional monitoring, analytical data results, and/or oil release rate information becomes available. Additionally, the DOR may need to change as the oil weathers or other conditions change. The Agency should consider providing a clarifying sentence recognizing that oil characteristics and effective DORs may vary and thus dispersant application rates/volumes cannot be fixed to pre-determined values as this practice may affect negatively the response.

The Agency should refrain from requiring estimates of dispersant volumes needed to effectively respond to the spill at the onset of the response. In the case of a subsea oil release, it is impossible to know how much oil will be released and , therefore, impossible to estimate what volume of dispersants might be necessary. Further, as oil weathers, DORs for surface application will need to be adjust ed, and these changing weathering conditions cannot be fully known in advance. Given current dispersant stockpiles in the U.S. and in the Global Dispersant Stockpile, it should be assumed that sufficient dispersants will be available if their use is warranted by NEBA.

B. *Identifying and reporting associated volatile petroleum hydrocarbons will be impossible with changing environmental conditions, and is unnecessary for response decision-making.*

The requirement to *"...document any associated volatile petroleum hydrocarbons..."* would be very difficult to achieve, given that volatiles will fluctuate with sun exposure and changing wind conditions. The reason for this requirement is not explained; therefore, the Agency should specify what is intended by this requirement or delete it.

C. *The Agency should accept best available industry practice for dispersant monitoring.*

There is no need to restate the requirement for documenting the results of toxicity testing. In general, the list of characteristics is practical and do es not create an undue burden ; however, there is a significant assumption in the requirements (i.e., that the condition of the discharge point is such that it will enable the acquisition of these data at any given time). A reference to a best available industry practice, or any of the existing guidance on dispersant sampling/monitoring (e.g., API guidelines on subsurface dispersant monitoring, API TR 1152) would be more effective for gathering the information requested by the agency without imposing undue b urden on response personnel. Additionally, there is no technical reason to differentiate subsurface discharges from the rest of this paragraph. We suggest removing this differentiation and suggests modifying the proposed language as follows:

As directed b y the OSC, the Responsible Party must monitor any subsurface use of dispersant in response to an oil discharge, surface use of dispersant in response to oil discharges of more than 100,000 U.S. gallons occurring within 24 hours, and surface use of dispersa nt for more than 96 hours in response to an oil discharge, and submit a Quality Assurance Project Plan for approval to the OSC covering the collection of operational monitoring data. When these dispersant use conditions are met, and for the duration of dispersant operations, the Responsible Party shall:

(a) Document the characteristics of the source oil; best estimate of the oil discharge flow rate, periodically reevaluated as conditions dictate, including a description of the method, associated uncertainti es, and materials; dispersant(s) product used, rationale for dispersant product choice(s), recommended dispersant-to-oil ratio (DOR); and the application method and procedures, including a description of the equipment to be used, hourly application rates, capacities, and total amount of dispersant needed.

XVII. Section § 300.913(b) Sampling Requirements

A. *Daily water sampling and testing is burdensome.*

The requirement to conduct these required tests on water samples daily may prove overly burdensome and not necessary after the initial efficacy tests. We suggest modifying the Proposed Rule to ensure that the OSC has discretion in h ow frequently the samples must be acquired after the initial efficacy tests are conducted. Sampling on a daily basis, once efficacy is determined and agreed, is arbitrary and does not fit the timeline required to provide in-depth analysis of samples.

The collection of water column samples where the dispersed oil plume is located is not necessary and in many cases is not possible for aer ial dispersant application. For spills of up to 100,000 gallons, aerial dispersant assets can be activated and apply dispersants to the entire spill area during Day 1, before a monitoring team can arrive on-site to conduct water sampling. It was shown during the DWH event that to collect water samples, special operations had to be developed and coordinated so that the vessel monitoring team had sufficient time to obtain the water samples of the dispersed oil. This was due to the fact that most of the area u nder the aerial dispersant application returned to normal background levels within one hour following the application. It should also be understood that water samples will only determine the amount of oil in the sample, not the effectiveness of the dispers ant, as there is no way of determining the amount of oil that was treated. As stated previously, these sampling requirements do not provide information on dispersant effectiveness and can therefore not inform the operational response. Water sampling requir ements are more appropriate to NRDA and should be directed under NOAA jurisdiction.

B. *The oil droplet size distribution measurement, as described, is not technically feasible.*

The requirement in 300.913(b)(1) to conduct *"in situ oil droplet size distribut ion, including the mass or volume mean diameters between droplet sizes ranging from 2.5 to 2000 µm* " is not possible for three reasons:

- The General Information section suggests that this measurement can be done via a Laser In Situ Scattering and Transmissometry (LISST) instrument, but the LISST detection limit is roughly 500 microns;
- Commercial droplet size measurement equipment suitable for deep water monitoring that ranges up to 2000 microns does not exist; and

- Even if such instrumentation became availab le in the future, there would be no way to safely deploy it in the resulting dispersed oil plume by either ROV or research vessel without interfering with other critical, oil spill response operations.

With respect to droplet size determination, the Agenc y should focus on the most important aspect of subsea dispersant injection, which is to significantly reduce the initial droplet size to slow and change the surface expression of oil release as well as "thin out" the surface slick for better dispersion on the surface. Work by API and sponsored by BSEE suggest that HD high speed photography or sonar are the most promising methods of studying changes in droplet size during a full scale applic ation of subsea dispersants. We propose that alternative methods (i. e., high definition, high speed photography; sonar; etc.), as they mature and become available, should be allowed. Additionally, there should be flexibility to use other, improved scientific methods as they become available.

C. *Fluorometry is only useful as a screening tool.*

Indirect measures, such as fluorometry, are useful only as a screening tool to help refine monitoring locations and not as direct evidence of oil or specific oil concentrations in the subsurface as suggested.

In 300.913(b)(2), in addition to *in-situ* fluorometry, the Proposed Rule also requires the Responsible Party to conduct a fluorescence intensity analysis on collected water samples to determine fluorescence signatures of the dispersed oil for use as a relatively simple and rapid mea ns to assess dispersion effectiveness. Fluorescence intensity in this context is redundant and not as meaningful a measure as particle size analysis. An alternative would be to simply suggest this as a potential measure that could be used as the situation demands. Moreover, dispersant effectiveness assessments using SMART Tier 1 visual monitoring is a relatively simple, rapid way to evaluate this and is a well-accepted practice, as is the use of simple fluorometry from the SMART Tier II protocol for surface dispersant application. The Agency should substantiate the need to replace the tiered monitoring approach of the SMART protocols and, rather than listing all possible tests that can be conducted, specify how they add value to response decision-making and offer improvements over other, existing approaches.

D. *Detailed chemical analysis is unnecessary and many of the tests are too di fficult to perform in the field.*

In 300.913(b)(4), the Agency should recognize that more real-time operational monitoring information can be obtained by "quick screening" some samples for total petroleum hydrocarbons (TPH) by means of a hand-held gas chromatograph flame ionization detector (GC -FID). Detailed chemical analysis will not inform the response decision-making process and should instead fall under the purview of NRDA.

The requirement in 300.913(b)(5) for carbon dioxide measurements is unclear. While pH and dissolved oxygen monitoring seem logical, carbon dioxide (CO_2) measurements are not routinely made in deep water. It is not clear from the Proposed Rule what benefit carbon dioxide monitoring would bring that dissolved oxygen does not already provide. Similarly, the proposed requirement to measure methane is also unnecessary as it is also linked to potential oxygen deple tion, and the measure of DO is a reliable and sufficient method. There is a limited amount of sensors and water sampling devices that can be deployed from a research vessel at one time and inclusion of CO_2 detection complicates other elements for the deployment of the instrument array.

Regarding the DO measurements, we suggest simply requiring the *in situ* measurement of DO using best available technology (which would currently be automated sensors) to measure dissolved oxygen at depth and not expose it to surface pressures and temperatures before or during analysis. Verification can be achieved through the use of consistent sensor cleaning procedures, calibration tests, and redundant sensors which can be compared. Winkler titration, as discussed in the Proposed Rule, is an outdated

analytical method that is impractical for use on unstable offshore vessels, is prone to the introduction of human errors, and would slow the information flow within the response. If periodic bench tests are required to verify the integrity of the *in situ* DO sensor measurements, there are more consistent and reliable techniques than Winkler titration. We also recommend that only a fraction of the water samples be used to verify the *in situ* DO measurements as opposed to every sample , which will slow the process and information flow.

With respect to TPH analysis, the recommendation would be to provide these data for a fraction of the water column samples as opposed to every water sample (as currently proposed).

The requirement in 300.913(b)(7) for analyzing heavy metals has no bearing on dispersed oil monitoring. There is no operational reason for collecting these data. This should fall under the purview of NRDA. The source samples of oil are much better sources for determining the proportion of individual constituents. The carbon dioxide, methane, and heavy metals analysis requirements do little to inform response decisions, add unnecessary time and cost to the response activities, and would have a high degree of uncertainty in the absence of understanding the natural variations that might occur in the water column or in the case that a compounding discharge event (e.g., major flood) occurs during the response.

The focus of the Proposed Rule is almost exclusively on empirical data a nd should include some elements of 3-D and 4-D modelling to broaden the overall understanding of subsurface conditions.

We suggest revising the proposed language as follows:

> *(b) In areas not affected by the discharge of oil, collect a representative set of background water column samples following standard operating and quality assurance procedures, at the closest safe distance from the discharge as determined by the OSC and in any direction of likely transport considering surface and subsurface currents and oil properties for the variables listed below. Adherence to API TR1152 meets the requirements of this subsection. In the dispersed oil plume, at an interval designated by the OSC, collect water column samples following standard operating and quality assurance procedures, at such depths and locations where dispersed oil is likely to be present to analyze for the following:*
>
> > *(1) In-situ oil droplet size distribution, including mass or volume mean diameter for droplet sizes, with the majority of data coll ected between the 2.5 and 100 µm size;*
> > *(2) In -situ fluorometry signatures targeted to the type of oil discharged and referenced against the source oil;*
> > *(3) Dissolved oxygen (DO);*
> > *(4) Total petroleum hydrocarbons (based on an extracted water sample), individual resolvable constituents including volatile organic compounds, aliphatic hydrocarbons, monocyclic, polycyclic, and other aromatic hydrocarbons including alkylated homologs, and hopane and sterane biomarker compounds;*
> > *(5) 3-D and/or 4-D modeling when/where practical*
> > *(6) Turbidity;*
> > *(7) Water temperature;*
> > *(8) pH; and*
> > *(9) Conductivity.*
>
> *The purpose of analyzing these components is to map the extent and location of subsurface oil ; to characterize the condition of that oil ; and to help inform transport models that are also a key part of the decision-making process by helping to characterize the overall movement of subsurface oil.*

XVIII. Section § 300.913(c) Dispersant Effectiveness and Oil Distribution Characterization

A. *The Proposed Rule needs to be clearer on what is required for surface monitoring and what is required for subsea monitoring.*

Section § 300.913 provides monitoring requirements collectively for "subsurface use of dispersant in response to an oil discharge, surface use of dispersant in response to oil discharges of more than 100,000 U.S. gallons occurring within 24 hours, and surface use of dispersant for more than 96 hours in response to an oil discharge…" However, the preamble is often unclear as to whether every requirement within this section applies to surface or subsea dispersant applications or both. To facilitate a better evaluation of the proposed changes, each subsection should be divided into those aspects that apply to subsea applications and those to surface applications and those that apply to both. Elements within this section are already addressed in other sections of this Proposed Rule, particularly water column monitoring. The sections ought to be combined. The concept of an informed monitoring program (one that includes fixed and adaptive sampling locations and modeling) is already well understood and acknowledged in the spill response community.

In 300.913(c), requiring best available technologies may result in equipment not suitable for field conditions. Consideration should be given to changing "*available*" to "*practicable*."

In 300.913(c), the best available technology requirement should acknowledge aerial photography as a tool to measure effectiveness. This was a key method of effectiveness assessment during DWH and is not mentioned in the Proposed Rule. It is much more practical than the concepts put forward in the present proposal.

The relative effectiveness of the surface application should be determined by using the SMART protocols. For surface application, it is impossible to determine a numerical effectiveness as the amount of oil on the surface that is being sprayed is not known. Note that the analysis equipment often cannot return to the spray site in time to capture the information requested as the dispersant plume quickly dilutes or cannot be found.

XIX. Section § 300.913(d) Ecological Receptor Characterization

A. *Monitoring required to determine possible environmental effects is too time consuming to support dispersant operations decisions.*

Industry agrees that environmental monitoring should be performed to support operational decision-making. Monitoring required to determine environmental effects, however, is likely to be too time consuming to support dispersant operations decisions and should remain a NRDA activity.

This section of the Proposed Rule requires the Responsible Party to characterize the ecological receptors and to consult with the OSC to determine an acute toxicity level of concern for the dispersed oil using available dose/response information relevant to potentially exposed species. Conducting the required ecological characterization of the spill site may not be possible in the available response time-frame. If the untreated oil is likely to drift ashore and impact a sensitive coastal resource within a day or two unless it is dispersed, there will be a very finite period of time for such considerations suggested in the Proposed Rule.

With respect to the proposed ecological thresholds, although it is constructive to have known benchmarks, it is not clear what decision would be forthcoming if a threshold were exceeded and would certainly be misplaced to derive new thresholds during a response. The documented toxicity of dispersed oil to individual laboratory organisms is by no means a measure of the overall population of that

organism, nor of the ecosystem as a whole, to recover from oil exposure. During a spill, dispersants operations might be stopped because of the threshold of an individual species even though there may be the potential for higher environmental damages beyond that species. During a spill, dispersants operations might be stopped based on a threshold for an individual species . The suggestion of using species sensitivity distributions (SSD) during an active response is a misuse of the method (which requires long periods of time to assess) and is counter to establishing frameworks that are relevant in the dynamic ocean setting.

Rather than requiring the Responsible Party to make this real-time assessment, a CERA/NEBA process (conducted as part of contingency planning) should serve as the basis to make operational decisions on whether dispersants and/or other agents should be used during a response. A CERA/NEBA is the only mechanism that allows a full environmental trade-offs analysis of all response options to be conducted.

XX. Section § 300.913(e) Immediate Reporting Requirements

A. *Reporting requirements should be more flexible.*

The Proposed Rule does not include any indication of what happens if such a requirement to immediately report the information is not met for any reason. From a functional standpoint, the idea of reporting is sound, but the OSC should have the discretion to determine the frequency of reporting.

The Agency is also requesting comments on whether similar requirements should be applied to surface dispersant application. There are already practical and agreed reporting requirements for surface dispersant use and the natural weathering and dispersion that takes place at the surface is fundamentally different than what might occur in the subsurface.

XXI. Section § 300.913(e)(1) Daily Sampling and Data Analyses Reporting

A. *The Agency should not develop requirements for daily authorizations of dispersant quantities.*

This section requires reporting of a deviation of more than 10 percent from the mean hourly volume of dispersant authorized for "*24 hours use*." The Proposed Rule does not require authorization of dispersant use in 24 hour increments. Such restrictive authorization requirements tremendously complicate dispersant operations while providing little environmental benefit. The Agency should not develop requirements for daily authorizations of dispersant quantities, as this decision should be based on the ongoing spill scenario and should be left to the OSC. Dispersant application rates may need to vary to account for dynamic spill conditions, environmental conditions, and other ongoing response operations. Placing daily limits on volumes of dispersants that may be used prevents trained response personnel from utilizing appropriate dispersant application rates. Furthermore, it circumvents the NEBA process that evaluates the best response options that protect the environment as a whole.

We suggest modifying the proposed language as follows:

> *(e) Report to the OSC as soon as practicable or at an interval determined by the OSC:*
> *(1) Deviation of more than 10 percent from the mean hourly dispersant use rate for subsurface application, based on the dispersant volume authorized for 24 hours use, and the reason for the deviation; and*
> *(2) Any threatened or endangered species, or other priority ecological receptors formally identified by the OSC in consultation with the Environmental Unit, that may be exposed, based on dispersed plume trajectory modeling and level of concern information.*

XXII. Section § 300.913(e)(2) Immediate Reporting of Ecological Receptors

A. *Real-time ecological receptor analysis is unrealistic and should be part of a CERA/NEBA process.*

The requirement in this section for real -time ecological receptor analysis is unrealistic. Such efforts need time and broad stakeholder participation to be meaningful. This information should be part of a NEBA process to document the resources at risk of the potentially affected ecosystem. Only through this detailed NEBA process can an adequate understating of overall ecosystem recovery be developed and assessed. Further, the process of overall environmental trade -offs is independent of individual species impacts and should be based at the ecosystem level.

XXIII. Section § 300.913(f) Daily Sampling and Data Analyses Reporting

A. *Daily reporting of water sampling data should only apply to subsea dispersant injection and is not useful for dispersant decision-making.*

This section should be amended to clarify that daily reporting of water sampling data only applies to subsea dispersant injection. Further, the requirement in Section 300.913(f)(3) for a 5-day turnaround time for analysis is unrealistic, given that it could take several days for the sample to be transported to shore and additional time for it to reach a qua lified laboratory and put in the queue for analysis. During DWH, the sheer quantity of samples overwhelmed both the regional and the nation's labs processing abilities. In many cases, the backlog of samples lasted 30 days or longer. A blanket requirement o f five days is unrealistic and should be replaced with a negotiated time that is staggered on the basis of sample data priority for operational decision-making. The data may be useful for NRDA, but not for dispersants decision-making because other monitori ng techniques can better inform decision-making. These water samples will provide information about concentrations in water from 5 or more days previously, but will be irrelevant for operational questions that require near real-time feedback.

We recommend combining this section with the proposed "*Immediate Reporting*" section into one section that notes the importance of reporting in supporting the coordination of response actions. Suggest modifying proposed language as follows:

(e) Reporting

(1) Report to the OSC as soon as practicable or at an interval determined by the OSC any:

(i) Deviation of more than 10 percent from the mean hourly dispersant use rate for subsurface application, based on the dispersant volume authorized for 24 hours use, and the reason for the deviation; and

(ii) Ecological receptors, including any threatened or endangered species that may be exposed based on dispersed plume trajectory modeling and level of concern information.

(2) Report to the OSC at an interval determined by the OSC, water sampling and data analyses collected in § 300.913(b) and include:

(i) Specific hourly dispersant application rate and the total amount of dispersant used for the previous reporting period established by the OSC with concurrence from the EPA representative to the RRT;

(ii) All collected data and analyses of those data within a timeframe necessary to make operational decisions, including documented observations, photographs, video, and any other information related to

dispersant use, based on a reasonable and appropriate timeframe authorized by the OSC;
(iii) Estimates of the transport of dispersed and non-dispersed oil and associated volatile petroleum hydrocarbons, and dispersants, using the best available trajectory modeling.

XXIV. Section § 300.915(a) General Information for any Product Category

A. *The proposed information requirements to be submitted by dispersant manufacturers may reduce the number of dispersant suppliers.*

The proposed requirements for information to be submitted, most likely by dispersant manufacturers, as described in 300.915 (a)(1)-(21), are extensive. API and NOIA are concerned that dispersant manufacturers may not have a sufficient business case to meet all proposed data requirements. The Agency therefore needs to demonstrate that this Proposed Rule will not collapse the market for dispersants and drive away all viable producers from supplying products to meet the need. Further, the Agency should consider developing a total re-listing cost analysis.

XXV. Section § 300.915(a)(5) Safety Data Sheet

A. *A Safety Data Sheet for each component in a product is unnecessary.*

The proposed requirement includes *"A Safety Data Sheet ('SDS') for the product."* We believe this is a reasonable request. However, in the preamble, the Agency solicited comments on the value of requiring an SDS for each individual component. We believe that requiring more than just an SDS for the whole product will add unnecessary burden to the submitter that will not add any protection. The information needed to protect responders will be provided in the SDS for the product as a whole.

XXVI. Section § 300.915(a)(11) Environmental Fate Information

A. *Vendors should not be required to generate new environmental fate information for their products.*

The proposed language in this section should be modified to clearly state that this data should be reported *only* if it is already available. As currently written it is unclear if the vendors are being asked to collect new data for their products to cover these parameters.

XXVII. Section § 300.915(a)(13) Identity and Concentration of Product Components

A. *Vendors should not be required to provide the identity and concentration of product components.*

Some vendors may refuse to submit this detailed data as it may threaten a proprietary advantage. This may result in less favorable/effective product being listed in the Product Schedule. We recommend that reporting should be restricted to naming the ingredients, but should not require that the percentage of each ingredient is disclosed. Although Proposed Rule Section 300.950(b) allows this information to be claimed as confidential business information, the requirement under 300.915(a)(13) still presents challenges because there is no guarantee that the claim of confidentiality will be accepted. This may discourage manufacturers from supplying dispersant products.

XXVIII. Section § 300.915(a)(15) Certification

A. *The requirement that product not contain levels exceeding the National Water Quality Standards is unnecessary.*

The agency is proposing certification, including data, methodology, and supporting documentation, indicating that the product does not contain levels that exceed the National Water Quality Standards lowest aquatic life acute value for the following contaminants: metals reasonably expected to be in the product including arsenic, cadmium, chromium, copper, lead, mercury, nickel, vanadium, zinc; cyanide; chlorinated hydrocarbons; pesticides; polychlorinated biphenyls (PCBs); and polynuclear aromatic hydrocarbons (PAHs).

The National Water Quality Standard Contaminants are defined as concentrations in the water column. Water quality criteria are applicable to receiving waters, not formulated products, and this proposal assumes the appropriate exposure is to full-strength (100%) product rather than a reasonable environmental-realistic exposure concentration.

This requirement is not reasonable because of the enormous dilution that occurs when any product is used in an oil spill situation, and it is not required for other chemicals released into the environment. We believe that the existing requirements to communicate hazardous impurities on product SDSs should be sufficient and suggests removing the requirement.

XXIX. Section § 300.915(a)(19) Annual Product Production Volume

A. *The requirement for vendor production capability is not realistic of the market for dispersants.*

Most dispersants are blends of components and are only manufactured upon request. Capacity is not fixed and varies with available blending tankage, existing business demands, other product orders, and component supplies/shipping constraints. While such data are very useful in a large spill where existing stockpiles could be depleted, the information provided in such a request at the time of the application would not be relevant to a future time when product manufacturing could be required during a response. Further, the development of both U.S. stockpiles and international Dispersant Global Stockpiles were designed to ensure that sufficient, effective dispersants will be available when needed. We believe this requirement should be removed. If not removed altogether, the Agency should consider modifying the language to require dispersant or agent producers to be able to provide such information within 24 hours should the OSC need it and make it a condition of product authorization. If the Agency is concerned about the availability of sufficient volume of dispersants required for operations, it should ensure that the main dispersants products that are used around the world and are extensively studied are included on the National Product Schedule and are available for response in the U.S.

XXX. Section § 300.915(a)(20) Recognition

A. *Design for Environment recognition is unnecessary.*

The Agency asks for recognition from EPA's Design for the Environment (DfE) if applicable. DfE recognition should not be included in the Proposed Rule because it is not required, and the Agency has other ways to advance voluntary programs.

XXXI. Section § 300.915(b)(1) Dispersant Efficacy

A. *The new efficacy test cannot predict field dispersant effectiveness.*

API and NOIA support the Agency's proposed change in efficacy testing from the Swirling Flask Test (SFT) to the Baffled Flask Test (BFT) method. The SFT was a very low energy test and required the use of low viscosity test oil s to achieve significant levels of measured dispersant effectiveness. The BFT is a much more energetic test method thus permitting the use of higher viscosity test oils to achieve higher levels of measured effectiveness with the same dispersant. It is impo rtant to recognize that such laboratory tests can evaluate relative effectiveness between different dispersants, but cannot be used to predict the effectiveness of dispersants in the field on specific oils under specific conditions , such as differences in wave height, possible application in high turbulence subsea or using prop wash in ice - covered waters.

B. *The new test oils may not provide comparable results if new test samples are obtained.*

We also support the Agency's proposed changes in test oils from South Louisiana Crude (SLC) and Prudhoe Bay Crude (PBC) to Alaska North Slope (ANS) and Intermediate Fuel Oil (IFO–120), since these new test oils provide a wider range of properties in the oils to be tested. The agency should note that ANS is a blend of c rude oils produced on the North Slope of Alaska, and the composition and properties have varied through the years as the crude oils produced on the Alaska North Slope have changed . Also, IFO-120 composition is entirely dependent on the crude run at the supplying refinery and their blending needs. However, IFO-120 is a blend of residual fuel components including vacuum resid uum cut with a lighter product to achieve a specified viscosity (i.e. , 120 cSt at 100F in this case), but will vary dramatically in composition between lots at a given refinery and between refineries. It is probable that the varying composition of IFO-120 will result in inconsistent DE results over time. This means that a single batch of IFO-120 will have to be preserved for all future pro duct testing to ensure comparability. The Agency should conduct stability tests of ANS and IFO -120 stocks to ensure they can maintain viable samples over time. The Agency could consider substituting a heavy crude oil rather than this heavy refined product or store a large single batch of IFO -120 with data provided on shelf stability or a provision to account for changes over time.

C. *Testing dispersant efficacy at different temperatures will not provide information that will predict dispersant effectiveness in real world conditions.*

We oppose introducing testing at different temperatures. This new approach implies that laboratory tests represent field conditions in some way which is not the case. The Agency proposes that dispersants should only be approved for the type of oil they worked in the lab and temperatures tested in the lab. This is incorrect as:

- different oils will be treated than the two tested in the laboratory;
- even the same oil will weather with potential effects to dispersant efficacy;
- turbulence in environment will surely be different;
- subsea injection even into the same oil in the Arctic is different because of oil temperature and turbulence level subsea; and
- dispersing oil in ice is also different from lab tests because of the mixing provided by vessel propellers.

In the preamble to this same section, the Agency appears to suggest that the Proposed Rule changes are intended to indicate the likely effectiveness of operational dispersant use on oil spilled in the Arctic or Gulf of Mexico (column 3, 80 Fed. Reg. 3403; both locales are specified). Relatively simple efficacy tests such as the BFT are incapable of simulating the range of parameters and processes that will be encountered and influence real -world dispersant effectiveness. The Rule sho uld clearly state that laboratory efficacy testing is a comparative screening tool for different dispersants under laboratory conditions and should recognize that a ctual dispersant effectiveness on oil treated at sea can vary a great deal from

effectiveness data collected in a laboratory. A dispersant/oil combination that produces an effectiveness result in the BFT laboratory method of 70% might result in >95% dispersion at sea (e.g., in a moderate sea state), and less dispersion in other circumstances (e.g., calmer sea state). Therefore as part of dispersant use authorization, divorced from the product approval process, the availability of suitable mixing energy becomes an operational consideration, coupled with the dilution potential for the dispersed oil. We suggest that reference to specific regions should be deleted from this section.

D. *Dispersant efficacy thresholds listed in the Proposed Rule are too high.*

In the preamble to this section (column 2, 80 Fed. Reg. 3403), the Agency's justification for dispersant efficacy thresholds (DE values) includes:

> "*Three of the eight dispersants tested clearly differentiated themselves from the other five dispersants for having the best DE_{LCL95} efficacy results… This natural break in the results provided the Agency with the basis for the proposed threshold criteria.*"

We believe the proposed thresholds of efficacy for listing on the Schedule are high. The supporting documentation in the docket shows that only six (not eight) dispersants were tested and two of these six dispersants were only tested with one oil. The rationale for selecting the proposed efficacy thresholds for listing on the Schedule is not convincing on the basis of the limited data presented. Data from another EPA study[31] shows significant variability in the results obtained with the BFT. Variability in test results is troubling and this variation could lead to confusing data sets where the same dispersant sometimes "passes" and sometimes "fails" because of the high threshold limit that has been set. While the Agency states it tested the dispersants currently listed and found three of them to be sufficiently effective, the EPA study on the BFT funded by BSEE and published in 2011 suggests otherwise. As shown in Table 3 of this BFT study, Corexit 9500 may not be listed based on published Dispersant Effectiveness (expressed as the LCL95) of 69% and 61% on ANS Fresh and IFO-120, respectively, at room temperature (15° C). This suggests that the recommended thresholds are potentially too restrictive and do not sufficiently take into account the variability of the BFT.

The Agency should reconsider the proposed efficacy thresholds for listing on the Schedule. We suggest that these thresholds could be lowered without any significant impairment to the effectiveness of operational dispersant use at a response. In addition, reporting only the DELCL95 reduces the amount of information available on a product. We recommend that the test average and standard deviation should be provided, which would provide additional information on the precision of the testing.

The Agency makes the following statement in the preamble (column 1, 80 Fed. Reg. 3404):

> "*As a result of this increased mixing energy, better dispersion is realized under conditions more realistic of wave action in the sea*"

We believe that this statement would be more accurate if it were re-phrased as follows:

> "*As a result of this increased mixing energy, higher dispersant effectiveness results are obtained.*"

Since the recent subsea dispersant injection development does not have major implications for the rationale behind the current tests for dispersant product approval, it might be important to recognize that the laboratory test data are sufficient to identify whether a product has appropriate effectiveness,

[31] Venosa and Holder, 2011, Laboratory-Scale Testing of Dispersant Effectiveness of 20 Oils Using the Baffled Flask Test

irrespective of whether the product may be considered for use in surface application or subsea injection (SSDI) scenarios. Additional testing for SSDI approval is not necessary.

XXXII. Section § 300.915(b)(2) Dispersant Toxicity tests and listing criteria

We offer the following comments on the proposed revisions to the toxicity testing and has ordered the comments by specific test.

A. *Standard static acute toxicity testing should be used only for the dispersant alone.*

The Agency proposes that a dispersant should be tested using a modified standard static acute toxicity test for the dispersant with *Americamysis bahia* and *Menidia beryllina* using the 48 hour and 96 hour duration LC_{50} procedure. We agree there is a need for toxicity testing of dispersants to prevent highly toxic (LC50 <1ppm) dispersants from being listed on the Schedule. The proposed toxicity test method, although designed for effluent testing and having no relevance to real-world exposures of marine organisms to dispersants during dispersant use on oil releases, is a convenient way to screen individual dispersants. We agree with this proposal for dispersant-only toxicity tests.

The Agency also specifies a threshold for a dispersant to be listed on the Schedule, *"the LC_{50} being that at the lower 95% confidence interval for all acute toxicity tests must be greater than 10 ppm."* We believe this is a reasonable threshold for the "dispersant only" toxicity test.

B. *Standard static acute toxicity testing of dispersant/oil mixtures does not represent real world exposures.*

The purpose of the proposed toxicity testing of dispersant/oil mixtures is not clear. If the objective of the toxicity testing is to ensure that any dispersant that is to be listed has less than a specified level of toxicity measured in the test, then a dispersant alone toxicity test is sufficient.

We oppose the proposed dispersant/oil acute toxicity testing as a requirement for a dispersant to be listed on the Schedule, for the following reasons:

- It is now widely accepted by scientists that any concerns about the potential for toxic effects on marine organisms resulting from the use of modern dispersants should consider the potential effects of dispersed oil, not the dispersant itself. This is logical because dispersant is used at low concentrations, compared to the dispersed oil concentrations produced by their use, and they have much lower toxicity than oil. The potential severity of toxic effects that could be caused to marine organisms by exposure to dispersed oil will be a function of exposure: the concentration of dispersed oil (or oil components) in the water, the duration of that exposure, and oil type and receiving organisms. The Agency proposed dispersant/oil mixture tests will not provide any information about real-world exposure.
- More sophisticated dispersant/oil mixture toxicity testing procedures, using more relevant exposure regimes, can produce information about the potential for toxic effects on marine organisms by oil dispersed (or oil compounds released in to the water) as the result of dispersant use. Such toxicity studies may be relevant to deciding where and when dispersant use may be authorized, but not to dispersants being listed on the Schedule.
- Toxicity testing of dispersant/oil mixtures (i.e., dispersed oil) using the proposed standard static acute LC_{50} procedures will inevitably discriminate against more effective dispersants which disperse more oil into the water, thereby increasing exposure to aquatic organisms. Such testing does not give any indication of the potential for toxic effects to be caused by dispersant use on spilled oil on the sea surface.

- Previous work on dispersant/oil mixture toxicity testing conducted by the Agency in 2010 (Comparative Toxicity of Louisiana Sweet Crude Oil [LSC] and Chemically Dispersed LSC to Two Gulf of Mexico Aquatic Test Species [published by Hemmer, Barron and Greene]) shows that the proposed 10 ppm threshold (determined with LSC oil, not ANS or IFO -120) with *Americamysis bahia* would not be met by any of the eight dispersa nts tested at that time. Only one dispersant would have met the 10 ppm threshold with *Menidia beryllina*.

In general, the Agency should clearly distinguish between the requirements of (i) the toxicity testing required to assess which dispersants should be listed on the Schedule, and (ii) toxicological studies with appropriate oils, test organisms and exposure conditions that will inform discussions about how the listed dispersants might cause impacts in U.S. waters under the specific circumstances of an oil spill or release. The two toxicity test approaches required are incompatible. Attempting to use the same standard, static acute LC_{50} procedures to provide information or guidance on both aspects will not achieve these goals. Since the proposed dispersant/oil mixture toxicity testing requirements in this section do not address item (ii) above, the Agency needs to clarify the objective and rationale of the proposed acute exposure toxicity testing of dispersant/oil mixtures and should explain how this relate s to the listing of a product on the Schedule.

C. *Testing of dispersants using the developmental assay for the purple sea urchin is not relevant.*

The Agency proposes a requirement for an EPA test protocol involving sea urchin embryos, routinely used in eff luent testing, to be used to assess the potential for a dispersant product to cause adverse effects on the developmental process. The relevance of this test, which was developed for the assessment of wastewater effluents, to dispersant use is highly questi onable. Again, trying to estimate potential real world consequences to dispersed oil exposure should be part of a NEBA decision -based process. The environmental trade-offs of using dispersants in offshore environments to protect sensitive shoreline habitats from oil exposure is being circumvented. Given that the purple sea urchin is found in shallow coastal waters, there is no relevance of applying purple sea urchin data given that dispersant operations are unlikely to occur in these environments. In additi on, the proposed threshold that the LC_{50} must be greater than 10 ppm is not a relevant indicator to inform any potential real -world effects of dispersant use in the environment. Additionally, if the agency applies their proposed toxicity thresholds to the sub-chronic sea urchin toxicity tests, it is likely that many (maybe all) current and approved dispersants in the U .S. will fail the threshold . Some of them could also fail with the sub -chronic *M. beryllina* tests.

We oppose the proposed developmental ass ay and do not believe it should be a requirement for a dispersant to be listed on the Schedule. API and NOIA are also concerned that little experience is available in application of this assay to dispersants, and it is unclear about the intra -lab precision associated with this proposed requirement and the practical challenges that may arise in interpretation of test results.

D. *Sub-chronic 7 -day static toxicity tests for dispersant are not relevant and are unnecessary.*

The Agency states (300.915(b) (2), 80 Fe d. Reg. 3405) that it " *has limited information concerning the possible sub -lethal effects of dispersants currently listed on the Product Schedule* " and that " *This information would also be of value as guidance to regional responders and OSC's on possible ad verse effects on survival and growth of larval fish and invertebrates caused by longer -term exposure to dispersants.*"

Chronic exposure to dispersant alone is not a relevant indicator of risks posed when dispersant is used to mitigate the effects of an oil release. As stated previously, this test was developed and validated for wastewater effluents and is not relevant to the use of dispersants in offshore spill response. Rather than proposing sub-chronic toxicity testing requirements for any dispersant to be listed on the Schedule, the Agency could undertake studies to establish whether this is a valid concern, or whether it could provide useful information under the likely conditions of dispersant use on offshore oil releases.

The Agency's proposal of a No Observed Effect Concentration (NOEC) equal to or greater than 1 ppm listing threshold level for sub-chronic effects is arbitrary. Although this threshold level provides a ten-fold safety factor over the proposed 10 ppm acute toxicity threshold values, it could also be questioned on the same basis; static toxicity tests over 48 to 96 hours do not represent relevant exposure scenarios in the marine ecosystem following offshore applications of dispersant.

We oppose the proposed sub-chronic toxicity testing and does not believe it should be a requirement for a dispersant to be listed on the Schedule. Sub-lethal/sub-chronic studies are not necessary (acute toxicity endpoints are considered relevant) since the global commercial dispersant products are confirmed as biodegradable so that the surfactants and solvent constituents of the dispersant formulation do not persist in the marine environment causing adverse effects. The French dispersant product approval regulator requires a biodegradability test of the dispersant as part of its product approval process. Commercial dispersants commonly stockpiled around the world are therefore readily biodegradable and pass the French test. If a dispersant is approved in France, it must have passed the biodegradation test (AFNOR standard NF T90-346). It is recommended that ready biodegradability of a dispersant be required for approval in the U.S. as well. Therefore any candidate dispersant product would need to be tested for biodegradability, or the dispersant manufacturer could be required to state that the formulation constituents are biodegradable and provide supporting evidence.

E. *Dispersant testing should only be used for screening individual dispersant products.*

If the objective of the toxicity tests are to select less toxic dispersants (based on an aquatic toxicity threshold), then dispersant alone toxicity tests are sufficient and the maximum toxicity threshold of a candidate dispersant should be set if the dispersant is significantly less toxic than the reference oils. The dispersed oil toxicity testing (CEWAF) should not be considered for dispersant use authorization as it discriminates against the effective dispersant products which disperse more oil into the water thereby increasing exposure to the aquatic test organisms. It is also important to note that CEWAF toxicity testing does not simulate actual dispersant use on spilled oil in the marine environment. Additionally, static toxicity tests over 48 to 96 hours do not represent relevant exposure scenarios in the environment following surface application of dispersants.

In summary, the Agency's suggested toxicity testing changes in the Proposed Rule do not take into account the essential role of NEBA in considering the potential benefits and risks of dispersant use as a response option for an offshore oil release. The Product Schedule should focus on the basic testing to compare the efficacy and toxicity of the dispersants against each other with the sole purpose of screening good products that should be listed. The Proposed Rule should not attempt to translate any laboratory data into possible real-world implications. This process should instead be defined by full stakeholder NEBA discussions specific to a given spill scenario.

XXXIII. Section 300.915(c)(1) Surface Washing Agent Efficacy

A. *Surface Washing Agent (SWA) efficacy testing should not be required until the Agency develops its own test protocol.*

In the preamble the Agency has requested comments on available methodologies and whether the rule should identify the specific methodologies to be used until the Agency develops and adopts a new testing protocol for SWA efficacy testing (column 1, 80 Fed. Reg. 3407). The Agency lists two tests by ASTM and Environment Canada as possible interim tests while the Agency develops its own test. There is no evaluation of how the ASTM test compares to the Environment Canada test. As a result, expecting similar results by both tests is unrealistic. The average efficacy in the published data reported using the Environment Canada test may indeed be approximately 30%, but the variation is high and the tests were performed on a Canadian oil using only one test. We believe the Agency should delay requiring SWA efficacy testing until it develops its own test protocol that utilizes a U.S. oil.

XXXIV. Section § 300.915(d) Bioremediation Agent Testing and Listing Requirements

A. *An additional protocol specific to products containing enzymes only would be appropriate.*

The Agency is requesting comments on whether an additional protocol specific to products containing enzymes only would be appropriate. This would consist only of exposure water, weathered oil and the enzymatic product in the concentrations specified by the manufacturer. A new protocol would be useful because effectiveness data from the testing would help determine whether this technology would be beneficial during a response. Many claims may be made about "safer" products to treat oil and thus more credible scientific information is warranted on products approved on the Schedule.

XXXV. Section § 300.915(e) Solidifier Testing and Listing Requirements

A. *Solidifier toxicity testing would be useful.*

The Agency is requesting comments on the need for acute toxicity tests conducted with solidifiers - reference oil mixtures. Toxicity tests with oil may be beneficial as they will help to evaluate efficiency of solidifiers in retaining water soluble hydrocarbons and preventing them from leaching into water. Simple efficiency tests may not provide such data.

XXXVI. Section § 300.915(g) Sorbent Requirements

A. *The proposed Sorbent Product List should not exclude natural sorbent materials.*

The Agency proposes to make available a Sorbent Product List that includes certain publically available non-proprietary sorbent materials. We believe this should be a generic list and should not exclude natural sorbent materials (e.g., hay) that could be obtained locally at a spill site.

XXXVII. Section § 300.950 Submission of Confidential Business Information (CBI)

A. *Full public disclosure of product information may reduce the number of products being made available in the U.S.*

In 300.950 (column 3, 80 Fed. Reg. 3426), the Agency requires everything in the product listing be made public except the actual concentrations of product ingredients. While the Agency may need full disclosure of product formulae, we do not believe the Agency needs to make them public and can accept products with both the ingredients and the concentrations as CBI. Any disclosure of information on product formulae (either ingredients or % concentrations) could put a manufacturer at a competitive disadvantage. This may discourage some manufacturers from listing their product at all and could result in effective dispersant products not being available in the United States.

XXXVIII. Section § 300.955 Addition of a Product to the Schedule

A. *The transition period for currently listed products is too short.*

In 300.955(f), the Agency specifies a 24 -month transition period for currently listed products. This is a very short timeframe given the variety of products listed and depth of technical work (e.g., toxicology studies) required to be contracted, conduc ted, analyzed, and reported. We believe the Agency should extend the transition period to the lesser of five years, the current product expiration date, or after suitable replacement products are listed and commercially available.

We also believe that this section should include a discussion of how currently owned stockpiles purchased in 2010 and 2011 (more than one million gallons of Corexit, in the U .S.) will be tested to comply with the proposed existing stockpile testing requirements of being tested every five years. It is recommended the Agency state that currently held stockpiles will have five years to be re-tested after that dispersant product is listed on the new Product Schedule.

XXXIX. Appendix C to Part 300 Requirements for Product Testing Protocols and Summary Test Data

A. *The dispersant-to-oil ratio (DOR) ratio used in the BFT should be 1:20.*

In Appendix C, Section 2.1 (column 3, 80 Fed. Reg. 3428), the BFT mandates a DOR of 1:25. A DOR of 1:20 has commonly been accepted for use in the U.S. and abroad. Further, the 1:25 DOR may not even be within the manufacturer's recommended use ratio. The Agency needs to ju stify this test requirement. We believe that the DOR for the BFT should be changed to 1:20 to align with the regulatory requirements in 33 CFR 154 and 155 for calculating aerial and vessel dispersant capabilities and to align with standard dispersant spray system calibration. A DOR of 1:20 leads to a 5 gallon per acre dosag e for surface spray systems and is the minimum amount of dispersant to oil slicks that can be visually identified as having sufficient thickness to warrant dispersant application. Having the testing procedure completed for the same DOR would provide more reliance that, when applied, the dispersant will be effective.

B. *The Agency should explain how it will address changes in the refe rence oils as they age and as new samples are acquired for the future.*

In Appendix C, Section 2.3.2, the Agency requires the u se of ANS and IFO -120 as standard reference oils. The Agency is supplying these materials to labs but no data is presented showing shelf stability over time for either and whether stable equivalent materials can be provided in the future. No provision is provided for addressing changes in dispersant efficacy due to changes in composition of ANS (e.g., field production changes, new fields in pipeline blend, etc.).

Also, IFO -120 composition is entirely dependent on the crude run at the supplying refinery an d their blending needs. It is a blend of residual fuel components including vacuum residue cut with a lighter product to achieve a specified viscosity (i.e., 120 cSt at 100 degrees F in this case), but it will vary dramatically in composition between lots at a given refinery and between refineries. If multiple IFO -120 samples were provided from different refineries to a toxicity laboratory, there would be varying results because IFO-120 composition changes from day to day and between refineries. This means that a single batch of IFO -120 will have to be preserved for all future product testing to ensure comparability. The Agency should conduct stability tests of ANS and IFO -120 stocks to ensure they can maintain viable samples over time.

CONCLUSIONS

In conclusion, as evidenced by the extensive substantive comments provided herein, it is clear that much work needs to be done before the Agency should finalize a rule in this key area of spill response, including to make sure that the final rule does not have the unintended consequence of eliminating all or most commercially available and future dispersants for use in spill response. We believe the Proposed Rule will likely result in dispersants being eliminated as a response technique, for the following reasons:

- The Proposed Rule does not recognize that response option decisions must be based on NEBA and that dispersing oil in offshore environments , where it may dilute and biodegrade, is often preferred over the long -term environmental damages that will occur when untreated oil strands and persists in shoreline environments;
- The Proposed Rule focuses on potential risks of dispersants without recognizing the primary purpose of dispersants, which is to rapidly dilute the spilled oil and enhance removal of the o il from the environment through microbial degradation, resulting in reduced VOCs (personnel safety), and a reduction in persistent, stranded oil in shoreline ecosystems (leading to faster ecosystem recovery);
- The Proposed Rule's dispersed oil toxicity tes ting thresholds could eliminate all dispersants that are on the current NCP list and could preclude the listing of future dispersants that are currently in development. Furthermore, the proposed dispersed oil toxicity testing thresholds favor ineffective dispersants over effective products and will mistakenly measure the toxicity of the standard test oils, not of the dispersant product;
- The Proposed Rule adversely constrains the ability of the OSC to make the necessary operational decisions to ensure for an expeditious, efficient, and effective response to mitigate the impacts of a spill to the greatest extent possible;
- The Proposed Rule raises significant issues related to USCG and BSEE facility and vessel oil spill response plan compliance and could resul t in unnecessary and increased environmental impacts and corresponding spill claims as a result of increased damages;
- The Proposed Rule's stockpile re-testing procedures have not taken into account manufacturer recommendations, nor considered scientific publications on the demonstrated, lengthy shelf-life of dispersant products; and
- The Proposed Rule's dispersant monitoring requirements are not focused on collecting data that can provide useful information regarding an ongoing dispersant operation. Instead, these requirements have the potential to delay dispersant use resulting in unnecessary environmental damage.

In addition, the RIA conducted by EPA is substantially flawed. The RIA falls woefully short of EPA's regulatory requirements. EPA fails to provide any quantification of the potential social benefits of the Rule; in fact, the RIA lists benefits associated with avoiding and limiting the impacts of oil spills as potential benefits of this Rule, even though the Proposed Rule has the potential to ag gravate the impacts of an oil spill by limiting response options. As a result, the RIA significantly underestimates the potential costs of the Proposed Rule , while also underestimating the direct costs that the Rule would impose on small businesses, government, and the greater industry.

Accordingly, API and NOIA strongly urge the Agency to consider these comments and suggested revisions to the Proposed Rule to ensure that the best dispersants and dispersant-use practices are available for offshore oil spill response. We recommend that there be further discussions between the Federal agencies and industry scientific and operational experts to add value to further revisions of the Proposed Rule to ensure that the proposed changes to Subpart J align with the latest scientific practices and do not artificially bias against the use of certain response options, such as dispersants.

Furthermore, API and NOIA recommend EPA initiate a Negotiated Rulemaking which has proven to be effective in controversial rulemakings such as this one. At a minimum, we urge the Agency to publish a Supplemental Proposed Rule in the Federal Register for additional public comments before publishing a final rule to ultimately make sure that responders, both from the government and industry, are able to use dispersants in the most effective and expeditious manner, taking into consideration necessary environmental and safety factors, to provide for the best response possible depending on the circumstances of a particular spill event. Given the time it will take to initiate and complete a new rulemaking after the final rule is published it is imperative for the general public and all stakeholders that we get it right the first time.

Thank you for your time and attention to these comments on the Proposed Rule. API, NOIA and our member companies share EPA's goal of establishing sound Dispersants Use Policy and are committed to working with the Agency and the other Federal Agencies involved in oil spill response to ensure the health and safety of people and minimize environmental and community impacts during an oil spill. Please do not hesitate to contact Emily Hague (202-682-8260, Hague@api.org) or Nicolette Nye (202-465-8463, nnye@noia.org) if you have any questions.

Sincerely,

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Attachment A

Analysis of EPA's Regulatory Impact Analysis for the Proposed Revisions to the National Oil and Hazardous Substances Pollution Contingency Plan in 40 CFR 300 Subpart J

Submitted by:

Policy Navigation Group

April 2015

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EXECUTIVE SUMMARY

Policy Navigation Group (PNG) was asked by the American Petroleum Institute to review the Regulatory Impact Analysis (RIA) for U.S. Environmental Protection Agency's (EPA) proposed rule entitled *National Oil and Hazardous Substances Pollution Contingency Plan.*[1] We were asked to evaluate whether the RIA for the proposed rule is consistent with the analytical standards set forward in OMB Circular A-4 and EPA's Guidelines for Preparing Economic Analyses and to perform an independent cost analysis.[2] In our analysis, the proposed RIA has the following principal deficiencies:

- The proposed rule's RIA does not have a consistent baseline that allows the public and policy officials to compare the incremental social costs and the incremental social benefits of EPA's proposed regulation and the individual policy options within the proposal.
- The RIA fails to estimate many policy scenarios and requirements issued in the proposed rulemaking. The RIA thus fails to provide the public a full description of the proposal's impact and undermines the public's opportunity to provide meaningful comment on the proposed rule.
- Further, for the provisions that it does give quantified social cost estimates, the RIA often underestimates compliance costs. The RIA thus underestimates the full social cost to comply and to administer the changes for both private firms and government agencies.
- The RIA does not provide any quantified social benefit estimates either for the proposal as a whole or for its individual options. Moreover, its qualitative description of social benefits is inaccurate and at times actually describes social costs of the proposal. Without estimates of the incremental social benefits of the rulemaking and the proposal's regulatory options, the public cannot provide meaningful comments on the merits of EPA's proposal.
- The RIA's methodology is designed to underestimate the small business impact. EPA's economic impact analysis is inconsistent with EPA's economic analysis guidelines and EPA's requirements under the Regulatory Flexibility Act (RFA).[3] In this analysis, we address some of the RIA's deficiencies and find that the rulemaking could have a significant impact on a substantial number of small businesses subject to the rulemaking.

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[1] 80 FR 3380. Also, U.S. Environmental Protection Agency, *Regulatory Impact Analysis for Proposed Revisions to the National Oil and Hazardous Substances Pollution Contingency Plan Regulations*, December 3, 2014.

[2] U.S. Environmental Protection Agency, *Guidelines for Preparing Economic Analyses*, 2014.

[3] 5 U.S.C. 601-612

- These principal issues are among many aspects of the analysis that are inconsistent with Executive orders on regulatory review, OMB guidance, and EPA's own guidance for economic analysis.[4]

In the RIA, EPA estimates that the total incremental net present value (at 7 percent) social cost of the rule is $7.8 million, or approximately an annualized cost of $0.7 million over 20 years. In our analysis, we find that the estimated social costs are at least three times higher than EPA's estimate. The cost of the major provisions are given below:

Table ES-1. Estimated Social Costs of the Proposal

	NPV at 7% ($)	Annualized Cost over 20 years at 7% ($)
Product Loss Costs	4,000,000-7,300,000	380,000-720,000
Product Testing Costs	5,300,000	500,000
Stranded Capital/Stockpile Value Loss	1,000,000-1,250,000	90,000-120,000
Label	180,000	20,000
Recovery Costs	1,700,000	160,000
Monitoring Costs	11,000,000	1,000,000
Preauthorization Costs	200,000	20,000
EPA Costs	800,000	80,000
Totals[5]	24,000,000-27,000,000	2,300,000-2,600,000

These costs disproportionately burden small businesses. Most producers in this market are small businesses. The RIA did not find a significant effect on a substantial number of these small businesses. However, when we adjust for the more significant costs in Table ES-1 for the provisions the RIA omits and for real cost of capital, 43 percent of small businesses that the RIA analyzed have compliance costs greater than three percent of their 2011 revenues. As shown in Table ES-2, many small businesses face severe impacts. EPA should evaluate whether it must comply with the procedural and other analytic requirements of the Small Business Regulatory Enforcement Fairness Act (SBREFA).

[4] Executive Order 12866 Regulatory Review, September 30, 1993.

[5] Throughout this report, totals and summaries may be different due to rounding. Reflecting the likely precision of these estimates, figures are presented to two significant digits or less.

Table ES-2. Economic Impact of the Proposal on Small Businesses

Pct of 2011 Revenue	Number of Product Types	Percent of Companies
<3%	17	57%
3%-5%	5	17%
>5%	8	27%

We recommend that EPA correct these deficiencies including undertaking a comprehensive benefit analysis to determine if the rule is in the national interest. Once EPA conducts its analysis of the incremental net social benefits of each proposed provision, it should select the regulatory options that maximize net social benefits. As EPA's economic analysis guidelines states:

> Preparing high -quality economic analysis can greatly enhance the effectiveness of environmental policy decisions by providing policy makers with the ability to systematically assess the consequences of various actions. An economic analysis can describe the implications of policy alternatives not just in terms of economic efficiency, but also in terms of the magnitude and distribution of an array of impacts.[6]

This report discusses the major issues with the RIA in more detail, provides alternative estimates for the proposal's social costs, and recommends how EPA should correct these flaws before reissuing a proposed rule.

[6] U.S. EPA, *Guidelines*, pg. 1-2.

SECTION 1. INCONSISTENCY BETWEEN BASELINE AND POST-REGULATION MARKET SCENARIOS

1.1. BASELINE IS INCOMPLETE AND INCONSISTENT WITH OMB GUIDANCE

The RIA's description of the analytic baseline is incomplete and inconsistent with OMB guidance.[7] There are several problems with the RIA's regulatory baseline:

- The RIA does not establish baseline conditions for many proposed requirements. As discussed in Section 2 below, the RIA does not fully estimate the social benefits and costs of all of the provisions of the proposal. As it corrects the serious deficiency of omitting cost estimates for proposed provisions, EPA must apply a consistent framework for both baseline and post-proposal market conditions in any final rulemaking.

- The RIA assumes a regulatory baseline where all existing manufacturers must pay to test their products. Even in absence of a rule, manufacturers may choose to conduct additional toxicity testing to demonstrate the inherent low hazard of their product and thus to differentiate their products in the market. Oil spill response organizations and responsible parties may also insist on further toxicity testing from producers due to liability concerns. Other jurisdictions also require testing of oil response products. For example, the corresponding European Union (EU) authority, the European Maritime Safety Agency, lists the dispersant testing requirements as of 2014 in the EU member states.[8] Eight EU members require testing of dispersant products. For all these reasons, producers may have some or all of the proposed testing data already available.

Recommendation. EPA should gather additional information on available data not only to prepare a more accurate economic analysis, but also to properly estimate the incremental social costs of this rule. If additional data already exists, EPA could tailor the final rule's requirements to this data and only mandate additional testing where meaningful data gaps exist.

1.2. PROPOSAL DOES NOT HAVE CONSISTENT SCENARIO FOR THE SOCIAL BENEFITS AND SOCIAL COST ESTIMATES

The RIA assumes all existing products comply with the new testing requirements and remain on the market.[9] The RIA also assumes new products are approved by EPA at the same

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[7] U.S. Office of Management and Budget, Circular A-4 Regulatory Analysis, September 2003.

[8] European Maritime Safety Agency, *Inventory of National Policies Regarding the Use of Oil Spill Dispersants in the EU Member States*, 2014

[9] U.S. Environmental Protection Agency, *Regulatory Impact Analysis for Proposed Revisions to the National Oil and Hazardous Substances Pollution Contingency Plan Regulations*, December 3, 2014.

pace as in the past. In other words, society gains the same benefits from products with the same capabilities and efficacy with or without the rule.

If this post-regulatory scenario is true, the rule has few, if any, social benefits.[10] For example, EPA cites reduced product toxicity on marine life as a potential social benefit. However, any potential ecological harm could only possibly be reduced if some existing (and future) products are withdrawn, not used, or disallowed due to the new toxicity testing requirement and due to the new EPA approval process.

However, the RIA's scenario is not the most plausible post-regulation scenario. It is more likely that some existing products will not remain on the approved list after the rulemaking. This outcome is more likely than the RIA scenario for two reasons. First, EPA may decide not to approve some of the existing products. It seems unlikely that EPA would use its scarce resources to promulgate increased toxicity testing standards if it did not have concerns with the toxicity of some existing products.

Second, given the uncertain sales volume, producers may not make a competitive expected rate of return with the additional testing and application expense and the greater risk of disapproval. In this case, they can be expected not to remain on the schedule after the rule is effective.

There is ample evidence that existing producers face a non-zero risk of product disapproval:

- Interest groups and media alleged significant concerns with oil spill product safety during the 2010 SONS.[11,12] Media attention and interest group attention to the issue does not mean that products are toxic per se; however, the threat of media scrutiny dampens producers' interest in bringing products to market. Increased attention is likely to lengthen EPA's approval process and the costs for the producer to respond to media inquiries. For producers, these response costs decrease the rate of return for oil spill products and potentially raise the costs for other company products.[13]

- Many producers are small businesses and need certain rates of return to compensate for their cost of capital and for the opportunity cost to innovate in

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[10] There is the argument that there is an information externality - the producers of the agents have a more concentrated interest and easier access to the potential toxicity information than the purchasers. However, since the producers are mostly small businesses and the purchasers are typically government agencies or large businesses, the purchasers can be expected to have sufficient resources and potential legal liability to overcome any potential information externality.

[11] See for example, http://www.biologicaldiversity.org/programs/public_lands/energy/dirty_energy_development/oil_and_gas/gulf_oil_spill/dispersants.html.

[12] E. Rothsenthal, *In Gulf of Mexico, Chemicals under Scrutiny*, The New York Times, May 5, 2010.

[13] For example, the parent company, and not individual product, may face public criticism.

other markets. Their internal rate of return requirements may preclude further investments once the costs and the risk increase.

In addition to the effect on existing products, the rulemaking is likely to affect the number of future products. By requiring additional testing and approval, the rulemaking increases market barriers. Some new products may not reach the market in the future due to the costs and risks that new products will not pass the new testing requirements.

1.2.1. Social Cost Estimate

To overcome these limitations, we conduct an alternative estimate to illustrate the importance of considering how the rule will raise market barriers. In Section 6 below, we demonstrate that many smaller producers could face a significant economic impact from the rule, i.e., greater than three percent of their annual revenue. As EPA and Small Business Administration guidance suggests, we assume those firms fail or leave the market due to the regulatory costs.[14]

The social cost is the lost value added to society from these products that leave the market. Value added is the remaining revenue after the costs of the inputs (e.g., labor, materials, and energy) are subtracted. Since value added is often proprietary information and varies from firm to firm, we use a recent value added metric for the chemical industry as a whole. From 2013 Bureau of Economic Analysis data, the average valued added in chemical manufacturing is 44 percent of revenue.[15] We assume that each company in the oil spill product market has a value added of 44 percent of revenue.

Once existing firms leave the market, society loses the value added of their products for Subpart J responses. However, in a competitive marketplace, other firms will enter and offer their own products. Since the regulation is not changing the demand for oil spill response products or acting to reduce the likelihood of spills, post-regulatory supply will rise to meet this unchanged demand. Society, therefore, only temporarily loses the availability of some oil response capabilities once existing producers leave the market in response to regulation.

We assume the value added is lost for three years. While three years is an assumption, it is a reasonable one given the proposed rule's timing. Since existing firms have two years to provide EPA with the new test data, if they decide not to reapply, they will likely try to stay on the market for the full two years. Once EPA removes them from the schedule, competitors will then see a market opening. We assume these competitors offer alternatives and submit their applications to EPA one year later.

We recognize other outcomes are possible. Instead of replacing existing products with new products at a 1:1 ratio, fewer new products could enter the marketplace, leaving the

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[14] U.S. Small Business Administration, *Guide for Government Agencies How to Comply with the Regulatory Flexibility Act*, May 2012. See U.S. EPA, *Final Guidance for EPA Rule writers: Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act*, November 2006.

[15] U.S. Department of Commerce, Bureau of Economic Analysis, *Value Added by Industry*, November 2014

approved products with a greater market share. In this case, compliance costs would be lower than this estimate; however, an additional social cost would be the loss of resiliency to responds to market disruptions. In addition to small firms, large firms may also not submit the new information due to the expense. On an individual product basis, larger firms may not find it profitable to continue.

Recognizing these limitations, based on these assumptions and the revenue information the RIA provides in Exhibit 7-1, Table 1-1 shows our estimate of the social cost of market disruption/transition due to the proposed rule.

Table 1-1. Social Costs from Market Transition

Annual Revenue	Product Type	Assumed Value Added	Social Cost	Discounted Social Cost (7 percent)
$ 62,000	Solidifiers	$ 27,000.00	$ 81,000.00	$ 74,000.00
$ 160,000	Surface Washing Agent	$ 71,000.00	$ 213,000.00	$ 195,000.00
$ 120,000	Solidifiers	$ 53,000.00	$ 159,000.00	$ 146,000.00
$ 200,000	Solidifiers	$ 88,000.00	$ 264,000.00	$ 242,000.00
$ 30,000	Solidifiers	$ 13,000.00	$ 39,000.00	$ 36,000.00
$ 120,000	Surface Washing Agent	$ 53,000.00	$ 159,000.00	$ 146,000.00
$ 150,000	Surface Washing Agent	$ 66,000.00	$ 198,000.00	$ 181,000.00
$ 1,000,000	Dispersant(2) & Surface Washing Agent	$ 441,000.00	$ 1,323,000.00	$ 1,211,000.00
$ 187,000	Surface Washing Agent	$ 82,000.00	$ 246,000.00	$ 225,000.00
$ 290,000	Bioremediation Agent	$ 128,000.00	$ 384,000.00	$ 352,000.00
$ 280,000	Surface Washing Agent	$ 123,000.00	$ 369,000.00	$ 338,000.00
$ 559,000	Bioremediation Agent	$ 246,000.00	$ 738,000.00	$ 676,000.00
$ 120,000	Bioremediation Agent	$ 53,000.00	$ 159,000.00	$ 146,000.00
Total (rounded)				$ 4,000,000.00

Summary	NPV at 7%	Annualized Cost over 20 years at 7%
Product Loss Costs	$4,000,000	$380,000

The social costs for existing products are estimated to be $4 million. If it takes longer for alternative products to enter the market, these costs would be higher. These social costs do not include the loss of efficacy and resiliency to respond to oil spills during this transition period. In Section 2.3 below, we expand this estimate to add the potential product loss social costs from the proposed ban on products containing NP and NPE.

As discussed previously, the regulation will not only discourage existing producers from re-qualifying, but also discourage new entrants by raising the costs and the risks of market

entry. The RIA assumes new entrants arrive after the rule at the same pace as in the baseline, or 10 per year. This assumption is not supported by economic theory. As discussed below in Section 3.4, we predict that application costs would rise by 40-50 percent for surface washing and stabilizer products, 260 percent for bioremediation products, and 120 percent for dispersants compared to current requirements. While we did not find estimates of the supply elasticity in these markets, such significant increases in prices will affect supply. We assume new product applications decrease by 30 percent from 10 to seven per year in response. The cost implications of this change are further discussed in Section 5.

1.2.2. **Recommendation**

Setting the baseline and policy alternative scenario is one of the key foundations of a regulatory analysis. As EPA's Guidelines for Economic Analysis states: "Because the level of detail presented in the baseline specification is an important determinant of the kinds of analysis that can be conducted on proposed regulatory options, careful thought in specifying the baseline is crucial."[16] The RIA has not shown this careful thought. For the final rule, EPA should understand the available toxicity and efficacy data available from producers. EPA should select, at a minimum, alternative market outcomes from the regulation in which some existing products do not return to the approved list. EPA must estimate the incremental social benefits and social costs from more accurate baselines.

[16] U.S. EPA, *Guidelines*, pg. 5-1.

SECTION 2. SOCIAL COSTS NOT INCLUDED IN THE RIA

2.1. STRANDED PRODUCTION CAPITAL AND PRODUCTS

EPA has not estimated the full social costs from a decision not to approve a product or from a producer's decision not to reapply. For the reasons listed in the previous section, it is plausible that some existing products will not be listed in the future due to the new regulatory requirements. In Section 1.2.1, we estimate the temporary lost value to society. The full social costs include the net change in value of the oil spill response product and the stranded human and physical capital used to produce the product. In addition, existing stockpiles of the dis-approved product can be expected to suddenly have lower value due to the disapproval. While on scene coordinators (OSC) could still allow their use during a spill response, the likelihood is lower once the product is no longer approved.

These costs are potentially significant. Stockpiling response products is an essential strategy to minimize oil spills' consequences. Response products must be deployed within hours of an oil spill; there is not time to ramp up production once a spill happens. Stockpiles are substantial and deployed across the globe. For example, a 2014 EU report lists nearly 3,500 metric tons of more than 40 different compounds in EU member state stockpiles.[17]

EPA has recognized this social cost category in other rulemakings. EPA has banned or phased-out products in other environmental programs. For example, EPA regulates the phase-out of ozone-depleting substances (ODS) under the Clean Air Act (CAA). EPA has conducted several major RIAs for the multiple phase-out decisions for ODS use under Title VI of the CAA. For example, in its Section 604 and Section 606 rulemakings, EPA considered the stranded capital and product costs for the ODS subject to the phase-out. EPA also attempted to estimate the social costs of the reduced efficacy of the substitutes.[18]

2.1.1. Social Cost Estimate

We consider the stranded capital and product costs separately. For the stranded capital, there are several considerations in estimating the social cost. First, the regulation does not destroy the labor and physical capital, but blocks its highest valued use. Workers and entrepreneurs can use their knowledge and machinery to make other products and/or the same product. Second, there is a distinct loss as suppliers move their capital from this highest valued use before the regulation to a lower valued use after the regulation. They also have costs as they retrain and retool their equipment for this shift.

This information guides our estimate. At one extreme, if the regulation completely destroyed the economic value of the enterprise, the loss could be estimated as the enterprise values of the firms. Using a standard financial estimation of small business enterprise value, the loss would be three to five times the firm's intrinsic value (i.e., value added). In this

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[17] European Maritime Safety Agency, *Inventory of National Policies Regarding the Use of Oil Spill Dispersants in the EU Member States*, 2014

[18] For a good summary, see Appendix G of *The Benefits and Costs of the Clean Air Act, 1990 to 2010*, U.S. EPA, 1999.

case, the maximum social cost would be $6 million to $8 million. At the other extreme, in a dynamic economy, excess capital and labor is rapidly moved from one use to another, with almost zero transition cost. Since the regulation fundamentally does not change demand, we assume that the stranded human and physical capital costs will be closer to the low end and assume a loss of $1 million.

For the stranded product costs, knowledge of which existing products will not return to the schedule and the amounts of those products are stockpiled is important information. The RIA gives information about the product types that are likely to leave the market due to regulation (see Section 6 below), but not the specific products.

For current amounts in stockpiles, in support of its 2009 vessel response plan (VRP) rulemaking, the Coast Guard complied data on US stockpiles of products listed on Subpart J.[19] Although this data is comprehensive, it is from 1998. The VRP rulemaking required responsible parties to have contracts with oil spill removal organizations (OSRO) or organic capacity to respond to categorical spills.[20] The rulemaking required owners and operators to have response resources capable of applying dispersants. This rulemaking, and subsequent ones, increased the amount of dispersants stockpiled in the United States.

From public information given by OSROs, most advertised dispersant capacity is for Corexit® formulations. While it is very likely that these organizations also stockpile stabilizers, surface washing agents, and potentially bioremediation agents, we did not find a current, comprehensive list of stockpiled substances.

We therefore constructed our estimate under two scenarios: (1) if EPA does not approve Corexit® formulations; and, (2) If EPA does not approve other agents. For the latter, we include these costs in Section 2.4. A potential ban on Corexit® is discussed in this section.

We gathered available data on current and relatively recent reports of Corexit® formulation stockpiles in the United States and globally. Since the chemical is not approved for use in Europe, we found that global stockpiles are located primarily in the United States and Brazil.[21] Table 2-1 gives the organization and the reported stockpile amount.

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[19] U.S. Coast Guard, "Caps" Review of Oil Spill Response Plan Equipment Capability, at https://homeport.uscg.mil/cgibin/st/portal/uscg_docs/MyCG/Editorial/20080725/combined%20document.pdf?id=213ab594d05ab39ffd49d74a2e188eb8246d23ed&user_id=7ee08b44562829c5918c18d08ac87c29.

[20] 74 FR 45004

[21] http://www.oilspillresponse.com/files/OSRL_GDS_Equipment_20Nov2014.pdf

Table 2-1. Estimated Stockpiles of Corexit® Formulations

Organization	Units	gal/unit	Total
MSRC[22]	1	104,000	104,000
Clean Seas Cooperative[23]	1	20,750	20,750
Oil Spill Response[24]	500	264	132,000
Alyeska Pipeline[25]	1	60,000	60,000
Clean Islands[26]	1	37,260	37,260
LOOP[27]	1	33,600	33,600
Clean Gulf Associates[28]	1	34,650	34,650
CISPRI[29]	1	20,570	20,570
Nalco[30]	1	12,000	12,000

Total (rounded)	450,000
Estimated Value	$ 250,000

[22] https://www-msrc-org-documents.s3.amazonaws.com/major-equipment-list/MSRC_Major_Equipment_List.pdf?AWSAccessKeyId=AKIAIGH7YZWA2HRSZUFA&Expires=1427976589&Signature=lYm5WdnIB7M4XV%2BR1foyl5kUg70%3D

[23] http://www.cleanseas.com/equipment.htm#ABSORBENTS/DISPERSANTS/SPRAY

[24] http://www.oilspillresponse.com/files/OSRL_GDS_Equipment_20Nov2014.pdf

[25] Minerals Management Service, *Assessment of the Use of Dispersants on Oil Spills in California Marine Waters*, S.L. Ross Environmental Research Ltd, June 2002.

[26] http://www.cleanislands.com/

[27] Minerals Management Service, *Assessment of the Use of Dispersants on Oil Spills in California Marine Waters*, S.L. Ross Environmental Research Ltd, June 2002.

[28] http://www.cleangulfassoc.com/equipment.

[29] Minerals Management Service, *Assessment of the Use of Dispersants on Oil Spills in California Marine Waters*, S.L. Ross Environmental Research Ltd, June 2002.

[30] http://www.rrt9.org/external/content/document/2763/904415/1/Nalco%20Dispersant%20Mfgr%20Capability.pdf

Table 2-1 may overestimate the amount stockpiled since different organizations may have overlapping agreements to use the same stockpile. The estimates may also be underestimates since we could not find publicly available data on the stockpiles of some of the larger OSROs such as NRC.[31] Based on a recently reported retail price from an OSRO of $0.55/gallon, the reported stockpiles in Table 2-1 are worth $0.25 million. Since the product is not approved for use in other jurisdictions, if EPA did not approve its continued use, it is likely that current stockpiles will have little residual value.

In summary, the stranded capital/stockpile value loss is the sum of the loss of enterprise value (assumed to be $1 million) and the potential loss of in value of Corexit® formulations. Since the loss in Corexit® formulations is speculative, we present our estimate for this rulemaking outcome as a range.

Summary	NPV at 7%	Annualized Cost over 20 years at 7%
Stranded Capital/Stockpile Value Loss	$ 1,000,000-$1,250,000	$90,000-$120,000

2.1.2. Recommendation

Once EPA establishes a more plausible baseline and post-regulation market conditions, it must account for all social costs that flow from an EPA decision not to approve products currently on the list. These costs include the stranded physical and human production capital, the loss in value of stockpiled products, and any loss in oil spill response efficacy from these decisions. EPA has access to data on oil response product stockpiles that it should use to better estimate the social costs of this rulemaking. EPA's analysis for the final rule should at least be as comprehensive as EPA's approaches in other comparable EPA rulemakings.

2.2. Periodic Revisions of Preauthorization plans

In the proposal, EPA requires Regional Response Teams (RRTs) to review and to update their preauthorization plans for chemical and biological response agents after major oil spills or at least once every five years. The RIA does not estimate the social costs of this proposed requirement.[32]

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[31] http://nrcc.com/our-services/response-services/response-equipment-rental-packages/

[32] On page 37 of the RIA, under the section entitled "Authorization of Agent Use (part 300.910)," the RIA notes that RRTs and Area Committees are required to provide a preauthorization plan and to follow other requirements. The RIA states: "The incremental burden for members of the RRT and Area Committees requires labor hours to participate in the development of preauthorization plans and to add them to RCPS and ACPs." However, it is not clear whether the extremely low burden the RIA uses (2 hours) is to update the 11 or more preauthorization plans or the title of section,

There is evidence that this provision would have meaningful costs if finalized. Recently, EPA's Inspector General (IG) issued a report finding defects in emergency management planning and contingency planning for oil spills.[33] In response, EPA stated:

> Thus, although we generally agree with the recommendations in this report, and they parallel our efforts, two key obstacles (i.e., limited involvement by other agencies and stakeholders and resources) must be overcome for their successful implementation.[34]

The EPA program response to the IG suggests that resources, not interest, is the barrier to updating preauthorization plans. If local governments and other RRT team members are constrained by a lack of resources, then it is not clear how a regulation will alter this reality. The social costs then must reflect this scarcity. The social costs are not limited to the full compensation costs and capital costs necessary to maintain that employee. Unlike private markets, the supply of government officials' time does not increase with greater demand. For this reason, the social costs are the opportunity costs of that official's time - i.e., the social benefits society would gain if the government official spends the time on the next most valuable use of that person's time--enforcement, policy setting, permit approvals, or other public matters. The opportunity cost of this resource - a government agency official's work time - is how EPA's Guidelines for Economic Analysis defines social cost.[35]

2.2.1. **Estimated Social Costs**

Based on the IG's analysis, we estimate the social costs as the resources required to update preauthorization plans more frequently than is current practice. We assume in the baseline that plans are currently revised once every seven years; the proposal requires them every five years or after major oil spills. Based on the IG report finding that some plans had not been updated since the 1990s, a seven year update frequency in the baseline may underestimate social cost. For the post-rule scenario, we use a five year frequency since the other trigger, major spills, are rare and may be expected to lead to preauthorization plan reviews even in the absence of this rulemaking.

The resources required are the time spent revising each plan and the review of each plan by the member organizations. From the agenda of recent RRT meetings, we count the number of distinct Federal and state agencies. In a recent Region 6 RRT meeting, 13 Federal agencies sent staff.[36] We assume that 13 Federal agencies are part of each RRT. States,

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authorization of agent use. In either case, the RIA's estimate is far too low to comply with the proposed requirement.

[33] U.S. Environmental Protection Agency, Office of the Inspector General, *EPA Could Improve Contingency Planning for Oil and Hazardous Substance Response*, February 15, 2013.

[34] Ibid, pg. 19.

[35] "Social cost represents the total burden that a regulation will impose on the economy. It is defined as the sum of all opportunity costs incurred as a result of a regulation where an opportunity cost is the value lost to society of any goods and services that will not be produced and consumed as a result of a regulation," *Guidelines*, p.8-1.

[36] http://www.rrt6.org/Uploads/Files/rrt_semi_annual_meeting_summary_2014_November.pdf

territories, and Tribes also serve on the RRTs. Among the 11 RRTs (one for each EPA region and one for Alaska), we assume 56 States, Tribes, and territories send representatives and participants.

We make some assumptions on the effort needed to revise each preauthorization plan. We assume 20 percent of the RRT's member organizations assign one staff person to serve on an RRT subgroup to revise the plan. Each assigned staff person spends 40 total hours in this revision process. Then, each Federal, State, Tribe, and territory agency reviews the draft revised plan in their organization. Three people in each organization are a part of the review to account for the agency's management and likely legal review. Each person reviewing the draft plan spends six hours reading and discussing the revised plan.

For the costs of government staff time, we use median and mean wages for Federal employees and State employees, respectively.[37] To these wages, we apply recent Federal government values for benefits and overhead to the Federal and State hourly wage values.[38] For the reasons discussed above, this estimate of the opportunity cost of this resource likely underestimates its true social value and thus the social cost of this proposed requirement.

We then compare the social costs for the baseline and proposed requirements - the costs of revising the plans on a seven versus five year frequency. We discount the baseline and proposal time stream of costs at a discount rate of seven percent and take the difference between those time streams as the social cost. The net present value of the additional social cost at a discount rate of seven percent is $0.18 million.

Summary	NPV at 7%	Annualized cost over 20 years at 7%
Preauthorization costs	$180,000	$20,000

2.2.2. Recommendation

The RIA must fully include the social costs and social benefits of this provision and calculate the social costs as the opportunity cost of government agency staff time.

2.3. Prohibition on Chemicals and Proposal to Ban EDCs

The RIA does not estimate the social benefits or the social costs for the proposed option to prohibit approving products containing nonylphenol (NP) and nonylphenol ethoxylates (NPE). More significantly, the RIA did not estimate the social benefits and costs of a regulatory option discussed in the preamble, a ban on endocrine disrupting compounds in approved products.

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[37] U.S. Bureau of Labor Statistics, May 2014 State Occupational Employment and Wage Estimates, http://www.bls.gov/oes/current/oes_ms.htm#11-0000.

[38] See for example, U.S. Office of Personnel Management, Federal Investigative Services Division, *White Paper: Support Services Contract Cost Benefit Analysis.*

Banning any compounds will have social costs and potentially social benefits. As discussed elsewhere in these comments, EPA has acknowledged in other rulemakings the loss of income and loss of productive capital from product bans. These costs must be included in the economic analysis of this option.

One notable option EPA lists is to prohibit materials containing endocrine disrupting compounds from the approved list. More broadly, EPA's proposed prohibition - without any stated criteria for the ban - raises significant market uncertainty. Without transparency into EPA's rationale for the prohibition, producers may decide not to pay for testing costs and risk disapproval, reducing the overall efficacy and variety of products available.

However, the social costs are more significant than the loss of net value in the oil spill response market. Bans by a government agency will cast a cloud over the public's perception of the health and safety of a chemical compound. States and companies maintain lists of "toxic" chemicals and have policies that discourage purchasing and use of chemicals on these lists.[39] By banning a substance in oil spill response products, it is more likely that the market for NP and NPE compounds will shrink throughout the overall economy.

Moreover, the incremental social benefits of the proposed NP and NPE ban are uncertain. The RIA did not quantify these benefits. There is reason to believe that any such social benefits will be small. EPA's own test data provides evidence that the proposed bans would have minimal, if any, social benefits. EPA conducted tests of eight dispersant compound-oil mixtures, some of which contained NPE, for their endocrine activity.[40] EPA found:

> None of the eight dispersants tested displayed biologically significant endocrine disrupting activity, with the exception of a weak response for two of the dispersants (Nokomis 3-F4 and ZI- 400) in one of the tests. This estrogenic result is likely not of biological significance. Cell death (degree the dispersant is toxic to living cells) was observed in some tests at concentrations above 10 parts per million. The endocrine and the cytotoxicity screening were conducted at dispersant concentrations from 0.001 parts per million up to 10,000 parts per million. None of the dispersants triggered cell death at the likely concentrations of dispersants expected in the Gulf.[41]

Therefore, although EPA's study had a small sample set, EPA's test data provides no evidence that these oil spill response compounds with NP and NPE pose any inherent hazard that would justify the social costs of a precautionary ban. The preamble does not provide quantified social benefit estimates to support a ban over other policy alternatives.

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[39] See, for example, Maine's "Chemicals of High Concern," at http://www.maine.gov/dep/safechem/highconcern/.

[40] Judson, R. S., Martin, M. T., Reif, D. M., Houck, K. A., Knudsen, T. B., Rotroff, D. M., Dix, D. J. (2010). *Analysis of Eight Oil Spill Dispersants Using Rapid, In Vitro Tests for Endocrine and Other Biological Activity.* Environmental Science & Technology, 44(15), 5979-5985. doi:10.1021/es102150z

[41] http://www.epa.gov/bpspill/dispersants-qanda.html#toxtest8. See also U.S. Environmental Protection Agency, *Toxicity of Louisiana Sweet Crude Oil (LSC) and chemical dispersed LSC to two Gulf of Mexico aquatic test species,* August 2010.

EPA failed to consider and to evaluate policy alternatives to its proposed ban. Under the Executive orders, EPA must evaluate available policy alternatives and select the ones in which the benefits justify the costs.[42] There are several policy alternatives EPA could choose and could evaluate besides a ban on NP and NPE compounds, such as imposing lesser restrictions or requirements. Such options could tailor the social costs more directly to any potential hazard than a product ban. Only through objective, transparent policy analysis of these alternatives can senior officials and the public weigh the options to decide upon the best policy.

2.3.1. **Estimated Social Costs**

We searched PubMED for published, peer-reviewed articles that found evidence of NP and NPE-containing oil spill response agents. The only study that specifically listed these compounds was EPA's 2010 work in response to the SONS.[43] It identified NP and NPE compounds in two listed dispersants, Nokomis 3-F4 and ZI-400. For the purpose of this estimate, we assume these products are subject to the proposal's ban.

Based on our evaluation, the manufacturers of these products are likely small businesses. To estimate the impact of the ban, we use a similar approach as in Section 1.2.1. The social costs are not permanent; the social value of the banned products is eventually replaced by substitutes or through greater sales of other dispersants. In EPA's testing, the most widely-used dispersant did not contain NP and NPE. The social costs, therefore, are limited to the immediate disruption in the market.

Since we do not know the actual sales of these dispersant products, we average the annual revenue from the three small business manufacturers of dispersant products given in the RIA. As done is Section 1.2.1, we use the value added of the chemical industry to estimate the added value from these products. The social cost of the ban is the lost value from these two products for a three year period.

There are several reasons this approach underestimates the likely social cost. First, medium and large companies may have their products banned also. While these companies may have resources to reformulate their products, there still will be social costs to switch to substitutes. Second, our estimate of two banned products comes from our search of the public, peer-reviewed literature. Given the controversy over dispersants during the SONS and EPA's proposed rule, companies have an incentive not to disclose voluntarily NP and NPE ingredients. Third, it is possible that NP and NPE compounds are used in other product types such as surface washing agents. Fourth, the manufacturers of the two dispersants that EPA identified as containing NP and NPE have similar products on the schedule. If these products also contain NP and NPE, they would also face bans under the proposal.

Finally, we do not estimate the social costs of a more sweeping ban on all EDC compounds. EPA's proposal is too vague for the public to understand its implications. First,

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[42] U.S. Office of Management and Budget, Circular A-4 Regulatory Analysis, September 2003, pg. 16.

[43] Judson RS, Martin MT, Reif DM, et al. Analysis of Eight Oil Spill Dispersants Using Rapid, In Vitro Tests for Endocrine and Other Biological Activity. *Environmental science & technology.* 2010; 44(15):5979-5985. doi:10.1021/es102150z.

EPA does not define what it means to be an EDC. Second, EPA does not state whether all compounded named as an EDC are banned as ingredients or whether *de minimis* amounts are permitted.

Since some of these same products may drop out of the market due to the new testing requirement, we structure our NP product ban cost estimate so as not to double count the product loss estimates already presented. In Section 1.2.1, one product is a dispersant. Our range is simply whether this product's loss is included in the $4 million product loss calculated in Section 1.2.1 or is an additional social cost.

Summary	NPV at 7%	Annualized Cost over 20 years at 7%
Product Loss Costs	$4,000,000-$7,300,000	$380,000-$720,000

2.3.2. Recommendation

The RIA must fully estimate the social costs and the social benefits of the proposal to ban NP and NPE compounds in listed products and the alternative to ban EDCs. To comply with the Executive orders and OMB guidance, EPA must also evaluate policy alternatives to banning compounds and select the one with the greatest net social benefits.

2.4. Expired Product Testing and/or Replacement Costs

EPA proposes that stockpiled products must be tested in order to be used after their expiration date. The RIA does not estimate the social costs of this requirement.

This provision has social costs and potentially social benefits. There are two costs: increased product testing costs and potentially the cost of more frequent product shipments to stockpile locations. The social benefits are potentially more effective products due to this requirement.

2.4.1. Estimated Social Costs

Over time organizations that stockpile oil response products will attempt to minimize the cost of this requirement through inventory management. They can change their ordering procedures to better match inventory to use. More significantly, they can shift sales of products past their official expiration date to other markets. Numerous oil spills and cleanups occur that do not involve Federal OSCs. Since many expiration dates are minimal (e.g., "at least two years"), buyers may be willing to accept response products with older shelf lives for a discount or because their spill response need is less. Vendors/organizations that stockpile will, over time, manage their inventories so that products with young shelf lives are reserved for any Subpart J needs and then, rather than retest to verify their continued use, are migrated to other markets.

This strategy can only work if the major stockpiled products have sufficiently long shelf lives. In the Attachment, the recommended shelf lives for each existing product are listed. We assign a shelf life of 20 years to products reporting unlimited shelf life.

Bioremediation products have the shortest average shelf life of less than three years. Dispersants have the longest average shelf life, with the most widely stockpiled dispersant having an unlimited shelf life. While products vary significantly, there are numerous products in each category with relatively long shelf lives to allow inventory management. To the degree there are effects, management of existing bioremediation products could be most vulnerable to the requirement for additional testing.

For these reasons, we model the social cost as a one-time event to shift management of existing inventories. We assume future purchases and sales will direct products with older shelf lives to cleanups outside National Contingency Plan jurisdiction. We also assume that some operators of existing stockpiles and inventories will decide it is more cost-effective to test rather than replace their existing inventory.[44] They may have quantities of the surface washing products with shorter shelf lives than the average nine year life-span of these products. Different stockpiles will have different products; therefore, the testing decision is based on the number of stockpile-product combinations. We assume that operators find 20 stockpile-product combinations where testing is more cost-effective than selling into other markets or discarding and replacing the product. Since dispersants have a much longer shelf live on average, we only assume four stockpile-product decisions to test. Table 2.2 presents the results based on these assumptions. This provision could have social costs of $1.7 million.

Table 2-2 Estimated Costs of Testing Expired Products

Product	Testing Cost	Number of Stockpiles-Products	Total Cost
Bioremediation Agent	$31,800	20	$1,270,000
Dispersant	$13,050	4	$52,200
Surface Washing Agent	$10,300	20	$206,000
Solidifier	$10,300	20	$206,000
Total			**$1,740,000**

In Section 2.1.1, we consider the social cost of managing stockpiles of existing products that are not approved in the post-regulatory scenario. We assume that OSRO and others manage their inventories of surface washing agents, sorbents, and other products to market them to non-NCP spill responses. In Section 5 we combine all of the provisions that require testing into one estimate so that the analysis makes consistent predictions of market dynamics after the rulemaking.

2.4.2. **Recommendation**

EPA must estimate the social benefits and social costs of this provision if it is included in the final rule. EPA should use current data on stockpile amounts and their expiration dates.

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[44] Or they will replace products in response to the rule up to the expected value of testing them to prove their efficacy. We use the testing cost as the upper limit of the cost to replace existing inventories.

2.5. RECOVERY OF AGENTS FROM ENVIRONMENT

In the proposal, EPA adds a regulatory requirement that responsible parties are obligated to recover certain oil spill response products from the environment. When stabilizers, surface washing agents, and sorbents are used, responsible parties must recover them when it is safe to do so. The RIA does not estimate any social benefits or social costs from this provision.

This requirement has social costs and potentially social benefits. For major spills, it is likely the regulation formalizes the likely site-specific orders by the OSC. By making it a regulatory requirement, the major change is that it subjects the responsible party to the full enforcement authorities under the Clean Water Act. The proposal reduces the government's administrative effort to levy fines and penalties.

The marginal increase in the threat of fines and penalties may change responsible party behavior. Responsible parties may put greater effort into recovery operations and respond to reports of agents in the environment after the spill for a longer period of time. More effort at recovery may then yield some environmental benefits on the margin. However, greater human activity - boats, motors, skimmers - in environmentally-sensitive areas may cause damage while recovering response products. The current framework - to take actions which have the greatest net environmental benefits - is more flexible and allows site-specific balancing of ecological, human safety, and response product use.

2.5.1. Estimated Social Costs

As a practical matter, this provision may not have any additional social costs for major Tier I, Tier II, or Tier III oil spills. On scene coordinators effectively order product recovery for these major spills. For larger spills, the greater level of government oversight in both the baseline and the post-regulation may be expected to lead to similar levels of responsible party activity. For smaller spills, the proposed regulatory requirement could increase social costs by diverting resources into product recovery, especially after the immediate spill response. It is difficult to estimate the additional costs in these site-specific decisions.

Since 2000, there have been on average 13 spills per year of between 5,000-10,000 gallons of oil products into U.S. navigable waters.[45] We assume that these spills are large enough that responsible parties use significant amounts of response products, but not so large that they trigger substantial government oversight.

We assume that the regulatory provision triggers an additional $10,000 in response costs per spill of this medium-to-large spill size. Since daily penalties under the Clean Water Act are up to $37,500 per day per violation, a responsible party may be willing to respond to reports of sorbents and other products in the environment after a spill rather than risk a penalty. They may be willing to spend much more than $10,000 per incident to avoid the fines. However, assuming an average per incident additional cost of $10,000, the net present value (at seven percent) social cost of this requirement is $1.7 million.

[45] United States Coast Guard, *Polluting Incidents In and Around U.S. Waters: A Spill/Release Compendium: 1969 – 2011*, December 2012.

2.5.2. **Recommendation**

EPA should articulate in any final rule the specific social benefits and social costs it believes will occur as a result of this provision. Specifically, EPA should explain the value of this requirement as a regulation as opposed to a site-specific/incident-specific decision that maximizes net environmental benefits.

SECTION 3. UNDERESTIMATED COSTS

3.1. MONITORING COSTS

The proposal requires responsible parties to carry out extensive monitoring of dispersant use, oil concentrations, and ecological effects in the event of a major oil spill where dispersants are used. The RIA estimates the cost of these monitoring requirements to be $500,000 per year for an average of one applicable major, off-shore oil spill per year.

The justification for the cost estimate in the RIA is two studies. However, these studies do not replicate the specific proposed requirements and therefore do not provide adequate justification for the RIA's estimate.

3.1.1. Estimated Social Costs

We build a bottom-up estimate of the social costs to monitor and to report the information listed in the proposed rule. We first make some assumptions concerning the duration of the spill. We assume the responsible party conducts active monitoring of the oil plume and dispersant use for 14 days, followed by 21 days of monitoring of the dissolved oil/dispersant mixture in the water column. Modeling of the oil movement in the water is carried out for 14 days; fluorescence monitoring occurs for the entire 35-day period.

Since dispersants are used, the oil spill is assumed to occur off shore, meaning boats are needed to obtain the water samples and to gather data for the modeling. Background samples are assumed to be gathered at four points upwind and downwind of the plume. In-plume measurements are assumed to be gathered at five points, with three different sampling points in the water column at each point. After the 14 day period, monitoring requirements for the next 21 days fall from five locations in the plume to four areas in the affected area. Background samples are still collected.

Field and test blanks are assumed to be analyzed for each background and plume collection point. The proposal also requires the responsible party to submit a quality assurance plan for the sampling and analysis.

Given the need for rapid decisions, the ecological characterization and risk assessment requirements are divided into two phases. For immediate decisions during the 14 day active response, experts gather available information from already-published studies and regional ecological evaluations. This study also sets the acute toxicity level from available data. Once the response moves to the 21-day monitoring of the ultimate dispersion, a more complete, written ecological characterization report is compiled.

The responsible party assigns 10 managerial and technical staff to manage, carry out, and to report compliance with the monitoring requirements during the 35-day event.

Based on this scenario, we gathered publicly-available price data from OSROs and commercial laboratories to build a social cost estimate. The Oil Spill Response Limited

organization has a global price list and cost data for their Florida-based response location.[46] Table 3-1 gives the principal data used in this cost estimate:

Table 3-1. Prices for Oil Spill Dispersant Use Modeling

Fluorescence Tracking[47]	659	GBP/day
Boat Rental[48]	400	GBP/day
Oil Modeling[49]	2,300	GBP/day
Heavy Metal Analysis[50]	350	$/sample
Volatile Organic Compounds and Benzene, Toluene, Ethylbenzene, and Xylenes[51]	250	$/sample
Total Petroleum Hydrocarbons[52]	150	$/sample
Other Parameters[53]	150	$/sample

Based on this scenario, the estimated monitoring costs are approximately $850,000 per spill. This value is substantially greater than the RIA estimate. This estimate does not include insurance costs, contingency costs, surcharges for rapid delivery, sample shipping costs, travel costs, or other logistical needs. Including these costs would increase the social costs of this provision.

Given the frequency of one spill per year, the net present value and annualized value of these social costs are given below.

Summary	NPV at 7%	Annualized Cost over 20 years at 7%
Monitoring Costs	$11,000,000	$1,000,000

[46] http://www.oilspillresponse.com/

[47] http://www.oilspillresponse.com/files/ScaleOfFees2015.pdf.

[48] Ibid

[49] http://www.oilspillresponse.com/files/ScaleOfFees2015.pdf.

[50] See for example, Price List from Water Testing Labs at http://www.wtlmd.com/wastewater-testing-pricing-maryland-md-va-dc-de.php.

[51] Ibid

[52] Ibid

[53] Ibid

3.1.2. Recommendation

EPA should use the available data from OSRO equipment price lists and laboratory sampling costs to build up a more complete cost estimate for all of the required parameters for dispersant modeling in the proposed rule. With a frequency of dispersant use of approximately once per year, there is sufficient existing data and markets to use market prices to estimate the social cost. EPA should also characterize plume size and expected monitoring requirements from past spill responses. Gathering this data will provide more support for a social cost estimate.

3.2. EPA Costs to Administer the Rule

The RIA underestimates the total resource cost for EPA to administer the rule because it fails to include the total compensation and overhead costs to employ Federal agency staff and it omits the time necessary for EPA to administer the new requirements. The RIA's approach does not comply with EPA's obligations under the Paperwork Reduction Act's implementing regulations (PRA).[54]

The RIA use BLS data from 2011 as estimates of the opportunity cost of government employees. There are several problems with this data:

- It is out of date. The BLS has compensation data available through September 2014.[55] Moreover, the General Services schedule of Federal wages for 2014 is also available as it determines EPA employees' paychecks.

- It underestimates total compensation. It is unclear whether the data the RIA uses is for salary and wages only or for total compensation. It appears that the RIA uses a labor cost of approximately $54 per hour for EPA employees.[56] The

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[54] See 5 CFR 1320.3(a)(1):

(1) *Burden* means the total time, effort, or financial resources expended by persons to generate, maintain, retain, or disclose or provide information to or for a Federal agency, including:

(i) Reviewing instructions;

(ii) Developing, acquiring, installing, and utilizing technology and systems for the purpose of collecting, validating, and verifying information;

(iii) Developing, acquiring, installing, and utilizing technology and systems for the purpose of processing and maintaining information;

(iv) Developing, acquiring, installing, and utilizing technology and systems for the purpose of disclosing and providing information;

(v) Adjusting the existing ways to comply with any previously applicable instructions and requirements;

(vi) Training personnel to be able to respond to a collection of information;

(vii) Searching data sources;

(viii) Completing and reviewing the collection of information; and

(ix) Transmitting, or otherwise disclosing the information.

[55] See the Employment Compensation Survey, http://www.bls.gov/ncs/tables.htm.

[56] Calculated from data in RIA, pg. 36.

RIA should use total compensation measures to account for Federal employee benefits such as pension, health care, disability insurance, and personal leave. This information is readily available in EPA budget documents, in OMB budget memoranda, and from the Office of Personnel and Management.

- The total resource costs for government services is more than the total compensation cost of labor. Government workers do not work in the open air. They need buildings, electricity, computers, telephones, water, and many other overhead costs. Estimating the overhead costs for government employment is a routine practice in Federal budgeting, in program evaluation, and for compliance with the Paperwork Reduction Act.[57]

Further, the RIA does not include the costs for EPA to administer certain provisions of the rule. In addition to the costs to participate in the RRT and AC meetings included in Section 2.2.1, the RIA fails to include the EPA resources necessary to remove a product from the listing schedule.

3.2.1. Estimated Social Costs

We estimate the social costs of EPA resources to oversee the proposed requirements. Although it is likely an underestimate, we retain the RIA's estimate of 26.5 hours for EPA staff to review each product application. Interestingly, the RIA estimates producers of existing products spend only 7.7 to 27.7 hours to submit the required testing data to EPA. Thus, by the RIA, EPA's review time is longer - up to three times longer - than the time needed to prepare the information. If this ratio is correct, EPA's review process could take over 100 hours. We also agree with the RIA's estimate that the same number of hours is needed when a manufacturer submits new testing data after a product has been reformulated.

However, the RIA assumes EPA spends only 2.5 hours reviewing resubmissions of data from applicants. Since EPA has only 90 days to review an application, it is likely to extend its review by asking applicants for additional information. It seems implausible that EPA would need less than 10 percent of its estimated total review time to review resubmitted data. We use an estimate of 20 hours. We also double the amount of time the RIA estimates to review an appeal of a product disapproval. We believe other divisions of EPA, including the Office of General Counsel, will support the Administrator's review of an appeal and a final Agency decision.

For the opportunity cost of EPA personnel time, we use the fully-loaded employment costs. In FY13, the median EPA employee salary was nearly $108,000, or nearly $55 per hour.[58] We apply OPM's benefit and overhead percentages to calculate a fully-loaded rate of

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[57] 5 CFR 1320.3(a)(1).

[58] U.S. Office of Personnel Management, *Salary Information for the Executive Branch Fiscal Year 2013*, April 2014.

$81.50 per hour.[59] This estimate is a slight underestimate of the likely median wage due to general schedule increases since FY13.

Using the post-regulation rate of existing product submissions and new product submissions, we calculate a net present value (at seven percent) of $0.81 million in social costs for EPA to administer the testing requirements.

3.2.2. Recommendation

The RIA should include costs of EPA to carry out all the proposal in its entirety. EPA should include the total compensation cost for government personnel and the overhead costs necessary to house and to equip these employees so that they can perform their new tasks under this proposed regulation. EPA must include these costs and the resources to oversee all of the provisions of the rule in subsequent analyses.

3.3. Testing and Product Listing Costs

The RIA underestimates the costs an organization expends to understand and to comply with this regulation. The RIA assumes essentially that one or two individuals are solitary actors that read, plan, and implement a regulation for a company. In reality, many employees and managers in an organization will be involved in a product's application.

In addition to underestimating the costs for producers, the RIA underestimates the costs to understand, to comply, and to submit product applications. For example, the RIA does not include these costs:

- Laboratory Personnel Understanding the Rule. The RIA does not include the cost for laboratory personnel either within the manufacturer or at a commercial lab to understand the new testing requirements.
- Legal Personnel Time. It seems implausible that a company would file an important submission to EPA without it undergoing legal review. The submission could determine the entire market for a product.
- Response Costs. Often EPA staff will seek clarifications from respondents on their data submissions to the agency. Seeking clarifications in lieu of outright denials/approvals conserves resources for both EPA and respondents. Oddly, the RIA includes EPA's cost to review these re-submissions, but not those of the respondents to prepare them.[60]

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[59] See for example, U.S. Office of Personnel Management, Federal Investigative Services Division, *White Paper: Support Services Contract Cost Benefit Analysis.*

[60] Even if the RIA estimates the full resource cost for the respondent to submit a "perfect" application that does not require clarification, the respondent is not in control of EPA staff comprehension of the submission and their ability to ask questions, triggering respondent costs.

3.3.1. Estimated Social Costs

In Table 3-2 below, we present alternative labor estimates for producers to comply with the rule that addresses the RIA's limitations. We include hours for all the provisions required of producers, including ones the RIA omits like the product label redesign.

Table 3-2. Estimated Skilled Labor Resources Producers Require to Comply with Proposal's Testing Requirements

(Hours)

	Labor Hours Needed		
	Managerial	Technical	Clerical
Hourly Compensation	$ 55.56	$ 55.56	$23.57
Understand Rule	4	8	2
Contract for Tests	2	16	4
Manage Tests	0	8	8
Prepare Documentation	4	40	16
Design Label	0.5	8	8
Legal Review	4	0	2
Revise Documentation	2	4	45
Respond/Follow up	4	16	8
Total (Hours)	20.5	100	93
Total ($) including overhead rate of 17 percent			$10,400

We include hours for essential tasks to prepare the required information. First, the producer must find and contract with an independent certified laboratory for the efficacy and toxicity testing. They must manage the outside laboratory's performance and review the results. In addition, the producer must prepare the written submission to EPA and follow up with any EPA questions.

For labor rates, we use the BLS Employer Cost for Employment Survey data for December 2014.[61] We use the same overhead rate as the RIA, 17 percent, and use the RIA's relative proportion of the application costs among dispersants, solidifiers, surface washing agents, and bioremediation agents. We use these labor costs for product testing in the multiple provisions in the proposal that require product testing.

[61] http://www.bls.gov/ncs/ect/sp/ececqrtn.pdf.

3.3.2. Recommendation

EPA should include all the costs to understand, to explain, and to incorporate the proposed rule into their organizations' operations. EPA is required to perform this analysis under the PRA regulations. In addition, from past applications, EPA should review whether, and if so, the scope of additional information requests it gave to applicants and include these costs in the any final rule. These costs must be assigned to the regulation.

3.4. Limitation To Tested Waters and Efficacy and Toxicity Testing Costs

In the proposal, EPA limits use of a product to the water characteristics of its toxicity and efficacy testing. Product data with just freshwater test data are limited to freshwater uses, for example. The proposed rule expands the number of efficacy tests for bioremediation agents and alters the efficacy test for dispersants. The proposed rule adds new toxicity tests for dispersants and freshwater/saltwater tests for bioremediation, solidifiers, surface washing agents, and other products.

The RIA makes a global assumption that producers chose just one testing environment, salt water or freshwater, and bear the costs for only one test protocol. Rather than chase market demand and maximize net profits, producers instead make their marketing decisions based on the testing cost. The RIA's assumption violates basic economic theory and thus underestimates social costs.

EPA's own data demonstrates this point. Producers list which of the current required toxicity and efficacy testing they have conducted. This information is available on the Subpart J schedule. Except for the bioremediation products, all other products list test data in both the reference saltwater and freshwater species. For bioremediation products, 27 products do not list any information; 21 report test data in both species. In other words, producers currently want to sell in both markets due to the demand for oil spill remediation in both waters. The rulemaking does not change this market demand.

3.4.1. Estimated Social Costs

Since producers currently market to oil spill response demands in both freshwater and saltwater environments, we assume existing and new product manufacturers will pay for the new efficacy and toxicity tests required for both environments. Using the RIA's testing costs, the total laboratory testing cost per product is listed in Table 3-3.

Table 3-3. Testing Costs by Product Type

Dispersants	$13,050
Bioremediation	$31,800
Solidifiers,	$10,300
Surface Washing	$10,300

We use these testing costs to estimate the application cost and the economic impact of the proposed rule. The labor and laboratory testing costs are combined and presented in Section 6.

3.4.2. Recommendation

Consumer demand will drive producers' decisions on marketing, not the testing requirements of the rule. EPA should align its economic analysis to observed producer decisions and thus expect increased testing costs rather than the estimates found in the RIA.

3.5. Retesting Whenever Chemical Composition Changes

In the proposal, producers would be required to retest its products and submit the results to EPA whenever they change the chemical compounds or their concentrations in an approved product. The proposal calls for comment on an option for allowing *de minimis* changes in concentrations or formulations, but proposes retesting for any change. The RIA assigns the same amount of cost to this requirement as it does for a new product application. For the reasons discussed in Section 3.3 above, the RIA underestimates social costs.

3.5.1. Estimated Social Costs

For a cost estimate, we assume that on average one product each year undergoes a change that triggers the requirement to retest. With more than 100 products and product lines on the Subpart J list, the RIA's assumption seems reasonable that approximately one product would undergo a change each year to trigger retesting.

Since we do not know which product type will undergo change, we take an average of the estimated testing costs for the four product types. Therefore, if one product triggers the retesting requirement per year, the net present value (at seven percent) of this proposed provision is $1.7 million/year.

3.5.2. Recommendation

EPA should articulate in any final rule the specific social benefits and social costs it believes will occur as a result of this provision. Specifically, EPA should explain the value of this requirement as opposed to a performance standard that makes manufacturers responsible to demonstrate that formulation changes do not affect toxicity or efficacy.

3.6. Product Label Redesign

In the proposed rule, applicants must submit a sample product label that includes the manufacture and expiration date, the storage conditions, and the mandatory disclaimer language. Producers must not only change the description on the label on the physical product, but also the description on any promotional material, websites, and other presentation forms. The RIA includes the social cost of submitting the sample label in its overall producer cost estimates.

EPA has estimated the social costs of mandatory labeling and labeling changes in multiple rulemakings.[62] The social costs include the one-time labor and capital costs to craft the new label design, any on-going incremental costs to produce the new label, and costs to digitize the information for electronic media.

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[62] See, for example, U.S. Environmental Protection Agency, *Final Technical Support Document, Fuel Economy Labeling of Motor Vehicles: Revisions to Improve Calculation of Fuel Economy Estimates*, EPA420-R-06-017, December 2006.

3.6.1. Estimated Social Costs

We include additional labor hours to account for the changes to a producer's website and marketing materials. Table 3-4 shows the labor costs for this requirement. We add $500 for each producer in capital and material costs to create the new label.

3.6.2. Recommendation

In any final rulemaking RIA, EPA should draw upon other EPA analyses to estimate the labor hours and capital cost requirements to redesign labels and marketing materials.

3.7. Accredited Laboratory Requirement

The proposed rule requires test data be generated from an accredited laboratory. In the baseline, companies could use any laboratory or generate the information in their own laboratories. While the RIA states that it gathered costs from laboratories to conduct the tests, it is unclear whether this cost information is from accredited labs.

3.7.1. Estimated Social Costs

If the RIA data is from accredited labs, then the costs of this requirement is included in the test costs used in the RIA. If it is not, then the RIA's costs for each test is likely underestimated.

3.7.2. Recommendation

In any final rule, the accompanying RIA should disclose the sources of its information so that policy officials and the public can evaluate the incremental social benefits and social costs of this provision as required by the Executive orders on regulatory review.

SECTION 4. THE RIA'S SOCIAL BENEFIT DESCRIPTION IS INACCURATE AND DOES NOT COMPLY WITH EPA'S REGULATORY ANALYSIS REQUIREMENTS

Fundamentally, the RIA fails to comply with the Executive orders on regulatory review because it does not quantify the potential social benefits either in dollars or in any other metric.[63]

Even more troubling, the RIA lists social benefits that are irrelevant to this rule and, if applicable at all, are actually social costs. The RIA lists qualitative benefits from avoiding oil spills such as lost tourism revenue and enjoyment. However, this rulemaking has the potential for aggravating the potential damages from oil spills. To the degree this rulemaking reduces chemical and biological agent availability and innovation, the nation will have less tools available to fight oil spill damage. A possible, but hopefully remote, outcome of this rule is that future oil spill damages would be more severe than they would be if the rule did not occur. Therefore, the potential social costs from oil spills should be considered, if at all, as a social cost of this rulemaking, not a benefit.

The RIA also does not quantify the marginal social benefits from each provision and each regulatory option. Under Circular A-4, agencies are required to estimate the marginal social costs and benefits for each regulatory provision.[64] Since this rulemaking proposes multiple changes to Subpart J, the public and policy officials cannot determine which provisions have net social benefits and which provision provides the most social benefits.

As discussed in Section 1, the other fundamental problem is that the RIA does not have a consistent baseline and post-regulatory alternative to allow a consistent measurement of social benefits. We present our recommended post-regulatory scenario in Section 5.

Recommendation. The RIA does not comply with the basic requirements of a social benefit estimate. First, it must define clearly what the social benefits are from this rulemaking and describe the real social goods that increase from the baseline to the post-regulation scenario. Second, an RIA for any final rulemaking must attempt to quantify the incremental amount of these social goods that can be attributed to this rulemaking and to the specific provisions of the rulemaking that will generate these social goods. Finally, EPA must use the established literature to value the gains, if any, in ecological services from the rulemaking.

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[63] OMB, Circular A-4, pg. 27.

[64] OMB, Circular A-4, pg. 7.

SECTION 5. TOTAL SOCIAL COSTS

5.1. POST-MARKET CONDITIONS

As discussed in Section 1, EPA's economic analysis guidelines emphasize the need for a clear and consistent market baseline and description of post-regulation market conditions. This guidance is especially relevant for this rulemaking because of the interaction of the requirements, the effect on regulated parties' behavior, and the ultimate social cost of the rulemaking.

This section describes a potential sequence of actions flowing from EPA's promulgation of the final rule. The social cost of these actions, and the time they occur, is the structure of our social cost estimates:

- In year 1, EPA promulgates the final rule.
- In year 1 and 2, existing products remain on the market. At the end of year 2, 13 existing products do not submit testing data due to high costs. The value of 13 comes from the results of the economic impact analysis in Section 6. Therefore, the number of existing submitted application is 13 less than the baseline. It is likely that these 13 products include the products banned due to the NP and NPE formulation ban.[65]
- Starting in year 1 and continuing, the rate of new product applications falls from 10 per year to 7 due to increased costs and market barriers
- In year 3, 13 new product applications are submitted to fill the baseline market demand.
- In years 1-3, 64 expired product applications come as suppliers adjust their inventory. We assume 24 in year 1 and 20 each in years 2 and 3.
- One new application appears each year for product reformulation.

[65] In other words, the social costs of the product loss from the banned products are estimated. However, we assume that for the one or two potential products subject to the ban, only one new product is added in the future.

Table 5-1. Pace of Product Applications

	Year						
	1	2	3	4	5	6	7
Baseline							
Existing Products	109						
Annual New Products	10	10	10	10	10	10	10
New Estimate							
Existing Products	59	27					
Expired Products	24	20	20				
Annual New Products/New Formulations	7	8	8	21	8	8	8
Total	**90**	**55**	**28**	**21**	**8**	**8**	**8**

5.2. ADDITIONAL SOCIAL COSTS

5.2.1. Additional Social Costs from this Analysis

Based on the information in Table 5-1, we can integrate the social cost estimates for the different provisions of the rule. Table 5-2 gives the net present value and annualized social costs for the provisions with estimates in this analysis. As in Table 5-1, the social cost for testing includes the costs for expired products, for new products, for retesting of existing products, and for impact of existing products dropping out of the market.

Table 5-2. Additional Social Costs of the Proposal

	NPV at 7% ($)	Annualized Cost over 20 years at 7% ($)
Product Loss Costs	4,000,000-7,300,000	380,000-720,000
Product Testing Costs	5,300,000[66]	500,000
Stranded Capital/Stockpile Value Loss	1,000,000-1,250,000	90,000-120,000
Label	180,000	20,000

[66] This number is the net present value of the weighted annual testing cost multiplied by the number of products per year that is given in Table 5-1. The weighted annual testing cost is that year's mix of dispersant, solidifiers, surface washing, and bioremediation products that submit testing information. For existing products, the each yearly mix of different product types is proportional to the number of each type on Subpart J and the number of each type subtracted/added to the additional testing cost. As discussed in Table 2-2, different product types also have a different frequency of expired product testing. This proportion thus changes the number of each product type tested per year and thus the weighted annual testing cost.

Recovery Costs	1,700,000	160,000
Monitoring Costs	11,000,000	1,000,000
Preauthorization Costs	200,000	20,000
EPA Costs	800,000	80,000

Totals[67]	24,000,000-27,000,000	2,300,000 --2,600,000

5.2.2. **Other Costs from the RIA**

The RIA included social costs estimates for other proposed requirements that are not re-estimated in this analysis. The RIA estimates the costs for some sorbent manufacturers to submit technical data to be considered on a Sorbent Product List. The RIA estimates the annualized cost to be approximately $15,000. Adding this provision to the costs in Table 5-2 does not materially change the social cost estimate.

[67] Throughout this report, totals and summaries may be different due to rounding. Reflecting the likely precision of these estimates, figures are presented to two significant digits or less.

SECTION 6. THE RIA UNDERESTIMATES THE SMALL BUSINESS IMPACT

The RIA's methodology underestimates the rule's economic impact on small businesses. The proposed rulemaking may have a substantial effect on a significant number of small businesses in the oil spill response product market. EPA should evaluate whether it must comply the procedural and other analytic requirements of the Small Business Regulatory Enforcement Fairness Act (SBREFA).

EPA's methodology underestimates the economic impact in two principal ways. First, as discussed above, it underestimates the direct labor and capital costs to comply with the rule. Second, it underestimates the cost of capital in at least two ways: (1) by assuming owners can finance testing requirements over a longer time period than is likely; and, (2) by underestimating the cost of capital for small businesses. Each of these issues is discussed below.

First, firms producing existing listed products only have two years to reapply and to resubmit the newly-required information. Yet, the RIA annualizes a firm's costs over a 20 year period. It is highly unlikely that a small business could borrow funds over a 20 year period for a product that may only have a limited market for two years. Nor would rational business owners with high opportunity costs for capital tie up their capital for such a long time period. A more realistic financing period is two years.

Second, as EPA's economic guidelines state for economic impact analyses, EPA should use the private cost of capital for small businesses.[68] EPA uses the social cost of capital established by OMB. However, due to the increased loss risk, capital lending institutions or capital investors charge higher effective interest rates for loans to small businesses. The Federal Reserve conducts routine survey of small business lending conditions.[69] In recent months, they have found completed, Small Business Administration-backed small business loans at an interest rate of between 5.1 and 5.6 percent. However, the average effective borrowing rate across all small businesses is much higher. As firms report, if they do not qualify for commercial credit, they use instruments with higher interest rates such as credit cards, trade credit, or debt consolidation. The average effective borrowing rate across all small businesses and all credit needs is substantially greater than seven percent.

We present an alternative estimate of economic impact to small business as an illustration of how large the impacts are likely to be. Table 6-1 shows the testing and the labor costs for existing producers to comply with the proposed rule using different discount rates and annualization periods.

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[68] EPA, *Guidelines*, pg. 9-16.

[69] Federal Reserve Banks of New York, Atlanta, Cleveland and Philadelphia, *Joint Small Business Credit Survey Report, 2014*, February 2015.

Table 6-1. Annualized Compliance Costs for New Testing Requirements, RIA Estimate and Revised Estimate

	Testing Costs	Estimated Labor Costs	RIA's Total Costs	Estimated Total Costs	Annualized at 7% over 20 Years	Annualized at 7% over 5 Years	Annualized at 7% over 2 Years
Dispersants	$13,050	$10,398	$14,240	$23,448	$1,344	$3,473	$12,969
Bioremediation	$31,800	$7,728	$14,042	$39,528	$1,325	$3,425	$21,863
Solidifiers,	$10,300	$6,412	$5,986	$16,712	$565	$1,460	$9,243
Surface Washing	$10,300	$5,077	$5,880	$15,377	$555	$1,434	$8,505

Table 6-2 replicates Exhibit 7-1 of the RIA to present the testing and application costs as a percentage of the firm's annual sales. For economic impact analyses, if a regulation's cost to a firm is three percent of its revenue or more, the general conclusion is that the firm is at risk of closure.[70] The RIA reviewed 30 of the 35 small businesses and found that none exceeded the three percent significant impact threshold. However, using a more realistic financing period and more realistic estimates of costs, 43 percent (13/30) of the firms would face compliance costs greater than three percent of their annual 2011 sales. We recognize that Table 3 uses 2014 values for labor costs and 2011 data for revenue. In any final rule, EPA should update the revenue estimates and recalculate the economic impact using costs and financing options that reflect market conditions.

[70] U.S. Small Business Administration, *Guide for Government Agencies How to Comply with the Regulatory Flexibility Act*, May 2012. See U.S. EPA, *Final Guidance for EPA Rulewriters: Regulatory Flexibility Act as amended by the Small Business Regulatory Enforcement Fairness Act*, November 2006.

Table 6-2. Economic Impact on Small Businesses

Company	Number of Employees	Annual Revenue	Product Type	Annualized Cost	Pct of Revenue
1	1	$ 62,000	Solidifiers	$9,243	14.9%
2	1	$ 1,000,000	Surface Washing Agent	$8,505	0.9%
3	1	$ 160,000	Surface Washing Agent	$8,505	5.3%
4	2	$ 2,500,000	Bioremediation Agent	$21,863	0.9%
5	2	$ 120,000	Solidifiers	$9,243	7.7%
6	2	$ 200,000	Solidifiers	$9,243	4.6%
7	2	$ 30,000	Solidifiers	$9,243	30.8%
8	2	$ 10,000,000	Solidifiers	$9,243	0.1%
9	2	$ 120,000	Surface Washing Agent	$8,505	7.1%
10	3	$ 280,000	Surface Washing Agent	$8,505	3.0%
11	3	$ 1,300,000	Surface Washing Agent	$8,505	0.7%
12	3	$ 150,000	Surface Washing Agent	$8,505	5.7%
13	3	$ 5,000,000	Surface Washing Agent	$8,505	0.2%
14	4	$ 559,000	Bioremediation Agent	$21,863	3.9%
15	4	$ 1,000,000	Dispersant(2) & Surface Washing Agent	$34,442.26	3.4%
16	4	$ 730,000	Solidifiers	$9,243	1.3%
17	4	$ 500,000	Surface Washing Agent	$8,505	1.7%
18	4	$ 187,000	Surface Washing Agent	$8,505	4.5%
19	4	$ 350,000	Surface Washing Agent	$8,505	2.4%
20	5	$ 5,000,000	Bioremediation Agent	$21,863	0.4%
21	5	$ 290,000	Bioremediation Agent	$21,863	7.5%
22	6	$ 120,000	Bioremediation Agent	$21,863	18.2%
23	6	$ 15,000,000	Dispersant(1) & Surface Washing Agent	$21,473	0.1%
24	6	$ 500,000	Surface Washing Agent	$8,505	1.7%
25	6	$ 5,000,000	Surface Washing Agent	$8,505	0.2%
26	7	$ 660,000	Surface Washing Agent	$8,505	1.3%
27	8	$ 3,054,214	Bioremediation Agent	$21,863	0.7%
28	8	$ 2,500,000	Surface Washing Agent	$8,505	0.3%
29	8	$ 1,500,000	Surface Washing Agent	$8,505	0.6%
30	9	$ 2,500,000	Surface Washing Agent	$8,505	0.3%

ATTACHMENT: SHELF LIFE OF LISTED AGENTS[71]

Product	Type	Shelf Life	Assumed Shelf Life (years)
AGROREMED (see SPILLREMED (MARINE)®)	Bioremediation Agent	one year	1
BILGEREMED (see SPILLREMED (MARINE)®)	Bioremediation Agent	one year	1
HYDROREMED (see SPILLREMED (MARINE)®)	Bioremediation Agent	one year	1
INIPOL EAP 22	Bioremediation Agent	one year	1
MUNOX SR®	Bioremediation Agent	over one year when stored at temperatures from 35°F to 95°F	1
OILCLEAN w/ACTIVATOR (see PRO-ACT)	Bioremediation Agent	one year	1
PRISTINE SEA II	Bioremediation Agent	As a dry bacterial blend, the shelf life is 1 year, and as a liquid bacterial mixture, the shelf life is 6 months	1
PRO-ACT	Bioremediation Agent	One year	1
SPILLREMED (INDUSTRIAL)	Bioremediation Agent	one year	1
VAPORREMED (see SPILLREMED (MARINE)®)	Bioremediation Agent	one year	1
BILGE CLEAR (see S-200)	Bioremediation Agent	1½ years if kept in the unopened original container	1.5
NANOBITE (see S-200)	Bioremediation Agent	1½ years	1.5
OIL GONE EASY (see S-200)	Bioremediation Agent	1½ years if kept in the unopened original container	1.5
S-200	Bioremediation Agent	1½ years	1.5
S-200C (see S-200)	Bioremediation Agent	1½ years	1.5

[71] Information compiled from individual products listed on schedule as of March, 2015. http://www2.epa.gov/emergency-response/alphabetical-list-ncp-product-schedule-products-available-use-during-oil-spill.

S-200 OIL CLEAN (see S-200)	Bioremediation Agent	1½ years	1.5
S-200 OIL GONE (see S-200)	Bioremediation Agent	1½ years	1.5
SHEENCLEAN (see S-200)	Bioremediation Agent	1½ years	1.5
Z-11 (see S-200)	Bioremediation Agent	1½ years	1.5
BIO-REGEN HYDROCARBON (see SOIL RX)	Bioremediation Agent	Shelf life exceeds 2 years when properly stored in the unopened original container	2
BIOREM-2000 OIL DIGESTER™	Bioremediation Agent	Two years when stored within the storage temperature range in the original container	2
BIOREM-2000 SC (see BIOREM-2000 OIL DIGESTER™)	Bioremediation Agent	Two years when stored within the storage temperature range in the original container	2
JE1058BS	Bioremediation Agent	2 years if stored in a cool dry area	2
REMEDIADE™	Bioremediation Agent	unopened is 2 years	2
SOIL RX	Bioremediation Agent	two years	2
SP 7010 (see REMEDIADE™)	Bioremediation Agent	two years	2
SUMP SAFE BIO-RECLAIM	Bioremediation Agent	The material must be used within 24-48 hours of constitution of the powdered bacteria portion in water. The dry material must be kept at -20°C and is stable for two years at this temperature. Once sent to the field, the material may be stored on ice for up to two weeks prior to constitution	2
SYSTEM E.T. 20 (formerly MCW.B 20)	Bioremediation Agent	2 years if maintained at 4ºC (39ºF)	2
WASTE AWAY®	Bioremediation Agent	Two years	2
WMI-2000	Bioremediation Agent	2 years if stored at ambient temperatures	2
B&S INDUSTRIAL (see STEP ONE)	Bioremediation Agent	Over 3 years	3
BET BIOPETRO (formerly BET BIOPETRO HEAVY)	Bioremediation Agent	More than 3 years in unopened original shipping container, stored in cool dry area	3
BIOWORLD BIOREMEDIATION HYDROCARBON TREATMENT PRODUCTS	Bioremediation Agent	exceeds 3 years when stored properly in cool, dry place out of direct sun light	3
SHAMANTRA BIO (see SHAMANTRA GREEN)	Bioremediation Agent	3 years when stored in sealed silos, polydrums, poly bags or totes	3
SHAMANTRA GREEN	Bioremediation Agent	3 years when stored in sealed silos, polydrums, poly bags or totes	3
STEP ONE	Bioremediation Agent	Over 3 years	3

VB591™, VB997™, BINUTRIX®	Bioremediation Agent	three years	3
ACT TERRA FIRMA	Bioremediation Agent	If kept in a sealed container with desiccant bag the shelf life is 5 years	5
ACT-TF (see ACT TERRA FIRMA)	Bioremediation Agent	If kept in a sealed container with desiccant bag the shelf life is 5 years	5
DRYLET™ MB BIOREMEDIATION	Bioremediation Agent	Minimum 5 years, with proper storage, in original packaging. Freezingdoes not harm shelf life; however, extreme heat (over 180°F) for long periods of time can shorten shelf life	5
DUALZORB®	Bioremediation Agent	unopened product is 5 years if not exposed toweather or direct sunlight	5
ERGOFIT MICRO MIX AQUA	Bioremediation Agent	5 years	5
LAND AND SEA RESTORATION	Bioremediation Agent	More than 5 years in unopened original shipping container, store in a cool, dry place	5
MICROSORB SC (see OPPENHEIMER FORMULA)	Bioremediation Agent	5 years	5
OIL SPILL EATER II	Bioremediation Agent	5 years	5
OPPENHEIMER FORMULA	Bioremediation Agent	5 years	5
The OPPENHEIMER FORMULA I (see OPPENHEIMER FORMULA)	Bioremediation Agent	5 year	5
TRAILZORB (see DUALZORB®)	Bioremediation Agent	5 years if not exposed to weather or direct sunlight	5
WHITZORB (see DUALZORB®)	Bioremediation Agent	unopened product is 5 years if not exposed to weather ordirect sunlight	5
MICRO-BLAZE®	Bioremediation Agent	Minimum 10 years	10
SUPERSPERSE™ WAO2500	Dispersant	one year	1
MARINE D-BLUE CLEAN™	Dispersant	2 years, if unopened	2
NOKOMIS 3-AA	Dispersant	two years	2
FFT-SOLUTION™	Dispersant	5 years	5
NEOS AB3000	Dispersant	five years	5
MARE CLEAN 200 (formerly MARE CLEAN 505)	Dispersant	10 years when stored indoors	10
NOKOMIS 3-F4	Dispersant	15 years or more if stored correctly in plastic drums	15
ACCELL CLEAN® DWD	Dispersant	unopened drums of ACCELL CLEAN® DWD is unlimited	20

BIODISPERS (formerly PETROBIODISPERS)	Dispersant	unlimited	20
COREXIT® EC9500A (formerly COREXIT 9500)	Dispersant	The shelf life of unopened drums of COREXIT® EC9500A is unlimited	20
COREXIT® EC9500B	Dispersant	The shelf life of unopened drums of COREXIT® EC9500B is potentially unlimited when containers remain capped and sealed to prevent contamination and evaporation of solvents	20
COREXIT® EC9527A (formerly COREXIT 9527)	Dispersant	The shelf life of unopened drums of COREXIT® EC9580A is unlimited	20
DISPERSIT SPC 1000™	Dispersant	The shelf life of Dispersit SPC 1000™ is unlimited in unopened containers	20
FINASOL® OSR 52	Dispersant	unlimited when the containers remain capped and sealed	20
JD-109	Dispersant	unlimited	20
JD-2000™	Dispersant	unlimited	20
SAF-RON GOLD	Dispersant	unlimited in unopened containers	20
SEA BRAT #4	Dispersant	Indefinite when stored properly	20
SEACARE ECOSPERSE 52 (see FINASOL® OSR 52)	Dispersant	potentially unlimited when the containers remain capped and sealed to prevent contamination and evaporation of solvents, and are stored in a place with stable temperatures and are unexposed to direct sunlight	20
SEACARE E.P.A. (see DISPERSIT SPC 1000™)	Dispersant	unlimited in unopened containers	20
SF-GOLD DISPERSANT (see SAF-RON GOLD)	Dispersant	unlimited	20
ZI-400	Dispersant	Unlimited in sealed polydrums of totes	20
ZI-400 OIL SPILL DISPERSANT (see ZI-400)	Dispersant	Unlimited in sealed polydrums of totes	20
MARI-ZYME (see ZYME-FLOW)	Miscellaneous Oil Spill Control Agent – MOSCA	1 year minimum	1
UNITED 658 PETRO-ZYME (see ZYME-FLOW)	Miscellaneous Oil Spill Control Agent – MOSCA	1 year minimum	1
ZYME-FLOW	Miscellaneous Oil Spill Control Agent – MOSCA	1 year minimum	1
ZYME-TREAT (see ZYME-FLOW)	Miscellaneous Oil Spill Control Agent – MOSCA	1 year minimum	1
PX 700™	Miscellaneous Oil Spill Control Agent – MOSCA	Two years	2

NORSOREX® APX	Miscellaneous Oil Spill Control Agent – MOSCA	3 years from date of production	3
ALSOCUP	Miscellaneous Oil Spill Control Agent – MOSCA	five years	5
CIAGENT (formerly CI AGENT, CHEAP INSURANCE, and PETRO-CAPTURE)	Miscellaneous Oil Spill Control Agent – MOSCA	5 years, if stored in cool dry area, away from direct sunlight	5
ELASTOL	Miscellaneous Oil Spill Control Agent – MOSCA	5 years when stored at temperatures below 150ºF	5
LIQUID ELASTOL (see ELASTOL)	Miscellaneous Oil Spill Control Agent – MOSCA	5 years when stored at temperatures below 150ºF	5
OIL BOND®	Miscellaneous Oil Spill Control Agent – MOSCA	5 years	5
OPFLEX®	Miscellaneous Oil Spill Control Agent – MOSCA	5 years	5
SEPARATE (see ELASTOL)	Miscellaneous Oil Spill Control Agent – MOSCA	5 years	5
PES-51	Miscellaneous Oil Spill Control Agent – MOSCA	6 years (unopened drum), 1 year (opened drum)	6
GELCO 200	Miscellaneous Oil Spill Control Agent – MOSCA	10 years when stored in dry, cool area out of sunlight	10
AQUA N-CAP™ POLYMER (see OIL SOLUTIONS POWDER)	Miscellaneous Oil Spill Control Agent – MOSCA	Not Limited	20
OIL SOLUTIONS POWDER	Miscellaneous Oil Spill Control Agent – MOSCA	Not limited	20
RAPIDGRAB 2000™	Miscellaneous Oil Spill Control Agent – MOSCA	unlimited	20
WASTE-SET #3200®	Miscellaneous Oil Spill Control Agent – MOSCA	unlimited	20
WASTE-SET #3400®	Miscellaneous Oil Spill Control Agent – MOSCA	unlimited	20
SILTECH OP-40	Surface Collecting Agent	three years	3
THICKSLICK 6535	Surface Collecting Agent	three years	3
CLEAN SPLIT (see SPLIT DECISION SC)	Surface Washing Agent	one year	1

DUO-SPLIT (see SPLIT DECISION SC)	Surface Washing Agent	one year	1
GREEN TECHNOLOGIES SOLUTIONS-OIL RECOVERY (GTS-OR)	Surface Washing Agent	One year minimum when stored between 50°F and 100°F	1
SPLIT DECISION SC (formerly SPLIT DECISION)	Surface Washing Agent	one year	1
TXCHEM HE-1000™	Surface Washing Agent	One year in a sealed container	1
AQUACLEAN	Surface Washing Agent	18 months if stored between 50ºF and 104ºF, and away from acids	1.5
BIOGRASS® EXTRA	Surface Washing Agent	Two years minimum	2
CN-110	Surface Washing Agent	2 years	2
CORIBA 700 ER (see CORIBA 700 SR)	Surface Washing Agent	Two years unopened minimum	2
CORIBA 700 OS (see CORIBA 700 SR)	Surface Washing Agent	Two years unopened minimum	2
CORIBA 700 SR	Surface Washing Agent	Two years unopened minimum	2
CORIBA 713 ER (see CORIBA 713 SR)	Surface Washing Agent	Two years unopened minimum	2
CORIBA 713 OS (see CORIBA 713 SR)	Surface Washing Agent	Two years unopened minimum	2
CORIBA 713 SR	Surface Washing Agent	Two years unopened minimum	2
DE-SOLV-IT CLEAN AWAY APC SUPER CONCENTRATE	Surface Washing Agent	Two years in sealed drums or totes	2
DE-SOLV-IT INDUSTRIAL FORMULA	Surface Washing Agent	Two years in sealed polydrums or totes	2
DO-ALL #18	Surface Washing Agent	at least two years	2
ECOVOOM-MARINE (see JEP-MARINE CLEAN)	Surface Washing Agent	minimum 2 years	2
ETHOS CLEAN	Surface Washing Agent	2 years in a sealed (unopened) container (tote, drum, pail) as delivered. 1 year in an opened container).	2
JEP-MARINE CLEAN	Surface Washing Agent	minimum 2 years	2
MARINE GREEN CLEAN™	Surface Washing Agent	2 years	2
MARINE GREEN CLEAN PLUS™	Surface Washing Agent	2 years	2

NONTOX™	Surface Washing Agent	minimum of two years	2
OSR-10	Surface Washing Agent	2 years in a sealed (unopened) container (tote, drum, pail)	2
PROCLEANS	Surface Washing Agent	2 years at recommended temperatures if unopened	2
SOC 10	Surface Washing Agent	two years	2
SUPERALL #38 (see TOPSALL #30)	Surface Washing Agent	two years	2
TOPSALL #30	Surface Washing Agent	two years	2
TULXA	Surface Washing Agent	Two years if stored in dry, fresh environment	2
EO ALL PURPOSE SOAP-LAVENDER	Surface Washing Agent	Three years	3
FIREMAN'S BRAND SPILLCLEAN (see SPILLCLEAN)	Surface Washing Agent	3 years. Avoid extreme heat and store in a dry, cool area	3
SPILLCLEAN or SPILLCLEAN ["Concentrate"]	Surface Washing Agent	three years	3
CLEAN GREEN	Surface Washing Agent	5 years in sealed polydrums or totes	5
CLEANGREEN® PLANET WASH (see CLEAN GREEN)	Surface Washing Agent	5 years in sealed polydrums or totes	5
MICRO CLEAN (see NATURE'S WAY HS)	Surface Washing Agent	five years	5
NATURE'S WAY HS	Surface Washing Agent	five years	5
NATURE'S WAY PC (see NATURE'S WAY HS)	Surface Washing Agent	five years	5
POWERCLEAN (see NATURE'S WAY HS)	Surface Washing Agent	five years	5
PREMIER 99	Surface Washing Agent	5 years	5
SAFE KLEEN	Surface Washing Agent	Five years if stored in tightly closed containers under dry conditions within temperature range	5
SC-1000™	Surface Washing Agent	Minimum of 5 years	5
SIMPLE GREEN®2013 Reformulation	Surface Washing Agent	five years	5
G-CLEAN OSC-1809	Surface Washing Agent	Five to ten years in sealed polydrums or totes	7.5
OIL SPILL CLEANUP (see G-CLEAN OSC-1809)	Surface Washing Agent	Five to ten years in sealed polydrums or totes	7.5
DYNAMIC GREEN™	Surface Washing Agent	6-10 years in sealed poly drums or totes	8

BIOSOLVE® HYDROCARBON MITIGATION™ AGENT	Surface Washing Agent	10+ year shelf life if unopened	10
CYTOSOL	Surface Washing Agent	Closed container: 10 years in a dry environment. Open container: 1 year in a warm, humid environment. The product does not deteriorate appreciably over time, but wil grow bacteria if water condensation accumulates in the container.	10
F-500	Surface Washing Agent	15 years when stored between 35ºF - 130ºF in unopened containers	15
NOKOMIS 5-W	Surface Washing Agent	15 years or more if stored correctly in plastic drums	15
ACCELL CLEAN® SWA	Surface Washing Agent	unopened drums of ACCELL CLEAN® SWA is unlimited	20
ALL PURPOSE CLEANER & REMEDIATOR (see GREEN BEAST™ OIL SPILL & ODOR REMEDIATOR)	Surface Washing Agent	Unlimited in sealed polydrums or totes	20
AWAN PRA OIL FIELD SOLUTION™ (see EPA OIL FIELD SOLUTION™)	Surface Washing Agent	Unlimited in sealed polydrums or totes (as delivered). Avoid direct sunlight.	20
BG-CLEAN™ 401	Surface Washing Agent	unlimited	20
COREXIT® EC9580A (formerly COREXIT 9580 SHORELINE CLEANER)	Surface Washing Agent	unlimited	20
ENVIROCLEAN (formerly ENVIRO CLEAN 165)	Surface Washing Agent	Unlimited if unopened	20
ENVIRONMENTAL 1 CRUDE OIL CLEANER	Surface Washing Agent	Unlimited in sealed polydrums or totes	20
ENVIRONMENTAL 1 WASHING AGENT (see ENVIRONMENTAL 1 CRUDE OIL CLEANER)	Surface Washing Agent	Unlimited in sealed polydrums or totes	20
EPA OIL FIELD SOLUTION™	Surface Washing Agent	Unlimited in sealed polydrums or totes (as delivered). Avoid direct sunlight.	20
E-SAFE©	Surface Washing Agent	Unlimited if left in unopened containers stored at 40º - 110ºF and away from direct sunlight	20
GLOBAL ENVIRONMENTAL CLEANER™ (see EPA OIL FIELD SOLUTION™)	Surface Washing Agent	Unlimited in sealed polydrums or totes	20
GOLD CREW SW	Surface Washing Agent	20 years (unopened)	20

GREEN BEAST OIL SPILL & ODOR REMEDIATOR	Surface Washing Agent	Unlimited in sealed polydrums or totes	20
GREEN BEAST WASHING AGENT (see GREEN BEAST OIL SPILL & ODOR REMEDIATOR	Surface Washing Agent	Unlimited in sealed polydrums or totes	20
HYDRO-CLEAN™ (see EPA OIL FIELD SOLUTION™)	Surface Washing Agent	Unlimited in sealed polydrums or totes	20
NALE-IT	Surface Washing Agent	Indefinite	20
NATURAMA G3 A-5	Surface Washing Agent	unlimited	20
PETRO-CLEAN	Surface Washing Agent	Indefinite when stored properly	20
PETRO-GREEN ADP-7	Surface Washing Agent	indefinite	20
PETROMAX PSC 3	Surface Washing Agent	Unlimited when stored in unopened, sealed 5 gallon containers, 55 gallon drums, polydrums, and totes	20
PETROMAX SOIL CLEANING AND WASHING AGENT (see PETROMAX PSC 3)	Surface Washing Agent	Unlimited when stored in unopened, sealed 5 gallon containers, 55 gallon drums, polydrums, and totes	20
PETROTECH 25	Surface Washing Agent	unlimited shelf-life when maintained in the factory sealed containers and stored within the prescribed temperature limits	20
SANDKLENE 950	Surface Washing Agent	Unlimited in sealed drums or totes	20
SHEEN-MAGIC©	Surface Washing Agent	Unlimited if left in unopened containers stored at 40º - 110ºF and away from direct sunlight	20
SIMPLE GREEN®	Surface Washing Agent	unlimited	20
VERU-SOLVE™ MARINE 200 HP	Surface Washing Agent	Indefinite, product will not degrade over time	20

To: Tulis, Dana[Tulis.Dana@epa.gov]; Deitz, Randy[Deitz.Randy@epa.gov]; Hull, George[Hull.George@epa.gov]
Cc: Perry, Dale[Perry.Dale@epa.gov]; Cohen, Nancy[Cohen.Nancy@epa.gov]; Bassler, Rachel[Bassler.Rachel@epa.gov]; Sonich-Mullin, Cynthia[Sonich-Mullin.Cynthia@epa.gov]
From: Matthiessen, Craig
Sent: Mon 4/20/2015 5:15:57 PM
Subject: RE: Inquiry on Use of Corexit in BP Oil Spill

Another option: perhaps refer queries to this website:
http://response.restoration.noaa.gov/deepwater-horizon-oil-spill?utm_source=OR%26R+Update+April+2015&utm_campaign=OR%26R+Update+Apr+2015&utm_mediun

Craig

From: Matthiessen, Craig
Sent: Monday, April 20, 2015 12:07 PM
To: Tulis, Dana; Deitz, Randy; Hull, George
Cc: Perry, Dale; Cohen, Nancy; Bassler, Rachel; Sonich-Mullin, Cynthia
Subject: RE: Inquiry on Use of Corexit in BP Oil Spill

There was a recent report in E&E (April 10) noting results of a study published online in the Deep-Sea Research II journal that Corexit dispersant was more toxic to coral than the oil. Based on a quick scan, our tox expert noted some serious problems with the study. Also, it is news to us that the UK "banned" Corexit due to worker health issues. The information we collected from the UK during BP was that they 'restricted' a certain type of Corexit to offshore use only (no rocky shoreline use) because it makes the little critters that attach to rocks slide off. Maybe we should refer folks to the GOMRI for a little science education. Craig

From: Tulis, Dana
Sent: Monday, April 20, 2015 11:33 AM
To: Deitz, Randy; Hull, George
Cc: Perry, Dale; Cohen, Nancy; Bassler, Rachel; Matthiessen, Craig; Sonich-Mullin, Cynthia
Subject: RE: Inquiry on Use of Corexit in BP Oil Spill

I really think we need to use the NRDA statement, but this was really irresponsible reporting.

From: Deitz, Randy
Sent: Monday, April 20, 2015 11:28 AM
To: Hull, George; Tulis, Dana
Cc: Perry, Dale; Cohen, Nancy; Bassler, Rachel; Matthiessen, Craig; Sonich-Mullin, Cynthia
Subject: RE: Inquiry on Use of Corexit in BP Oil Spill

Pretty shameful saying certain studies have "suggested" that dispersant use "may" have been more harmful than the oil. I suspect that there are a whole bunch of studies that indicate that the use of dispersants has not resulted in the wholesale damage to the Gulf or to response personnel predicted by activists. It would be great if we could reference findings like that if we have them.

Randy Deitz

Attorney Advisor

Office of Solid Waste and Emergency Response

(202) 566-0197

From: Hull, George
Sent: Monday, April 20, 2015 11:02 AM
To: Tulis, Dana
Cc: Perry, Dale; Cohen, Nancy; Deitz, Randy; Bassler, Rachel; Matthiessen, Craig; Sonich-Mullin, Cynthia
Subject: RE: Inquiry on Use of Corexit in BP Oil Spill

I was hoping to respond by essentially taking excerpts from some of these Q+A, but I think I need to enlist OEM's help with a statement. Here is an LA Times article that ran today. Note the fourth paragraph from the end. – George

The L.A. Times on the Deepwater Horizon anniversary. Note the reference to EPA, fourth paragraph from the bottom.

http://www.latimes.com/opinion/op-ed/la-oe-0420-smith-bp-20150420-story.html

Another oil rig caught fire in the Gulf of Mexico early this month. Orange flames shot high into the night sky; the local news reported that multiple workers were missing; and residents of the beleaguered Gulf Coast waited for the other shoe to drop.

On that occasion, our worst environmental fears were not realized. The deadly April 1 explosion on a rig belonging to Mexico's state-run Pemex oil company did not lead to a massive oil spill. But it served as a reminder that, five years after the April 20, 2010, Deepwater Horizon rig explosion, the government has done far too little to prevent another disaster.

In the months and days after the accident, which killed 11 workers and triggered a spill of more than 4 million barrels of crude oil, President Obama said all the right things. In June 2010, he addressed the nation on the BP spill and said his administration would take steps to "ensure that a disaster like this does not happen again."

But Congress — controlled by Republican lawmakers indebted to their Big Oil campaign contributors — still has not enacted the offshore-drilling safety measures recommended by the president's Oil Spill Commission. It has not given strong regulatory powers to the agency that replaced the scandal-scarred Minerals Management Service. And it has not raised the ridiculously low cap of $75 million for corporate liability on major spills.

Congress has also failed to make money available for an oil-spill research fund. A proposed "safety institute" hasn't materialized. Neither has the new training center for federal regulators, meant to help them carry out more rigorous inspections of offshore rigs.

The Obama administration, for its part, has been a lot more aggressive about awarding new leases than developing stricter regulations for blowout preventers similar to the one that failed aboard the Deepwater Horizon.

New rules weren't proposed until this month, and although they are clearly a step in the right direction, they don't change the bigger picture. Indeed, the rules, which aim to upgrade oil-rig technology, took so long that some environmentalists worry they'll soon be out of date. On balance, the culture of safety for offshore drilling has not substantially improved since April 2010.

Lax government standards for highly toxic dispersants are yet another problem. In 2010, BP sprayed 1.8 million pounds of Corexit onto the surface of the gulf to make the oil

slicks disappear. Since then, a string of scientific studies has suggested that exposure to Corexit may have been more damaging to the health of cleanup workers and marine life than the initial exposure to spilled oil.

Despite these damning reports, the U.S. Environmental Protection Agency refuses to follow the lead of Britain, which banned use of the dispersant because of the risks to workers. That means the next time a large spill occurs in the gulf — or other areas where the Obama administration has proposed expanded offshore drilling, including a large swath of the Atlantic coastline — cleanup crews could make the same toxic, avoidable mistake.

But the truth is that the next time officials have to consider spraying Corexit, it will already be too late to save the gulf, which has not fully recovered from the BP disaster. A second spill probably would ruin the ecology of this precious national resource for good.

On the fifth anniversary of the Deepwater Horizon accident, workers continue to clean up tar balls and giant tar mats of weathered BP oil along beaches from Louisiana to Florida. Black crude still clogs the edges of our ever-shrinking wetlands. A recent report by the National Wildlife Federation chronicled significant health damage to some 20 species of marine plants and birds, while people who took part in 2010 cleanup efforts struggle with headaches, nausea and other symptoms.

Can you imagine what would happen if an additional 4 million or 5 million barrels were dumped on top of this environmental catastrophe? The BP spill should have inspired Congress and the Obama administration to more rapidly enact the strictest offshore drilling regulations in the world, and to freeze new exploration until new technologies came online. Instead, five years later, the Gulf of Mexico is as vulnerable to accident as ever.

Stuart H. Smith is a New Orleans-based environmental attorney and author of "Crude Justice" and "What You Should Know About the New Environmental Attack on America."

From: Tulis, Dana
Sent: Monday, April 20, 2015 10:23 AM
To: Hull, George
Cc: Perry, Dale; Cohen, Nancy; Deitz, Randy; Bassler, Rachel; Matthiessen, Craig; Sonich-Mullin, Cynthia
Subject: Re: Inquiry on Use of Corexit in BP Oil Spill

Yup, just like I said :)

Dana S. Tulis

Deputy Office Director

Office of Emergency Management

US EPA

202-564-7938

On Apr 20, 2015, at 10:21 AM, "Hull, George" <Hull.George@epa.gov> wrote:

Just found this in the Q+A on Phase II toxicity testing on 8 dispersants:

The results indicate that the eight dispersants tested are similar to one another based on standard toxicity tests on sensitive aquatic organisms found in the Gulf. These results confirm that the dispersant used in response to the oil spill in the Gulf, Corexit 9500A, is no more or less toxic than the other available alternatives.

From: Tulis, Dana
Sent: Monday, April 20, 2015 10:19 AM
To: Hull, George
Cc: Perry, Dale; Cohen, Nancy; Deitz, Randy; Bassler, Rachel; Matthiessen, Craig; Sonich-Mullin, Cynthia
Subject: Re: Inquiry on Use of Corexit in BP Oil Spill

We should have the results of EPA's study on the BP site. ORD's NHSRC was the lead. The reporters statement is not true there were all found to be about the same in toxicity.

Dana S. Tulis

Deputy Office Director

Office of Emergency Management

US EPA

202-564-7938

On Apr 20, 2015, at 10:15 AM, "Hull, George" <Hull.George@epa.gov> wrote:

I've got a second reporter who has contacted us requesting an interview on the use of Corexit. She specifically said she wants to know why Corexit was used when EPA testing showed two less toxic alternatives. I vaguely remember this issue during the spill response. My inclination is to answer in writing. If anyone can point me to information I can use to inform that written response, I would appreciate. I did some looking at our web pages on dispersant use last Friday, but have not found this specific point addressed. Thanks, George

From: Perry, Dale
Sent: Thursday, April 16, 2015 10:39 AM
To: Hull, George; Tulis, Dana
Cc: Cohen, Nancy; Deitz, Randy; Bassler, Rachel
Subject: RE: Inquiry on Use of Corexit in BP Oil Spill

You might also point them to this page as well that details all of the directives we issues to BP.

http://www.epa.gov/bpspill/dispersants.html

Basically, EPA and the Coast Guard approved the use of Corexit and then monitored BP's activities and amended them as necessary.

The EPA and the U.S. Coast Guard have authorized BP to use dispersants underwater, at the source of the Deepwater Horizon leak. Subsea dispersant application has been in use since May 15, 2010. While BP pursues the use of subsurface dispersants, the federal government reviews its effectiveness and impact on the environment daily; EPA specifically monitors the water and air for dispersant and its potential impacts through a rigorous monitoring program. Below is EPA's directive to BP, including the monitoring plan that the company must adhere to in order to ensure the protection of the environment. The Federal Government reserves the right to discontinue the use of this dispersant method if negative impacts on the environment outweigh the benefits, and the Coast Guard's Federal On-Scene Coordinator has the authority to make daily decisions regarding any request by BP to adjust the use of dispersant.

Dale H. Perry, Ph.D.

Science Advisor to the Office of Public Affairs

1200 Pennsylvania Ave. N.W., Mail Code 1701A

Washington, D.C., 20460

Office: 202-564-7338

Cell: 202-380-6517

From: Hull, George
Sent: Thursday, April 16, 2015 10:31 AM
To: Tulis, Dana
Cc: Perry, Dale; Cohen, Nancy; Deitz, Randy; Bassler, Rachel
Subject: Inquiry on Use of Corexit in BP Oil Spill

I have an inquiry from a reporter writing for the New Orleans Environmental News Examiner, which is a web based publication. Here are her questions: 1)How did BP work together with the US EPA in dispersing the Corexit? 2) If BP did work with EPA, who approved and at what point was it agreed that we would work together? She would like a response this week. Thanks,

George Hull

Office of Media Relations

U.S. EPA

Tel. 202-564-0790

To: Barron, Mace[Barron.Mace@epa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Conmy, Robyn[Conmy.Robyn@epa.gov]
From: Matthiessen, Craig
Sent: Mon 4/13/2015 5:45:42 PM
Subject: RE: FYI - : BP dispersant toxic

Hi, Mace;

Here is a link to the Oceans article: http://www.eenews.net/stories/1060016566

And a link to the study paper:
http://www.sciencedirect.com/science/article/pii/S0967064515000740

Looks like you'd have to purchase it. However, the EPA library system may be able to get it.

And I forgot Michael retired. Thanks - Craig

From: Barron, Mace
Sent: Monday, April 13, 2015 1:38 PM
To: Matthiessen, Craig; Wilson, Gregory; Principe, Vanessa; Conmy, Robyn
Subject: Re: FYI - : BP dispersant toxic

Hi Craig: I read the summary below and the abstract, but don't have access to the paper.

Should I request through interlibrary loan from our librarian, or do you have a copy?

PS: Michael is retired, so I took him off this email.

Mace

From: Matthiessen, Craig
Sent: Monday, April 13, 2015 12:31 PM
To: Wilson, Gregory; Principe, Vanessa; Conmy, Robyn; Barron, Mace; Hemmer, Michael
Subject: FW: FYI - : BP dispersant toxic

Any thoughts? Thanks - Craig

From: Nichols, Nick
Sent: Monday, April 13, 2015 10:16 AM
To: Matthiessen, Craig; Oliveira, Beatriz; DeHaven, Leigh; Gioffre, Patricia; Howard, MarkW; Swackhammer, J-Troy
Subject: FYI - : BP dispersant toxic

FYI

OCEANS:

Gulf spill cleanup dispersant more toxic to coral than oil -- study

Katherine Ling, E&E reporter

Published: Friday, April 10, 2015

The chemical dispersant used to break down the oil spilled in the 2010 Deepwater Horizon accident in the Gulf of Mexico is more toxic to coral than the oil, according to a study released on the eve of the fifth anniversary of the disaster.

The accident marked the first time that a dispersant was used below the ocean surface during an oil spill in addition to the traditional surface use. Almost 2 million gallons of the dispersant Corexit 9500A -- with slightly less than half released underwater -- was used to emulsify the around 5 million barrels of crude oil that poured out due to the rig explosion.

When exposed to the chemical dispersant, three species of cold-water coral showed "more severe health declines" at lower concentrations than the same species exposed to a mixture of oil and dispersant and to just oil, according to findings by scientists from Temple University and Pennsylvania State University. The oil-dispersant mixture was also more toxic than just oil, the team found.

Its study was published online in the journal *Deep-Sea Research II*.

The scientists became interested in the experiment after observing post-spill that several damaged Gulf coral populations were coated with a dark-colored wool-like slime that was found to contain oil from the spill and residues from the dispersants.

"We wanted to know if the damages that had been witnessed could have been caused by the oil, the dispersant itself, or a combination of both," Danielle DeLeo, a Temple doctoral student who was the study's lead author, said in a statement.

"We know that the corals in the Gulf were exposed to all of these different combinations, so we have been trying to determine the toxicity of the oil and the dispersants, and see what their impact would be on the corals," she said.

The corals may have a higher tolerance for the oil because they have adapted to natural seeps of oil over time in their environment, the team noted. The study also said that despite the results, "it is unclear whether short-term exposures to oil and dispersant have long-term effects," that the matter would require further study, and that long-term oil exposure could have significant sub-lethal impacts.

"Applying the dispersants at depth was a grand experiment being conducted in real-time," Erik Cordes, an associate professor of biology at Temple, said in a statement. He has been studying Gulf of Mexico coral communities for more than a decade.

He added: "It was a desire to immediately do something about the oil coming out of the well, but they really didn't know what was going to happen as a result."

The team concluded that to improve future oil spill response efforts, "alternative methods of oil cleanup are needed and caution should be used when applying oil dispersants at depth, as it may induce further stress and damage to deep-sea ecosystems."

The study was funded by the Gulf of Mexico Research Initiative, an independent agency BP PLC funded at $500 million for 10 years in the wake of the Deepwater Horizon disaster that explores the impacts of oil spills and dispersants on local ecosystems, as well as developing improved spill mitigation, oil and gas detection, and other technologies.

Another recent study from the University of Alabama, Birmingham, found that the Corexit 9500A dispersant can damage respiratory cells of humans and animals. But a study by U.S. EPA in 2010 found the dispersant-oil combination isn't worse for shrimp, fish and other sea creatures than oil alone already is.

EPA announced a proposal to update regulations for the use of dispersants earlier this year. The plan would provide a new, well-tested and peer-reviewed laboratory method for gauging the effectiveness of products in different environments and an aquatic toxicity threshold to ensure qualifying products offer "greater performance at less environmental impact" (***Greenwire***, Jan. 13).

To: Gregory Wilson[Wilson.Gregory@epa.gov]; Vanessa Principe[Principe.Vanessa@epa.gov]; Robyn Conmy (Conmy.Robyn@epa.gov)[Conmy.Robyn@epa.gov]; Barron, Mace[Barron.Mace@epa.gov]; Hemmer, Michael[Hemmer.Michael@epa.gov]
From: Matthiessen, Craig
Sent: Mon 4/13/2015 5:31:56 PM
Subject: FW: FYI - : BP dispersant toxic

Any thoughts? Thanks - Craig

From: Nichols, Nick
Sent: Monday, April 13, 2015 10:16 AM
To: Matthiessen, Craig; Oliveira, Beatriz; DeHaven, Leigh; Gioffre, Patricia; Howard, MarkW; Swackhammer, J-Troy
Subject: FYI - : BP dispersant toxic

FYI

OCEANS:

Gulf spill cleanup dispersant more toxic to coral than oil -- study

Katherine Ling, E&E reporter

Published: Friday, April 10, 2015

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When exposed to the chemical dispersant, three species of cold-water coral showed "more severe health declines" at lower concentrations than the same species exposed to a mixture of oil and dispersant and to just oil, according to findings by scientists from Temple University and

Pennsylvania State University. The oil-dispersant mixture was also more toxic than just oil, the team found.

Its study was published online in the journal *Deep-Sea Research II.*

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The corals may have a higher tolerance for the oil because they have adapted to natural seeps of oil over time in their environment, the team noted. The study also said that despite the results, "it is unclear whether short-term exposures to oil and dispersant have long-term effects," that the matter would require further study, and that long-term oil exposure could have significant sub-lethal impacts.

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He added: "It was a desire to immediately do something about the oil coming out of the well, but they really didn't know what was going to happen as a result."

The team concluded that to improve future oil spill response efforts, "alternative methods of oil cleanup are needed and caution should be used when applying oil dispersants at depth, as it may induce further stress and damage to deep-sea ecosystems."

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EPA announced a proposal to update regulations for the use of dispersants earlier this year. The plan would provide a new, well-tested and peer-reviewed laboratory method for gauging the

effectiveness of products in different environments and an aquatic toxicity threshold to ensure qualifying products offer "greater performance at less environmental impact" (*Greenwire*, Jan. 13).

To: Adg449@nyu.edu[Adg449@nyu.edu]
Cc: Karrie, Joan[Karrie.Joan@epa.gov]; Reggie Cheatham (cheatham.reggie@epa.gov)[cheatham.reggie@epa.gov]; Gregory Wilson[Wilson.Gregory@epa.gov]; Vanessa Principe[Principe.Vanessa@epa.gov]; Leigh DeHaven[DeHaven.Leigh@epa.gov]; Gerain Cogliano[Cogliano.Gerain@epa.gov]; Barbara Hostage[Hostage.Barbara@epa.gov]
From: Matthiessen, Craig
Sent: Wed 4/8/2015 7:34:30 PM
Subject: RE: Question on Revisions to National Oil and Hazardous Substances Proposed Rule File
EO12866_Subpart J_2050-AE87_NPRM_RIA_REDLINED_20141203_REF_20150402.pdf

Dear Andrew Grubin;

I received your voicemail and I hope you received my return message as well. The Regulatory Impacts Analysis (RIA) file that is in the Subpart J proposed rule docket has deleted text shown in side bubbles. For two pages (64 and 81) of the document, the deleted text was more extensive than was able to be accommodated in the side bubbles, thus the entire deletion is not shown.

Attached is a revised redline-strikeout of the RIA which reformats the file with deletions shown within the text as opposed to in editorial side bubbles. After review, we did not identify any similar issues with the redline-strikeout for the proposed rule currently in the docket.

Please contact me if you have any additional questions. Regards – Craig Matthiessen

R. Craig Matthiessen, PE, FAIChE

US EPA - OSWER/OEM/RID

1200 Pennsylvania Ave, NW (5104A)

Washington, DC 20460

202-564-8016

From: Cheatham, Reggie
Sent: Monday, April 06, 2015 2:08 PM
To: Adg449@nyu.edu
Cc: Karrie, Joan
Subject: Question on Revisions to National Oil and Hazardous Substances

Dear Mr. Grebin:

I understand that you are a researcher from the Policy Integrity Institute at New York University and are looking for a copy of docket # EPA-HQ-OPA-2006-0090-0010 (Rule language and regulatory impact analysis) to view the Office of Management and Budget comments on the proposed rule to amend the requirements in Subpart J of the National Oil and Hazardous Substances Pollution Contingency Plan. Your request was passed on to me, as the proposed rule was promulgated out of the Office of Emergency Management.

The documents that you have requested are all available via the internet. Links and explanations are supplied below.

The number that you have cited (EPA-HQ-OPA-2006-0090-0010) is actually the specific document number for the Adobe Acrobat version of the Federal Register Notice itself, published on January 22, 2015 (80 FR 3380). The link for it is http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPA-2006-0090-0010.

Documents that show OMB review changes for both the Federal Register Notice of Proposed Rulemaking and for the Regulatory Impacts Analysis are available in the public docket via the http://www.regulations.gov website, under "Supporting Documents for Docket # EPA-HQ-OPA-2006-0090." The documents reflect the changes that were made to the proposal and the regulatory impacts analysis based on comments from OMB. Direct links for them are as follow:

National Oil and Hazardous Substances Pollution Contingency Plan Subpart J NPRM Proposed Rule [OMB Redline]:

http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPA-2006-0090-0002

Regulatory Impact Analysis for Proposed Revisions to the National Oil and Hazardous

Substances Pollution Contingency Plan Regulations (40 CFR Part 300 Subpart J) [OMB Redline]

http://www.regulations.gov/#!documentDetail;D=EPA-HQ-OPA-2006-0090-0008

I hope these links will meet your need. Please let me know if you have any further questions about the OMB comments to the proposed rule.

Sincerely

Reggie Cheatham, Acting Director

Office of Emergency Management, USEPA

202.564.8003 (O); 202.689.9400 (M);

cheatham.reggie@epa.gov

To: Cohen, Nancy[Cohen.Nancy@epa.gov]; Becky Brooks[Brooks.Becky@epa.gov]
Cc: Kim Jennings[Jennings.Kim@epa.gov]; Vanessa Principe[Principe.Vanessa@epa.gov]; Leigh DeHaven[DeHaven.Leigh@epa.gov]; Gregory Wilson[Wilson.Gregory@epa.gov]; Dana Tulis[Tulis.Dana@epa.gov]; Reggie Cheatham (cheatham.reggie@epa.gov)[cheatham.reggie@epa.gov]
From: Matthiessen, Craig
Sent: Fri 1/9/2015 8:42:15 PM
Subject: Subpart J Product Manufacturers - a few contacts for outreach

Here are some suggestions for manufacturers with whom you could contact for an outreach call next week. There are about 90 manufacturers; I chose these based on previous contacts; we can always provide more. Craig

Nalco Environmental Solutions LLC (Corexit dispersant)
7705 Highway 90-A
Sugar Land, TX 77478
Product Management:
Office: (281) 263-7709
Mobile: (832) 851-5164
E-mail: debby.theriot@nalco.com
(Ms. Debby Theriot)

TOTAL PETROCHEMICALS USA, INC. (Finasol dispersant)
1201 Louisiana St., Suite 1800
Houston, TX 77002
Phone: (713) 483-5712
Fax: (713) 483-5700
Web Site: www.totalspecialfluids.com Exit
(Mr. Peter Egan)

GlobeMark Resources Ltd. (JD 2000 dispersant0
1312 Mill Creek Drive
Salado, TX 76571
Mobile: (254) 231-2251
Email: joannie@globemarkresources.com or fiddler656@gmail.com
Web Site: http://www.globemarkresources.com Exit
(Ms. Joannie Docter)

International Environmental Products, LLC (bioremediation agent)
Two Villanova Center

795 E. Lancaster Ave., Suite 280
Villanova, PA 19085
Phone: (610) 520-7665
Fax: (610) 520-7663
Email: info@iepusa.com
(Mr. Jim Lynn)

OSEI Corporation (Formerly Sky Blue Chems) (enzymatic bioremediation agent)
P.O. Box 515429
Dallas, TX 75251-5429
Phone: (972) 669-3390
E-mail: oseicorp@msn.com
Web Site: www.osei.us Exit
(Mr. Steven Pedigo, Chairman, CEO, Inventor)

B.R.A.T. Microbial Products Inc. (surface wash and dispersant chems)
P.O. Box 7089
Pasadena, TX 77508
Phone: (713) 724-9226
E-mail: alabastercorp@gmail.com
(Mr. John Sheffield)

Sunshine Makers, Inc. (Simple Green surface wash agent)
15922 Pacific Coast Highway
Huntington Beach, CA 92649
Phone: (800) 228-0709
(562) 795-6000
Fax: (562) 592-3830
(Ms. Carol Chapin)

Opflex Solutions (miscellaneous oil spill control agent)
P.O. Box 355
West Hyannisport, MA 02672
Phone: (508) 776-2995
Fax: (508) 425-2990
E-mail: ssmith@opflex.com
Web site: www.opflex.com Exit
(Mr. Scott Smith)

John S. Brinkman, President (Imbiber beads sorbent)

<jsb@imbiberbeads.com>

Telephone (1) (905) - 641-2323.

NA - Toll free - 1-888-THE-BEAD (843-2323)

Website - www.imbiberbeads.com

To: Reggie Cheatham (cheatham.reggie@epa.gov)[cheatham.reggie@epa.gov]; Becki Clark (Clark.Becki@epa.gov)[Clark.Becki@epa.gov]; Leigh DeHaven[DeHaven.Leigh@epa.gov]; Vanessa Principe[Principe.Vanessa@epa.gov]; Gregory Wilson[Wilson.Gregory@epa.gov]; James Bove[Bove.James@epa.gov]; Robyn Conmy (Conmy.Robyn@epa.gov)[Conmy.Robyn@epa.gov]; Joshua Woodyard[Woodyard.Joshua@epa.gov]; Gilberto Irizarry[Irizarry.Gilberto@epa.gov]
Cc: Kim Jennings[Jennings.Kim@epa.gov]
From: Matthiessen, Craig
Sent: Fri 6/17/2016 11:49:54 AM
Subject: FYI from BNA - Canada Approves Corexit Products for Treating Oil Spills

FYI from BNA Report:

Oil Spills

Canada Approves Corexit Products for Treating Oil Spills

BNA Snapshot

Canada Approves Oil Spill Treatments

Key Development: Canada publishes regulations confirming the use of Corexit EC9500A and Corexit EC9580A to treat major oil spills from offshore production facilities.

Potential Impact: Although most public comment oppose authorization of the Corexit dispersant on the basis that it is toxic to humans and marine life, Environment and Climate Change Canada says it offers "best-in-class" performance.

By Peter Menyasz

June 16 — Canada published regulations confirming the use of two oil-treating agents for major spills from offshore production facilities.

The federal government's conclusion that the products are the best-available alternatives to address major offshore spills did not ease environmental groups' concerns about their potential toxicity, while industry warned that conditions on their use would hinder their effectiveness in emergencies.

Nalco Co.'s Corexit EC9500A dispersant and Corexit EC9580A surface washing agent are acceptable for offshore use because they offer "best-in-class" performance while posing a low risk of environmental harm, Environment and Climate Change Canada said June 15.

The regulations replace a July 2015 Cabinet order to apply an exemption under the Energy Safety and Security Act to existing legal prohibitions against the use of spill-treating agents in Canadian waters, the department said in the June 15 Canada Gazette, Part I. They go into effect immediately.

"The inclusion of spill-treating agents to expand the available response options is necessary to enable a spill to be addressed to the maximum possible extent in order to protect the overall integrity of the environment," it said.

The department acknowledged that the majority of comments it received in July 2015, after publishing draft regulations, opposed authorization of the Corexit dispersant on the basis that it is toxic to humans and marine life and safer alternatives are available. Some comments noted that the product is banned in some jurisdictions and may soon be banned in the U.S., the department said.

But Environment and Climate Change Canada said, based on current evidence, it is satisfied that the product is suitable for Canadian offshore waters because there is no known alternative that is safer, more effective and has undergone rigorous study and real-world testing.

Corexit EC9500A is listed on the U.S. National Contingency Plan, so the possibility of that changing is speculation, and in any event decisions by other jurisdictions do not preclude Canada from taking action it deems appropriate, it said.

Environmental Groups' Opposition

Greenpeace Canada, along with other environmental and aboriginal groups, opposes authorization of Corexit for offshore spills and is unhappy that the government continues to support its use, Greenpeace spokesman Alex Speers-Roesch said June 16. “The concerns basically stand,” he told Bloomberg BNA. “It's a toxic chemical.”

There is significant evidence from the disaster following the explosion of BP Plc's Deepwater Horizon that dispersants add to environmental damage caused by major oil spills, according to Speers-Roesch. “There's no evidence it can produce a positive result,” he said.

The conditions the regulations impose before an approved product can be used set a “fairly low bar” and the regulations overall don't set clear criteria for how the products should be used, he said.

The Canadian Association of Petroleum Producers was unable to respond June 16 to a request from Bloomberg BNA for comment on the regulations, but Environment and Climate Change Canada acknowledged in its regulatory impact analysis the concerns the oil industry raised during the July 2015 public comment period.

Industry questioned the need to rely on regulatory decision-makers to determine the appropriate use of spill-treating agents in emergency situations and to consult with federal and provincial officials before they are used because it could delay decisions and impede optimal spill response, the department said.

Leaving final approval until a spill has occurred and requiring consultation with federal and provincial officials provides flexibility to ensure that decisions are based on the facts at the time, Environment and Climate Change Canada said.

Regulations Impose Conditions

The regulations impose the following conditions:

• authorization by an offshore oil and gas regulator such as the Canada-Nova Scotia Offshore Petroleum Board, Canada-Newfoundland and Labrador Offshore Petroleum Board or the National Energy Board;

• approval by the regulator's chief conservation officer, based on a finding that it will likely provide a net environmental benefit;

• use of the product under conditions imposed by regulations or stipulated by the regulator at the time of the spill; and

• in the period through 2020, during which regulations specifying conditions of use may be developed, consultation at the time of a spill with the federal ministers of environment and natural resources and the appropriate provincial minister.

In addition, monitoring dispersed oil in the environment following the dispersant's use is an obligation of the party responsible for an oil spill, the department said.

Oil dispersant Corexit EC9500A was used in the 2010 Deepwater Horizon well blowout, while Corexit EC9580A, a surface washing agent used on shorelines and manufactured structures, was used in the 1994 Morris J. Berman spill in Puerto Rico, Environment and Climate Change Canada said. No ingredient in either product is listed as toxic under the Canadian Environmental Protection Act, it said.

For More Information

The Regulations Establishing a List of Spill-treating Agents (Canada Oil and Gas Operations

Act) are available at http://src.bna.com/fZj.

From: Mandsager, Kathy
Location: via WebEx (login directiosn below)
Importance: Normal
Subject: State-of-Science: EcoTox panel meeting
Start Date/Time: Tue 12/20/2016 7:30:00 PM
End Date/Time: Tue 12/20/2016 9:30:00 PM
2016.11.17_EcoToxicity and Sublethal Impacts.docx
2016.12.16_EcoToxicity and Sublethal Impacts.docx

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,,,,,,,,
MEETING REMINDER! Attached is the latest version of the document.

This is to confirm our next meeting for **TU December 20 from 230 – 430 ET**.
Attached is the latest version of our document.
Below are the directions to login to WebEx:

Ecotox

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1-650-479-320 Call in toll num (US

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Can't join the meet

From: Mandsager, Kathy
Sent: Thursday, December 01, 2016 12:49 PM
Subject: RE: ECOTOX panel for state-of-science for dispersant use in Arctic waters

Dear Ecotox panel members:

It appears that perhaps one more meeting will finish up this discussion and document. Please take a moment and submit your availability on this doodle poll by Wednesday 12/7. It has been time-zone enabled for your convenience. I will do my best to find a time that suites the majority of you as, like you, we are eager to complete this task.

Click here for the doodle poll>> http://doodle.com/poll/nir5p37i2f68u99t

Thank you!

From: Mandsager, Kathy
Location: via WebEx (login instructions below)
Importance: Normal
Subject: State-of-Science for Dispersant Use in Arctic Waters DEGRDATION & FATE group
Start Date/Time: Wed 12/14/2016 7:00:00 PM
End Date/Time: Wed 12/14/2016 9:00:00 PM
2016.11.28_Degradation and Fate.docx

.....
,,,,,,,
This is a reminder that we have TWO meetings scheduled this week: tomorrow/Wednesday 12/14 AND Thursday 12/15; both begin at 2:00 pm ET. The WebEx login instructions are below and attached is our latest version of the document for your preparation in the discussion.

Degradation & Fate group

Wednesday, December 14, 2016

2:00 pm | Eastern Standard Time (New York, GMT-05:00) | 2 hrs

Meeting
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From: Mandsager, Kathy
Location: via WebEx below
Importance: Normal
Subject: State-of-Science EcoToxicity Panel meeting
Start Date/Time: Thur 11/17/2016 7:00:00 PM
End Date/Time: Thur 11/17/2016 9:00:00 PM
2016.08.17_EcoToxicity and Sublethal Impacts.docx

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This is a reminder of our upcoming call (Thursday at 2 ET). We look forward to everyone's participation and are eager to complete this document.

Please mark your calendar for this call on: **Thursday, November 17; 2 – 4 pm ET**.

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From: Mandsager, Kathy
Sent: Thursday, October 06, 2016 12:22 PM
Subject: RE: ECOTOX panel for state-of-science for dispersant use in Arctic waters

Thus far, from the doodle poll, we have a unanimous selection of **TH 11/17 at 2 pm ET** for our meeting. To those of you who have not yet responded to the poll, could you please confirm your availability to meet on this date?

As stated previously, we need all of you on this call to finalize this document for Public Input. I'd like to confirm this meeting on your calendars as soon as possible.

Thank you!

From: Mandsager, Kathy
Sent: Wednesday, October 05, 2016 3:51 PM
Subject: ECOTOX panel for state-of-science for dispersant use in Arctic waters

Dear Ecotox panel members:

It has been awhile since we have met together so I would like to schedule a meeting to finalize the outstanding issues on this paper. Please take a moment and submit your availability on this doodle poll

by Wednesday 10/12. It has been time-zone enabled for your convenience. It is very important that ALL of you participate and give your final input to this document prior to the Public Input phase!
Click here for the doodle poll>> http://doodle.com/poll/g55p84bgx7fnnk74
Thank you!

Kathy Mandsager
Coastal Response Research Center
Center for Spills and Environmental Hazards
220 Gregg Hall, 35 Colovos Rd
University of New Hampshire
Durham, NH 03824
603.862.1545

From: Mandsager, Kathy
Location: via WebEx instructions below
Importance: Normal
Subject: Degradation & Fate science panel meetings
Start Date/Time: Mon 10/3/2016 6:00:00 PM
End Date/Time: Mon 10/3/2016 8:00:00 PM
2016.08.30_Degradation and Fate.docx

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From: Mandsager, Kathy
Location: via WebEx (instructions below) per CRRC
Importance: Normal
Subject: Transport & Behavior dispersant science panel meeting
Start Date/Time: Thur 9/29/2016 6:00:00 PM
End Date/Time: Thur 9/29/2016 8:00:00 PM
2016 08 16c_state-of-science on Physical Transport and Chemical Behavior (key adjustments).docx

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This is a reminder of our call scheduled for tomorrow. Below is the link to join via WebEx and attached is the latest version of the document.

Transport and Behavior Science panel

Thursday, September 29, 2016

2:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

Meeting num (acc code 737 534 457

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From: Mandsager, Kathy
Location: via WebEx (instructions below)
Importance: Normal
Subject: Public Health/Human Toxicity panel
Start Date/Time: Wed 9/28/2016 6:00:00 PM
End Date/Time: Wed 9/28/2016 8:00:00 PM
2016.07.21_Public Health and Food Security_post human tox work & reference check.docx

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This is a reminder of our call scheduled for tomorrow. Below is the link for joining via WebEx. And attached is the latest version of the document. Please review and come prepared for this discussion. Thank you!

Public Health, Food Security and Human Toxicity Panel meeting

Wednesday, September 28, 2016

2:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

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From: Mandsager, Kathy
Location: via WebEx (details below)
Importance: Normal
Subject: State of Science Degradation & Fate group
Start Date/Time: Tue 8/30/2016 6:00:00 PM
End Date/Time: Tue 8/30/2016 8:00:00 PM
2016.08.18_LINDEN_Degradation and Fate with public input.docx

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This is a reminder of our next WebEx call. Attached is the latest version of our document. Please review carefully, peruse unfamiliar publications, and make verbiage suggestions in your margins to encourage more efficient discussion.
Thank you!

Degradation & Fate group

Tuesday, August 30, 2016

2:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

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From: Mandsager, Kathy
Location: via WebEx (link and instructions below)
Importance: Normal
Subject: State-of-Science: Public Health group & sub group
Start Date/Time: Wed 8/24/2016 5:00:00 PM
End Date/Time: Wed 8/24/2016 7:00:00 PM
2016.07.21_Public Health and Food Security_post human tox work & reference check.docx

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This is a reminder of our next WebEx call (tomorrow). Attached is the latest version of our document. Please review carefully, peruse unfamiliar publications, and make verbiage suggestions in your margins to encourage more efficient discussion.
Thank you!

Public Health

Wednesday, August 24, 2016

1:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

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From: Mandsager, Kathy
Location: via WebEx (instructions below)
Importance: Normal
Subject: state-of-science: Efficacy & Effectiveness group
Start Date/Time: Tue 8/23/2016 5:00:00 PM
End Date/Time: Tue 8/23/2016 7:00:00 PM
2016.07.12 _CRRC state-of-science on EFFICACY and EFFECTIVENESS.docx
References from Public Input.docx

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From: Kinner, Nancy
Location: via WebEx (directions below)
Importance: Normal
Subject: State of Science: Transport & Behavior group
Start Date/Time: Thur 6/16/2016 7:00:00 PM
End Date/Time: Thur 6/16/2016 9:00:00 PM
2016.05.17_state-of-science on Physical Transport and Chemical Behavior.docx

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I am booking **3 timeslots** for our next calls. Perhaps we won't need them all, but during the summer months it is best to book when possible. I will also send this to you via Outlook calendar.
Thursday 16 June at 3 – 5 pm ET
Tuesday 19 July at 4-6 pm ET

Tuesday 16 August at 3-5 pm ET
From: Mandsager, Kathy
Sent: Wednesday, May 18, 2016 3:18 PM
To: 'chris.barker@noaa.gov' <chris.barker@noaa.gov>; 'CJ.Beegle-Krause@sintef.no' <CJ.Beegle-Krause@sintef.no>; 'conmy.robyn@epa.gov' <conmy.robyn@epa.gov>; 'Thomas.s.coolbaugh@exxonmobil.com' <Thomas.s.coolbaugh@exxonmobil.com>; 'fingasmerv@shaw.ca' <fingasmerv@shaw.ca>; 'ali.khelifa@ec.gc.ca' <ali.khelifa@ec.gc.ca>; 'jrpayne@sbcglobal.net' <jrpayne@sbcglobal.net>; 'wspegau@pwssc.org' <wspegau@pwssc.org>; 'creddy@whoi.edu' <creddy@whoi.edu>
Cc: Kinner, Nancy <Nancy.Kinner@unh.edu>
Subject: state-of-science: transport and behavior group
Thanks for making headway on incorporating the public input into your document. Attached is the draft after yesterday's session. I'm also attaching the Weingartner et al 2013 reference for your perusal. The references that were suggested via the public input process will eventually be incorporated into the database. But please let me know if you are unable to access a particular manuscript for review.
In order to schedule a couple more meetings, please fill in all 2-hour time slots on the doodle poll that you can possibly attend. This has been tine-zone enabled for you convenience and if you could make your selection by early next week that would be helpful in order to secure these dates over our busy summer months. Thank you!

From: Kinner, Nancy
Location: via WebEx (instructions below)
Importance: Normal
Subject: State 0f Science: Transport & Behavior group
Start Date/Time: Tue 7/19/2016 8:00:00 PM
End Date/Time: Tue 7/19/2016 10:00:00 PM
2016.06.17_state-of-science on Physical Transport and Chemical Behavior_AK.docx

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This is just a reminder of our meeting scheduled for tomorrow at 4ET. Attached is the latest version of the document.

state-of-science: Transport & Behavior group

Tuesday, July 19, 2016

4:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

Meeting num (acc code 730 305 089

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From: Mandsager, Kathy
Location: via WebEx
Importance: Normal
Subject: State of Science: Transport & Behavior group
Start Date/Time: Tue 8/16/2016 7:00:00 PM
End Date/Time: Tue 8/16/2016 9:00:00 PM
2016.07.19_state-of-science on Physical Transport and Chemical Behavior.docx
2016.07.19_state-of-science on Physical Transport and Chemical Behavior.docx

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This is just a reminder of our call (tomorrow at 3 ET). Attached is the latest document.
As follow-up to our last call, I have located the Spaulding et al 2015 paper. It is too large to send as an email attachment. It is located in the Transport and Behavior database. https://unh.box.com/s/dwsrta5l41t3ienuolutleq6mzy594tg. I'm also attaching our latest version of the document.
The WebEx directions for our next call is below:

Transport & Beh

Tue: Aug 16, 201(2:00 pm | Eas: Day Tim((Ne\ York GM 04:0 | 2 hrs

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From: Sjogren, Mya
Location: 866-299-3188; 202-564-3324 &
http://epawebconferencing.acms.com/shcpartners
Importance: Normal
Subject: Sustainable and Healthy Communities research program update with Program and Regional Partners
Start Date/Time: Wed 1/13/2016 7:00:00 PM
End Date/Time: Wed 1/13/2016 8:00:00 PM
SHC 3.62 Oil Research Program jan2016_conmy.pdf
SHC_PartnersUpdate_LawrenceMVD_final.pdf

In this monthly meeting, the Sustainable and Healthy Communities (SHC) research program will share ongoing and completed research with program office and regional partners.

Call in number: 866-299-3188; 202-564-3324# &
http://epawebconferencing.acms.com/shcpartners
Facilitator: Mike Slimak, National Program Director for Sustainable and Healthy Communities research program

Agenda for Jan 13, 2016 Partner Meeting:

1. Speaker 1: Overview of ORD Oil Research Program (Robyn Conmy) (presentation attached)

2. Speaker 2: Status update on Lawrence, MA Making a Visible Difference (MVD) project (Valerie Zartarian, Marilyn TenBrink, Jeff Yang) (presentation attached)

3. Regional Sustainable Environmental Science (RESES) proposal season (Michele Conlon)

4. FY15 products and summaries are posted to the Deliverables Database (Greg Grissom)
    a. Demonstration of RMS and our Deliverables Database

Upcoming Seminars:

NIH-IHS Joint Research Partnership Highlighted. On **January 19th at 3pm,** the Indian Health Service (IHS) and the National Institutes of Health will co-present on their joint partnership supporting the Native American Research Centers for Health (NARCH). The NARCH initiative, started in the year 2000, supports partnerships between AI/AN Tribes or Tribally-based organizations and institutions that conduct intensive academic-level biomedical, behavioral and health services research. This webinar will be the third in the newly re-established EPA Tribal Science Webinar Series, co-hosted by SHC, NCER, and OSP.

System Dynamics Model for Community Transit Planning. **On January 26th at 3pm**, Rochelle Araujo of ORD's National Exposure Research Laboratory will present her team's findings as described in their recently finalized case study, "The Durham-Orange Light Rail Project: A System Dynamics Model for Integrated Decision Making." This report is a culmination of efforts dating back to SHC's inception to build capacity among decision-makers in understanding the holistic

nature of community issues and how their social, economic, and environmental aspects are interconnected.

Continuing the conversation on biomimicry. Diana Hammer of Region 8 will present "Tapping into Nature's Genius: Biomimicry and EPA," a reflection on the recent biomimicry workshop in Region 8 and on how those lessons might be more broadly applied across the Agency in its work. Jayne Michaud of the National Center for Environmental Research, who attended the workshop, will co-present, offering an ORD perspective. Date and time are TBD.

Past:

Tribal Science Webinar featuring STAR Grantee Work. On January 12th EPA STAR grantees John Doyle, Anne Camper, and Mari Eggers presented on their project, "Water, Our Voice to the Future: Climate change adaptation and waterborne disease prevention on the Crow Reservation." They highlighted the complex environmental issues facing many tribal and indigenous communities.

Typology of Sustainable Communities Revisited. Nearly a hundred people participated in-person and via webinar on December 1st as SHC hosted Mike Nye, Kate Mulvaney, and Alex Hall's presentation, "Predicting community engagement with sustainability using geographically weighted regression." These three ORD scientists illustrated the ongoing progress of the Community Typology project in SHC 1.61 and discussed potential applications for EPA and partner organizations.

Resources:

- Visit SHC's intranet site to access recordings of past seminar series presentations as well as science moment presentations.
- ORD's Research Management System includes descriptions of ongoing and planned research for all of ORD's programs.
- SHC's Deliverables Database houses SHC's completed products.

From: Mandsager, Kathy
Location: via WebEx
Importance: Normal
Subject: State-of-Science: Toxicity Group
Start Date/Time: Mon 9/21/2015 6:00:00 PM
End Date/Time: Mon 9/21/2015 9:00:00 PM
RE: State-of-Science dispersant use in Arctic water: TOXICITY group - doodle poll for next meeting

We have a majority! Please mark your calendars for **Monday 9/21 beginning at 2pm ET**.
Attached is the latest version of the document for your review prior to this call.
I will send all of this information in a calendar request as well. WebEx instructions here>>

State-of-Science: Toxicity Group

Monday, September 21, 2015
2:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 3 hrs

Join WebEx meeting

Meeting number: 736 235 319

Join by phone

1-855-244-8681 Call-in toll-free number (US/Canada)
1-650-479-3207 Call-in toll number (US/Canada)
Access code: 736 235 319
Global call-in numbers | Toll-free calling restrictions

Can't join the meeting? Contact support.

To: 'sarah.allan@noaa.gov'[sarah.allan@noaa.gov]; Barron, Mace[Barron.Mace@epa.gov]; 'abejarano@researchplanning.com'[abejarano@researchplanning.com]; 'jewel_bennett@fws.gov'[jewel_bennett@fws.gov]; 'DFrenchMcCay@asascience.com'[DFrenchMcCay@asascience.com]; 'peter.hodson@queensu.ca'[peter.hodson@queensu.ca]; sharon.hook@csiro.au[sharon.hook@csiro.au]; 'rrhopcroft@alaska.edu'[rrhopcroft@alaska.edu]; John Incardona - NOAA Federal[john.incardona@noaa.gov]; 'Angela_Matz@fws.gov'[Angela_Matz@fws.gov]; 'Teri.Rowles@noaa.gov'[Teri.Rowles@noaa.gov]; mathijs.smit@shell.com[mathijs.smit@shell.com]; Sprenger, Mark[Sprenger.Mark@epa.gov]; 'Robert.Suydam@north-slope.org'[Robert.Suydam@north-slope.org]; 'rstjeerdema@ucdavis.edu'[rstjeerdema@ucdavis.edu]; 'dana@mote.org'[dana@mote.org]; 'john.wise.sr@gmail.com'[john.wise.sr@gmail.com]; 'BGardiner@environcorp.com'[BGardiner@environcorp.com]; 'mhziccardi@ucdavis.edu'[mhziccardi@ucdavis.edu]
Cc: Ian Gaudreau[iangaudreau@gmail.com]; Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Mandsager, Kathy
Sent: Fri 9/11/2015 4:07:25 PM
Subject: RE: State-of-Science dispersant use in Arctic water: TOXICITY group - doodle poll for next meeting
2015.08.17_Toxicity and Sublethal Impacts.docx

We have a majority! Please mark your calendars for **Monday 9/21 beginning at 2pm ET**.

Attached is the latest version of the document for your review prior to this call.

I will send all of this information in a calendar request as well. WebEx instructions here>>

State-of-Science: Toxicity Group
Monday, September 21, 2015
2:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 3 hrs

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Access code: 736 235 319
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Can't join the meeting? Contact support.

From: Mandsager, Kathy
Sent: Tuesday, September 08, 2015 11:36 AM
To: 'sarah.allan@noaa.gov' <sarah.allan@noaa.gov>; 'Barron.Mace@epa.gov' <Barron.Mace@epa.gov>; 'abejarano@researchplanning.com' <abejarano@researchplanning.com>; 'jewel_bennett@fws.gov' <jewel_bennett@fws.gov>; 'DFrenchMcCay@asascience.com' <DFrenchMcCay@asascience.com>; 'peter.hodson@queensu.ca' <peter.hodson@queensu.ca>; sharon.hook@csiro.au; 'rrhopcroft@alaska.edu' <rrhopcroft@alaska.edu>; 'John Incardona - NOAA Federal' <john.incardona@noaa.gov>; 'Angela_Matz@fws.gov' <Angela_Matz@fws.gov>; 'Teri.Rowles@noaa.gov' <Teri.Rowles@noaa.gov>; 'mathijs.smit@shell.com' <mathijs.smit@shell.com>; Sprenger, Mark <Sprenger.Mark@epa.gov> (Sprenger.Mark@epa.gov) <Sprenger.Mark@epa.gov>; 'Robert.Suydam@north-slope.org' <Robert.Suydam@north-slope.org>; 'rstjeerdema@ucdavis.edu' <rstjeerdema@ucdavis.edu>; 'dana@mote.org' <dana@mote.org>; 'john.wise.sr@gmail.com' <john.wise.sr@gmail.com>; 'BGardiner@environcorp.com' <BGardiner@environcorp.com>; 'mhziccardi@ucdavis.edu' <mhziccardi@ucdavis.edu>
Subject: State-of-Science dispersant use in Arctic water: TOXICITY group - doodle poll for next meeting

Dear Toxicity Group:

I would like to schedule yet another WebEx to continue the discussion on this paper. Although we are nearing the end, we do need to have **a fish and mammals** discussion. Please fill out the doodle poll as soon as possible so we can confirm a date for a potential 3-hour call this month. All are invited to participate in this discussion, but we must have the fish and mammals folks on the call for this discussion.

Doodle poll (time zone enabled) for dates in September>>
http://doodle.com/poll/t5h37gydqctcm5mf

Thank you!

Kathy Mandsager

Program Coordinator

Coastal Response Research Center

Center for Spills and Environmental Hazards

234 Gregg Hall, Colovos Rd

University of New Hampshire

Durham, NH 03824

603.862.1545

From: Mandsager, Kathy
Location: via WebEx (instructions below)
Importance: Normal
Subject: state-of-science: Efficacy & Effectiveness group
Start Date/Time: Tue 8/23/2016 5:00:00 PM
End Date/Time: Tue 8/23/2016 7:00:00 PM
2016.07.12 _CRRC state-of-science on EFFICACY and EFFECTIVENESS.docx
References from Public Input.docx

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From: Mandsager, Kathy
Location: via Webex (instructions below)
Importance: Normal
Subject: State of Science: Degradation & Fate
Start Date/Time: Thur 8/18/2016 6:00:00 PM
End Date/Time: Thur 8/18/2016 8:00:00 PM
2016.06.25_LINDEN_Degradation and Fate with public input.docx

;;;;;;;;
Reminder of our meeting scheduled for tomorrow at 2pm ET. [Since Karl Linden is on sabbatical this summer and unable to participate in call tomorrow, the attached document includes some of his comments].

Degradation & Fate group

Thursday, August 18, 2016

2:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

Meeting num (acc code 737 208 178

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From: Mandsager, Kathy
Location: via WebEx
Importance: Normal
Subject: State of Science: Transport & Behavior group
Start Date/Time: Tue 8/16/2016 7:00:00 PM
End Date/Time: Tue 8/16/2016 9:00:00 PM
2016.07.19_state-of-science on Physical Transport and Chemical Behavior.docx
2016.07.19_state-of-science on Physical Transport and Chemical Behavior.docx

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This is just a reminder of our call (tomorrow at 3 ET). Attached is the latest document.
As follow-up to our last call, I have located the Spaulding et al 2015 paper. It is too large to send as an email attachment. It is located in the Transport and Behavior database. https://unh.box.com/s/dwsrta5l41t3ienuolutleq6mzy594tg. I'm also attaching our latest version of the document.
The WebEx directions for our next call is below:

Transport & Beh

Tue: Aug 16, 201(2:00 pm | Eas: Day Tim((Ne\ York GM 04:0 | 2 hrs

Meeting num (acc code 734 342 130

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From: Mandsager, Kathy
Location: via WebEx (link and instructions below)
Importance: Normal
Subject: State of Science: Public Health group & sub group
Start Date/Time: Thur 7/21/2016 6:00:00 PM
End Date/Time: Thur 7/21/2016 8:00:00 PM
2016.07.06_Public Health and Food Security_post human tox work & reference check.docx

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This is just a reminder of our meeting scheduled for tomorrow 7/21 beginning at 2:00 pm ET via the WebEx instructions below. Attached is the latest version of the document.

Public Health

Thursday, July 21, 2016

2:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

Meeting num (acc code 735 156 379

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From: kathy.mandsager@unh.edu
Location: via WebEx (instructions below)
Importance: Normal
Subject: State 0f Science: Transport & Behavior group
Start Date/Time: Tue 7/19/2016 8:00:00 PM
End Date/Time: Tue 7/19/2016 10:00:00 PM
2016.06.17_state-of-science on Physical Transport and Chemical Behavior_AK.docx

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This is just a reminder of our meeting scheduled for tomorrow at 4ET. Attached is the latest version of the document.

state-of-science: Transport & Behavior group

Tuesday, July 19, 2016

4:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

Meeting num (acc code 730 305 089

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To: Conmy, Robyn[Conmy.Robyn@epa.gov]; fingasmerv@shaw.ca[fingasmerv@shaw.ca]; tchazen@utk.edu[tchazen@utk.edu]; robert.jones@noaa.gov[robert.jones@noaa.gov]; mandyjoye@gmail.com[mandyjoye@gmail.com]; ken.lee@csiro.au[ken.lee@csiro.au]; tracee.nguyen@csiro.au[tracee.nguyen@csiro.au]; mbleigh@alaska.edu[mbleigh@alaska.edu]; karl.linden@colorado.edu[karl.linden@colorado.edu]; kmmcfarlin@alaska.edu[kmmcfarlin@alaska.edu]; msmiles@lsu.edu[msmiles@lsu.edu]; thomas.s.coolbaugh@exxonmobil.com[thomas.s.coolbaugh@exxonmobil.com]; mathijs.smit@shell.com[mathijs.smit@shell.com]; Sprenger, Mark[Sprenger.Mark@epa.gov]
Cc: Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Mandsager, Kathy
Sent: Fri 6/24/2016 1:20:17 PM
Subject: state-of-science: degradation & fate-incorporate public input
2016.06.23_Degradation and Fate with public input.docx
COMBINED_degredation and fate_public input.docx
References submitted by public input.docx

Dear scientific panel:

As you know, the public input period closed on the *Physical Transport & Chemical Behavior* document. We received a total of 7 individual responses. A collated list of these responses are attached for your perusal. Also attached is the list of suggested references by the public input.

To make it a little easier to edit, we have incorporated the public input into the actual document (note the items highlighted in gray). However, this does skew the line numbering for identification.

It is now time to schedule another WebEx meeting in order to discuss this information and/or incorporate or edit the original document as you deem appropriate. Please use the doodle poll to select a time for two meetings (July & August). It is time-zone enabled for your convenience and if you could **respond by June 29** it will help in securing a date and getting it on your busy calendars.

Here is the doodle poll>> http://doodle.com/poll/t62cq932rd25dzd7

Thank you so much!

Kathy Mandsager

Coastal Response Research Center

Center for Spills and Environmental Hazards

220 Gregg Hall, 35 Colovos Rd

University of New Hampshire

Durham, NH 03824

603.862.1545

To: john.wise@louisville.edu[john.wise@louisville.edu]; John Wise[john.wise.sr@gmail.com]; jberner@anmc.org[jberner@anmc.org]; sandrine.deglin@alaska.gov[sandrine.deglin@alaska.gov]; robert.dickey@utexas.edu[robert.dickey@utexas.edu]; jim.fall@alaska.gov[jim.fall@alaska.gov]; PESA@gci.net[PESA@gci.net]; jgohlke@vt.edu[jgohlke@vt.edu]; sklasing@oehha.ca.gov[sklasing@oehha.ca.gov]; richard.kwok@nih.gov[richard.kwok@nih.gov]; ken.lindemann@bp.com[ken.lindemann@bp.com]; masten@niehs.nih.gov[masten@niehs.nih.gov]; fabs@pitt.edu[fabs@pitt.edu]; stevencraiglewis@comcast.net[stevencraiglewis@comcast.net]; jwickif@tulane.edu[jwickif@tulane.edu]
Cc: nancy.kinner@unh.edu[nancy.kinner@unh.edu]; Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Mandsager, Kathy
Sent: Thur 6/23/2016 7:00:31 PM
Subject: State-of-science for dispersants: public health group
2016.06.13_Public Health and Food Security_post human tox work.docx

Dear Panelists,

The human toxicity sub-group met together on numerous occasions and have completed their task. Attached is the latest version of the document with all comments. We now submit it to the whole group at-large to discuss and finalize.

In order to do this, I would like to secure 2 meeting times. Please use this doodle poll to find a time that works for the majority of you – for 2 meetings.

Use this doodle poll (by June 30)>> http://doodle.com/poll/xakmh29hmzccrh82 for dates in July and August.

Thank you!

Kathy Mandsager

Coastal Response Research Center

Center for Spills and Environmental Hazards

220 Gregg Hall, 35 Colovos Rd

University of New Hampshire

Durham, NH 03824

603.862.1545

To: Mandsager, Kathy[kathy.mandsager@unh.edu]; sarah.allan@noaa.gov[sarah.allan@noaa.gov]; Barron, Mace[Barron.Mace@epa.gov]; abejarano@researchplanning.com[abejarano@researchplanning.com]; jewel_bennett@fws.gov[jewel_bennett@fws.gov]; DFrenchMcCay@asascience.com[DFrenchMcCay@asascience.com]; michel.gielazyn@noaa.gov[michel.gielazyn@noaa.gov]; sharon.hook@csiro.au[sharon.hook@csiro.au]; rrhopcroft@alaska.edu[rrhopcroft@alaska.edu]; john.incardona@noaa.gov[john.incardona@noaa.gov]; Angela_Matz@fws.gov[Angela_Matz@fws.gov]; Teri.Rowles@noaa.gov[Teri.Rowles@noaa.gov]; Mathijs.Smit@shell.com[Mathijs.Smit@shell.com]; Sprenger, Mark[Sprenger.Mark@epa.gov]; robert.suydam@north-slope.org[robert.suydam@north-slope.org]; rstjeerdema@ucdavis.edu[rstjeerdema@ucdavis.edu]; dana@mote.org[dana@mote.org]; john.wise@louisville.edu[john.wise@louisville.edu]; bgardiner@environcorp.com[bgardiner@environcorp.com]; mhziccardi@ucdavis.edu[mhziccardi@ucdavis.edu]
Cc: Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; nancy.kinner@unh.edu[nancy.kinner@unh.edu]; Wilson, Gregory[Wilson.Gregory@epa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]
From: Peter Hodson
Sent: Thur 6/9/2016 2:20:52 AM
Subject: RE: State-of-Science for Dispersant: Eco-Tox panel
2016.05.10_Draft_EcoToxicity and Sublethal Impacts - pvh comments June 8 2016.docx

Kathy

I made a few minor edits – I also noted that the reference style is inconsistent – will need a careful review.

Nevertheless, an interesting and useful document!

Peter

Peter Hodson

School of Environmental Studies

Queen's University

Kingston, ON

K7L3N6

613 533 6129

613 539 1423 (cell)

Peter.hodson@queensu.ca

From: Mandsager, Kathy [mailto:kathy.mandsager@unh.edu]
Sent: June-08-16 11:59 AM
To: sarah.allan@noaa.gov; barron.mace@epa.gov; abejarano@researchplanning.com; jewel_bennett@fws.gov; DFrenchMcCay@asascience.com; michel.gielazyn@noaa.gov; Peter Hodson; sharon.hook@csiro.au; rrhopcroft@alaska.edu; john.incardona@noaa.gov; Angela_Matz@fws.gov; Teri.Rowles@noaa.gov; Mathijs.Smit@shell.com; Sprenger.Mark@epa.gov; robert.suydam@north-slope.org; rstjeerdema@ucdavis.edu; dana@mote.org; john.wise@louisville.edu; bgardiner@environcorp.com; mhziccardi@ucdavis.edu
Cc: Gary Shigenaka - NOAA Federal; doug.helton@noaa.gov; Kinner, Nancy; 'wilson.gregory@epa.gov'; 'principe.vanessa@epa.gov'
Subject: State-of-Science for Dispersant: Eco-Tox panel

Dear Panelist,

I am attaching the latest draft of the Eco-tox document. I am hoping Teri Rowles, and others of you noted in this document could firm up the outstanding information needed to finalize this document. It is ready for your approval.

Your task:

Step 1: please complete the missing information in this document.

Step 2: please confirm that your name and affiliation are noted correctly at the end of this document.

Step 3: please carefully review this document.

Step 4: and then please reply via email <u>your written approval</u> of this document.

As soon as we receive all panelists written approval, this document will then be posted for the public input period.

Again, thanks for your guidance on this important document.

Kathy Mandsager

Coastal Response Research Center

Center for Spills and Environmental Hazards

220 Gregg Hall, 35 Colovos Rd

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To: jberner@anmc.org[jberner@anmc.org]; sandrine.deglin@alaska.gov[sandrine.deglin@alaska.gov]; robert.dickey@utexas.edu[robert.dickey@utexas.edu]; jim.fall@alaska.gov[jim.fall@alaska.gov]; jgohlke@vt.edu[jgohlke@vt.edu]; sklasing@oehha.ca.gov[sklasing@oehha.ca.gov]; richard.kwok@nih.gov[richard.kwok@nih.gov]; ken.lindemann@bp.com[ken.lindemann@bp.com]; PESA@gci.net[PESA@gci.net]
Cc: Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Mandsager, Kathy
Sent: Mon 4/11/2016 6:27:53 PM
Subject: FW: State-of-Science for dispersant use in Arctic waters HUMAN TOXICITY group
2016.04.05_Public Health and Food Security.docx

Public Health Panel:

Just letting you know that another WebEx meeting has been scheduled for the Human Toxicity sub-group. As usual, you are welcome to join if you are able.

From: Mandsager, Kathy
Sent: Monday, April 11, 2016 2:22 PM
Subject: RE: State-of-Science for dispersant use in Arctic waters HUMAN TOXICITY group

This is to confirm our next meeting **for Tuesday 10 May at 1-3 pm ET**. (I will also send this via Outlook calendar for your convenience.)

Please remember to review and share your thoughts and edits to the document (attached here again). I'd like to encourage you to continue this discussion via email in order to keep this conversation progressing.

Thank you so much for your input!

Here are the WebEx instructions to login:

Human Toxicity - dispersant state-of-science
Tuesday, May 10, 2016
1:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

Join WebEx meeting

Meeting number: 736 699 385

Join by phone
1-855-244-8681 Call-in toll-free number (US/Canada)
1-650-479-3207 Call-in toll number (US/Canada)
Access code: 736 699 385

To: sarah.allan@noaa.gov[sarah.allan@noaa.gov]; Barron, Mace[Barron.Mace@epa.gov]; abejarano@researchplanning.com[abejarano@researchplanning.com]; jewel_bennett@fws.gov[jewel_bennett@fws.gov]; DFrenchMcCay@asascience.com[DFrenchMcCay@asascience.com]; michel.gielazyn@noaa.gov[michel.gielazyn@noaa.gov]; peter.hodson@queensu.ca[peter.hodson@queensu.ca]; sharon.hook@csiro.au[sharon.hook@csiro.au]; rrhopcroft@alaska.edu[rrhopcroft@alaska.edu]; john.incardona@noaa.gov[john.incardona@noaa.gov]; Angela_Matz@fws.gov[Angela_Matz@fws.gov]; Teri.Rowles@noaa.gov[Teri.Rowles@noaa.gov]; Mathijs.Smit@shell.com[Mathijs.Smit@shell.com]; Sprenger, Mark[Sprenger.Mark@epa.gov]; robert.suydam@north-slope.org[robert.suydam@north-slope.org]; rstjeerdema@ucdavis.edu[rstjeerdema@ucdavis.edu]; dana@mote.org[dana@mote.org]; john.wise@louisville.edu[john.wise@louisville.edu]; bgardiner@environcorp.com[bgardiner@environcorp.com]; mhziccardi@ucdavis.edu[mhziccardi@ucdavis.edu]
Cc: nancy.kinner@unh.edu[nancy.kinner@unh.edu]; Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Mandsager, Kathy
Sent: Thur 3/10/2016 6:34:37 PM
Subject: State-of-Science for Dispersant Use in Arctic Waters: Eco-Toxicity group
2016.03.08_Draft_EcoToxicity and Sublethal Impacts (002) (1).docx

We would like to schedule another group discussion in order to finalize this document.

Please review the attached version carefully. The yellow highlights are NEWLY added verbiage for your consideration. And there are many side comments that will need to be addressed by you, the experts.

In order to schedule our next 2-hour meeting for some time in April, please use this doodle poll **(by Tuesday 3/15)** to select all possible timeslots>> http://doodle.com/poll/2syitseguts8ntbd . Of course, we would like all of you on this – what we hope will be – our final call.

Thanks so very much for your attention to this document!

Kathy Mandsager

Coastal Response Research Center

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234 Gregg Hall, Colovos Rd

University of New Hampshire

Durham, NH 03824

603.862.1545

To: jberner@anmc.org[jberner@anmc.org]; sandrine.deglin@alaska.gov[sandrine.deglin@alaska.gov]; robert.dickey@utexas.edu[robert.dickey@utexas.edu]; jim.fall@alaska.gov[jim.fall@alaska.gov]; PESA@gci.net[PESA@gci.net]; jgohlke@vt.edu[jgohlke@vt.edu]; sklasing@oehha.ca.gov[sklasing@oehha.ca.gov]; richard.kwok@nih.gov[richard.kwok@nih.gov]; ken.lindemann@bp.com[ken.lindemann@bp.com]
Cc: Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]; nancy.kinner@unh.edu[nancy.kinner@unh.edu]; Mandsager, Kathy[kathy.mandsager@unh.edu]
From: Mandsager, Kathy
Sent: Mon 2/29/2016 6:12:15 PM
Subject: State-of-Science: Public Health and Food Security - human toxicity sub group
2016.01.19_Public Health and Food Security.docx

Dear Public Health panel members,

As you may remember form our last discussion, it was determined that we needed additional expertise in the area of human toxicology, particularly in the area of molecular/cellular level expertise with regard to DDO in order to address the small, but growing scientific literature with this focus.

Last week this project's Steering Committee approved of the selection of 4 additional scientific experts to this panel. And, we have scheduled a one-hour meeting with these folks. You are welcome to join in this conversation tomorrow, **Tuesday 1 March at 12noon ET** via WebEx (with sincere apologies for the late notice).

This sub-group includes:

- Scott Masten, NIEHS (http://www.niehs.nih.gov/research/atniehs/dntp/assoc/ons/staff/masten/index.cfm)
- James Fabisiak, University of Pittsburgh, Dept of Environmental and Occupational health (**MailScanner has detected definite fraud in the website at "www.pitt.edu". Do *not* trust this website:** http://www.pitt.edu/~fabs/)
- Steven Lewis, Integrative Policy & Science, Inc. (see attached bio)
- Jeffrey Wickliffe, Tulane University http://tulane.edu/publichealth/ehs/faculty_wickliffe.cfm

Feel free to review the publications that have been collected thus far by using this link, where you will find the spreadsheet as well as the pdfs of each document. https://unh.box.com/s/dfxte8nwk8yz74voirrmtvt35jqi44mh.

Human Toxicity working group
Tuesday, March 1, 2016
1:00 pm | Eastern Standard Time (New York, GMT-05:00) | 1 hr

Join WebEx meeting

Meeting number: 734 769 690

Join by phone
1-855-244-8681 Call-in toll-free number (US/Canada)
1-650-479-3207 Call-in toll number (US/Canada)
Access code: 734 769 690
Global call-in numbers | Toll-free calling restrictions

Kathy Mandsager

Coastal Response Research Center

Center for Spills and Environmental Hazards

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University of New Hampshire

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From: Mandsager, Kathy
Sent: Thur 2/25/2016 10:50:24 PM
Subject: State-of-Science for Dispersants Use in Arctic Water: Degradation & Fate Group
2016.02.25_Degradation and Fate with appendices for panel final review.docx

Dear Panel:

We would very much appreciate your review of this final version of the *Degradation and Fate* document. This document incorporates the edits and suggestions made via email and final discussion.

If you could reply by email with your approval of this document by **Monday, March 17** (2 weeks for this review) that would be greatly appreciated. I will need each of you that participated in this discussion to reply in the affirmative that you approve this document.

Please also confirm that your name and affiliation are listed correctly at the end of this document.

You deserve kudos for this great accomplishment! Thank you very much!

Kathy Mandsager

Program Coordinator

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From: Mandsager, Kathy
Sent: Thur 2/25/2016 6:54:24 PM
Subject: State-of-Science for dispersant use in Arctic - EFFICACY & EFFECTIVENESS Group
2016.02.25_combined public input responses.pdf

Dear Panel,

We have successfully completed the Public Input phase of the Efficacy and Effectiveness document. They (12 total) are attached here for your perusal.

Our next step is to schedule a meeting for discussing these comments. Please use this doodle poll (time-zone enabled) for all potential time slots for a meeting later in March. If you could make your selections by Tuesday 3/2 that would be very helpful.

Doodle poll>> http://doodle.com/poll/e55b7yh8gpxaihyz

Thank you so much!

Kathy Mandsager

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From: Mandsager, Kathy
Sent: Wed 12/23/2015 3:59:33 PM
Subject: State-of-Science Arctic Dispersants: Degradation & Fate group - REPLY REQUESTED
2015.12.22_Degradation and Fate.docx

Dear Colleagues in the Degradation & Fate group,

Thank you for participating in our recent call (on 12/16). Attached is the latest draft of our document for your perusal. Please review the comments that still need to be discussed and/or edited.

In order to select our next WebEx meeting as soon as possible (in January), please use this doodle poll>> http://doodle.com/poll/vdivwmyha6ma6593 by Monday 1/4 so that a date can be selected. It is time-zone enabled for your convenience.

Wishing you all a wonderful holiday season and we look forward to continuing our work in the New Year!

Kathy Mandsager

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Chemical dispersants can suppress the activity of natural oil-degrading microorganisms

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During the Deepwater Horizon oil well blowout in the Gulf of Mexico, the application of 7 million liters of chemical dispersants aimed to stimulate microbial crude oil degradation by increasing the bioavailability of oil compounds. However, the effects of dispersants on oil biodegradation rates are debated. In laboratory experiments, we simulated environmental conditions comparable to the hydrocarbon-rich, 1,100 m deep plume that formed during the Deepwater Horizon discharge. The presence of dispersant significantly altered the microbial community composition through selection for potential dispersant-degrading Colwellia, which also bloomed in situ in Gulf deep waters during the discharge. In contrast, oil addition to deep water samples in the absence of dispersant stimulated growth of natural hydrocarbon-degrading Marinobacter. In these deepwater microcosm experiments, dispersants did not enhance heterotrophic microbial activity or hydrocarbon oxidation rates. An experiment with surface seawater from an anthropogenically derived oil slick corroborated the deep water microcosm results as inhibition of hydrocarbon turnover was observed in the presence of dispersants, suggesting that the microcosm findings are broadly applicable across marine habitats. Extrapolating this comprehensive dataset to real world scenarios questions whether dispersants stimulate microbial oil degradation in deep ocean waters and instead highlights that dispersants can exert a negative effect on microbial hydrocarbon degradation rates.

oceanography | microbial dynamics | hydrocarbon cycling | chemical dispersants | oil spills

Crude oil enters marine environments through geophysical processes at natural hydrocarbon seeps (1) at a global rate of ~700 million liters per year (2). In areas of natural hydrocarbon seepage, such as the Gulf of Mexico (hereafter, the Gulf), exposure of indigenous microbial communities to oil and gas fluxes can select for microbial populations that use petroleum-derived hydrocarbons as carbon and energy sources (3, 4). The uncontrolled deep-water oil well blowout that followed the explosion and sinking of the Deepwater Horizon (DWH) drilling rig in 2010 released about 750 million liters of oil into the Gulf. Seven million liters of chemical dispersants were applied (5) with the goal of dispersing hydrocarbons and stimulating oil biodegradation. A deep-water (1,000–1,300 m) plume, enriched in hydrocarbons (6–11) and dioctyl sodium sulfosuccinate (DOSS) (12, 13), a major component of chemical dispersants (14), formed early in the discharge (7). The chemistry of the hydrocarbon plume significantly altered the microbial community (11, 15–17), driving rapid enrichment of low-abundance bacterial taxa such as Oceanospirillum, Cycloclasticus, and Colwellia (18). The natural hydrocarbon degraders in Gulf waters were either in low abundance or absent in DWH deep-water plume samples (18).

Chemical dispersants emulsify surface oil slicks, reduce oil delivery to shorelines (19), and increase dissolved oil concentrations, which should make oil more bioavailable (20) and stimulate biodegradation (21). The efficacy of dispersants in stimulating oil biodegradation is debated (22) and negative environmental effects have been documented (23). Dispersant application often requires ecological tradeoffs (24). Surprisingly little is known about the impacts of dispersants on the activity and abundance of hydrocarbon-degrading microorganisms (25). This work addressed three key questions: (i) Do dispersants influence microbial community composition? (ii) Is the indigenous microbial community as effective at oil biodegradation as microbial populations following dispersant/dispersed oil exposure? (iii) Does chemically dispersed oil stimulate hydrocarbon biodegradation rates?

Laboratory experiments were used to unravel the effects of oil-only (supplied as a water-accommodated fraction, "WAF"), Corexit 9500 ("dispersant-only"), oil–Corexit 9500 mixture (chemically enhanced

ENVIRONMENTAL SCIENCES

Significance

Oil spills are a significant source of hydrocarbon inputs into the ocean. In response to oil spills, chemical dispersants are applied to the oil-contaminated seawater to disperse surface slicks into smaller droplets that are presumed to be more bioavailable to microorganisms. We provide evidence that chemical dispersants applied to either deep water or surface water from the Gulf of Mexico did not stimulate oil biodegradation. Direct measurement of alkane and aromatic hydrocarbon oxidation rates revealed either suppression or no stimulation of oil biodegradation in the presence of dispersants. However, dispersants affected microbial community composition and enriched bacterial populations with the ability to use dispersant-derived compounds as growth substrates, while oil-alone amendments enriched for natural hydrocarbon degraders.

Author contributions: S.K., S.H., S.Y.M., and S.B.J. designed research; S.K., M.S., K.Z., K.L., S.H., S.Y.M., M.J.P., J.F., and U.P. performed research; S.G., K.L., M.J.P., J.F., M.L.S., T.D., and P.M.M. contributed new reagents/analytic tools; S.K., M.S., K.Z., S.G., S.H., S.Y.M., M.J.P., J.F., M.L.S., T.D., U.P., P.M.M., and S.B.J. analyzed data; and S.K., M.L.S., P.M.M., and S.B.J. wrote the paper.

The authors declare no conflict of interest.

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Data deposition: 16S rRNA amplicon Illumina sequencing data were deposited in the GenBank database (BioProject accession no. PRJNA253405).

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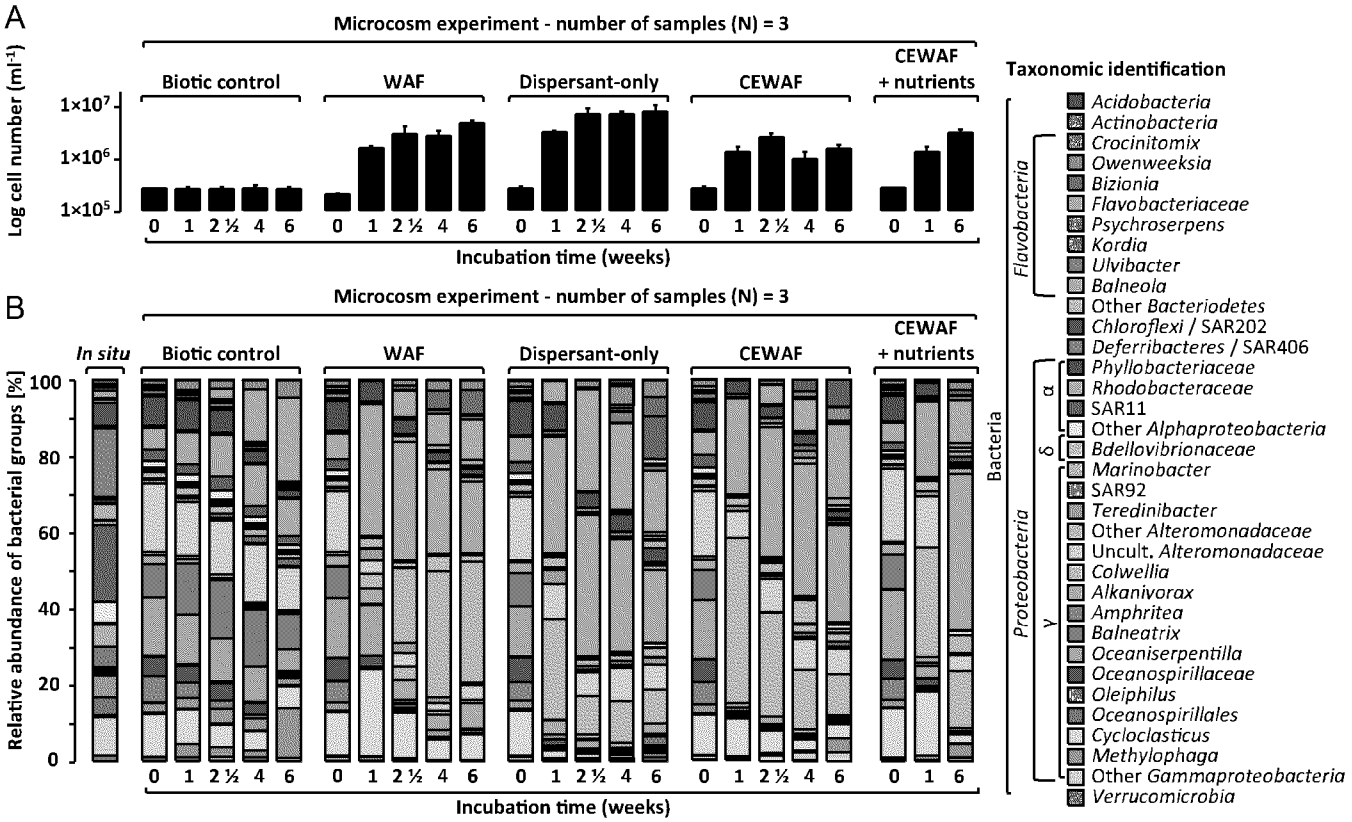

Fig. 1. Dispersants affect the evolution of oil-degrading microbial populations. (A) Average and standard deviation (SD) of cell numbers from sample triplicates (log scale) monitored for 6 wk in microcosms. (B) Relative abundance of bacterial groups in Gulf of Mexico deep water in situ samples and in the microcosms (average of triplicate samples). Reads of the V4V5 regions of the 16S rRNA gene were clustered into operational taxonomic units and taxonomy was assigned with Global Alignment for Sequence Taxonomy (GAST).

water-accommodated fraction, CEWAF) or a CEWAF with nutrients (CEWAF + nutrients) (SI Appendix) on Gulf deep-water microbial populations (SI Appendix, SI Text and Figs. S1 and S2). Experimental conditions (SI Appendix, Table S1) mimicked those prevailing in the DWH deep-water hydrocarbon plume (6–13, 18), the chemistry of which varied substantially over space and time (18). Amending samples with WAFs and CEWAFs assured that observed differences in microbial community composition and activity would be driven by compositional differences (e.g., the presence or absence of dispersants) in the dissolved organic carbon (DOC) pool rather than by differences in the bulk DOC concentration (26, 27). We developed an improved radiotracer method to directly quantify hydrocarbon oxidation rates. The microbial community composition was monitored over time using 16S rRNA amplicon sequencing. Dispersant application selected for specific microbial taxa and oligotypes with 16S rRNA gene sequences similar to those recovered in situ during the DWH discharge. Surprisingly, CEWAF (± nutrients) addition did not enhance microbial activity or microbial oil-degradation rates.

Results and Discussion

Dispersant Significantly Altered Microbial Community Composition. We hypothesized that dispersants would alter microbial community composition in the deepwater samples and that selection of one population over another would drive differences in hydrocarbon-degradation rates, altering the oil-degradation efficiency. We explored patterns in microbial abundance (Fig. 1A) using microscopy and community composition by Illumina paired-end sequencing of bacterial 16S rRNA gene amplicons (Fig. 1B). We resolved closely related bacterial taxa using oligotyping analysis (28) (Fig. 2 and SI Appendix, Fig. S3). We elucidated the ecological preference of specific taxa using statistical correspondence analysis (SI Appendix, Figs. S4–S8).

All dispersant-amended treatments showed ingrowth of Colwellia (SI Appendix, Fig. S4), a group containing both hydrocarbon and dispersant degraders (29). After 1 wk, the relative abundance of Colwellia increased from 1% to 26–43% in dispersant-only and CEWAF (± nutrients) treatments (Fig. 1B). In contrast, Colwellia was a minority (1–4%) in WAF treatments. Selective enrichment of Colwellia in dispersant-only treatments indicates that dispersant components served as growth substrates (29). The relative abundance of Colwellia oligotypes 01, 02, and 05 increased in dispersant treatments (Fig. 2 and SI Appendix, Fig. S5), whereas oligotypes 03 and 10 increased in treatments receiving oil only, underscoring the role of dispersants in driving variation in Colwellia taxa. Phylogenetic analysis of the 16S rRNA gene amplicons confirmed that these oligotypes were closely related to species detected in DWH plume samples in situ (9, 16, 18) (SI Appendix, Fig. S9), verifying the environmental relevance of these organisms during the DWH discharge.

The dominant microbial responder to WAF addition was Marinobacter, whose relative abundance increased from 2% to 42% after 4 wk (Fig. 1B). In contrast, in dispersant-only and CEWAF (± nutrients) treatments, Marinobacter comprised only 1–5% of all sequences. The correspondence analysis emphasized the dominance of Marinobacter in WAF samples (SI Appendix, Fig. S6) and the same Marinobacter oligotypes occurred across all treatments, illustrating that dispersants did not select for specific Marinobacter taxa, as was the case for Colwellia (SI Appendix, Fig. S3A). Marinobacter (SI Appendix, Fig. S10) degrade a wide variety of hydrocarbons, including pristane, hexadecane, octane, toluene, benzynes, and phenanthrene (30–32) and are likely dominant hydrocarbon degraders under natural conditions. However, their abundance clearly declined in the presence of dispersants. Whether

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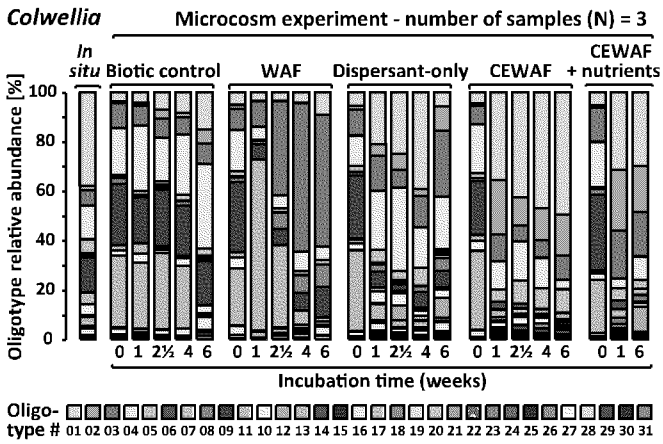

Fig. 2. Different microbial oligotypes respond to dispersants or oil (WAF). Oligotyping enabled the interpretation of 16S rRNA gene sequence diversity at the level of specific oligotypes. Relative abundance (averaged across biological triplicates) of Colwellia oligotypes in microcosms, simulating DWH spill-like plumes.

Colwellia outcompetes Marinobacter or whether Marinobacter is inhibited by some component of Corexit 9500 or the CEWAF remains to be resolved (SI Appendix).

Like Marinobacter, the abundance of Cycloclasticus increased primarily in the WAF treatments, where their relative abundance increased from 12% to 23% after 1 wk and an oligotype (type 03) closely related to Cycloclasticus pugetii (SI Appendix, Figs. S3B and S11), which degrades naphthalene, phenanthrene, anthracene, and toluene as sole carbon sources (33), increased substantially. Cycloclasticus also increased slightly in relative abundance in the CEWAF + nutrients treatment (Fig. 1B), but less so than in the WAF treatment.

Oceaniserpentilla (also known as DWH Oceanospirillum) (34) abundance decreased consistently across treatment, regardless of the presence or absence of WAF, dispersant, or CEWAF (± nutrients) (Fig. 1B and SI Appendix, Figs. S3C and S8). The observed oligotypes closely resembled those observed in situ during the DWH incident (18) (SI Appendix, Fig. S12). The DWH Oceanospirillum oxidize n-alkanes and cycloalkanes (17); cycloalkanes are absent in surrogate Macondo oil, possibly explaining the low abundance of Oceanospirillum in the microcosms.

Cell Growth and Exopolymer Formation. Initially, cell abundance was similar across treatments (3×10^5 cells·mL^{-1}; Fig. 1A). At the experiment's termination, microbial abundance in WAF treatments had increased by a factor of 60, which was significantly higher (T_4: $P < 0.0001$) than microbial abundance in CEWAF (± nutrients) treatments. Microbial abundance in dispersant-only treatments increased by a factor of 29, less than in WAF treatments but showing clear stimulation of growth by dispersant alone.

Marine oil snow, here defined as particles >0.5 mm in diameter, formed in WAF, dispersant-only, and CEWAF (± nutrients) microcosms, but differed in appearance, size, and abundance across treatments (SI Appendix). Microbial exopolymeric substances, including transparent exopolymer particles (TEP), are a matrix for marine snow formation (35). Oil-degrading bacteria produce TEP as biosurfactants (36). TEP production increased in the WAF microcosms relative to controls, underscoring the metabolic activities of oil-degrading bacteria (SI Appendix, Table S1). The abundance of TEP could not be quantified in dispersant treatments (SI Appendix) but extensive formation of oil snow was observed in the CEWAF + nutrients treatments (SI Appendix), inferring that TEP levels were likely elevated. The macroscopic particles observed in these experiments resembled marine oil snow observed in situ during the DWH oil spill (SI Appendix, Fig. S13 F and G). Catalyzed reporter deposition in combination with fluorescence in situ hybridization (CARD–FISH) revealed that Gammaproteobacteria and Alteromonadales, which includes the Colwellia, dominated microaggregate populations in CEWAF + nutrients treatments (SI Appendix, Fig. S13 P–R and SI Text). These findings suggest that Colwellia plays an important role in marine oil snow formation in the presence of dispersants.

Microbial Activity and Oil and Dispersant Degradation. Dispersant addition did not enhance bacterial oil degradation or microbial activity in general, as reflected in rates of hydrocarbon oxidation, bacterial protein production, and exoenzyme activities. Radiotracer assays allowed direct quantification of alkane ([1-^{14}C]-hexadecane) and polycyclic aromatic hydrocarbon (PAH) ([1-^{14}C]-naphthalene) oxidation rates across treatments (SI Appendix) (Fig. 3 A and B and SI Appendix). Hexadecane oxidation rates were significantly reduced (T_3 and T_4: $P = 0.004$) in dispersant-only and CEWAF (± nutrients) treatments (Fig. 3A), implying that dispersants suppressed hexadecane degradation. Similarly, naphthalene oxidation rates in the WAF treatments were higher than those in dispersant-only and CEWAF (± nutrients) treatments (T_3 and T_4: $P < 0.0001$), inferring that dispersants did not stimulate microbial naphthalene degradation (Fig. 3B). When substrate turnover constants instead of concentration-dependent rates were considered, inhibition of hexadecane turnover remained apparent, whereas naphthalene turnover was comparable between WAF and CEWAF treatments (SI Appendix, Fig. S14). Together, these data show a clear concentration-independent inhibition of hexadecane oxidation by dispersants and further show that dispersants did not stimulate naphthalene biodegradation rates.

To validate the patterns of rates in these deepwater samples in another Gulf habitat, we determined hydrocarbon turnover of hexadecane and naphthalene in highly oil-contaminated (SI Appendix) surface seawater samples with and without dispersant addition (dispersant to seawater dilution was 1:100,000 vol/vol). Application of the radiotracer assay demonstrated that hexadecane turnover was inhibited significantly by dispersant amendments and that naphthalene turnover was not stimulated (SI Appendix, Fig. S15). These findings mirror those observed in the deepwater microcosms and underscore their broad relevance.

Further, in the deepwater experiments, not only were rates of hydrocarbon oxidation highest in the WAF treatments, rates of bacterial protein synthesis and exoenzyme activities indicative of potential bacterial degradation rates of carbohydrate- and protein-rich exopolysaccharides (EPSs) were also maximal in WAF treatments (Fig. 3C and SI Appendix, Table S1). All enzyme assays exhibited up to one order of magnitude higher activities in the WAF and dispersant-only treatments compared with the CEWAF (± nutrients) treatments (Fig. 3 D–F and SI Appendix, Table S1), underscoring that dispersant-only and CEWAF (± nutrients) did not stimulate bacterial production (T_3 and T_4: $P < 0.001$) relative to the WAF treatments.

Results from gas chromatography-massspectrometry (GC-MS) and excitation/emission matrix spectra (EEMS) in deepwater samples further confirmed the patterns of hydrocarbon degradation across deepwater treatments. Concentrations of n-alkanes and hexadecane decreased more significantly in WAF treatments (SI Appendix, Fig. S16). In the WAF treatment, microorganisms preferentially degraded low molecular weight n-alkanes ($<C_{20}$) relative to high molecular weight ($\geq C_{21}$) compounds and the isoprenoids, pristane and phytane. In the dispersant treatments, this pattern was not observed (SI Appendix, Fig. S17). The temporal changes in n-alkane concentration (SI Appendix, Fig. S17) supported the rate data (SI Appendix, Table S1) and emphasized the fact that oil degradation was highest in WAF treatments and that addition of CEWAF, even in the presence of additional nutrients, did not generate higher overall hydrocarbon degradation rates.

Biodegradation of anionic surfactant DOSS to α/β-ethyhexylsulfosuccinate (EHSS) occurs under aerobic conditions (37). In the dispersant-only treatment, a significant ($P < 0.05$) decrease (8%) of DOSS and an increase of EHSS (15%) was observed at T_3 (SI Appendix, Fig. S18 A and B). The nonionic surfactants were

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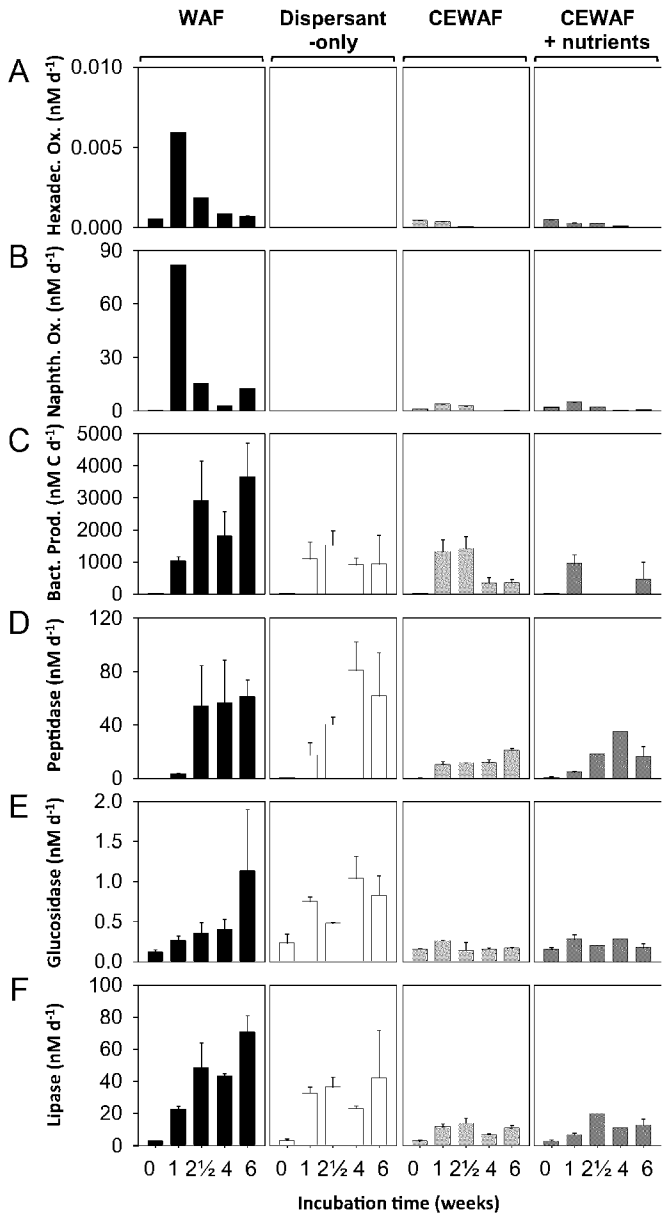

Fig. 3. Microbial activity, hydrocarbon oxidation and enzymatic activities are not enhanced by dispersed oil (CEWAF ± nutrients). (A and B) Oxidation rates of ^{14}C-hexadecane and ^{14}C-naphthalene as model compounds for alkanes and PAHs degradation, respectively (SI Appendix, Table S1C). Rates of bacterial production increased up to three orders of magnitude in the 2 wk between the first and second sampling point (SI Appendix, Table S1). (D–F) Potential activities of peptidase, glucosidase, and lipase measured using fluorogenic substrate analogs were up to one order of magnitude higher in the WAF and dispersant-only compared with the CEWAF ± nutrients treatments. All data are illustrated as average of biological triplicates and error bars show SD of the mean (note that a lack of error bars indicates SDs were too small to be shown on the plot scale).

consumed within 1 wk driving concentrations below detection (20 μg L^{-1}; SI Appendix, Fig. S18 C and D). In the CEWAF (± nutrients) treatments, DOSS decreased significantly ($P < 0.05$) after 6 wk (SI Appendix, Fig. S18A). No significant change in EHSS concentrations was observed in CEWAF (± nutrients) treatments (SI Appendix, Fig. S18B), indicating that DOSS was converted to other products, an observation supported by formation of sulfur-containing compounds detected by ultrahigh-resolution Fourier transform ion cyclotron resonance mass spectrometry (FT-ICR-MS) (38) (Fig. 4 D and E).

Molecular Characterization of Dissolved Organic Matter. High-resolution FT-ICR-MS analysis provides a much more robust way to assess the molecular diversity of hydrocarbons in oil than does conventional GC-MS analyses (39, 40). The FT-ICR-MS results further suggest that significantly more oil-derived dissolved organic molecules were degraded in the WAF compared with CEWAF (± nutrients) treatments, again leading to the conclusion that more extensive biodegradation occurred in the absence of dispersant (Fig. 4 and SI Appendix, Fig. S19). Between 50% and 74% of the degraded compounds were highly unsaturated molecular formulae containing only the elements C, H, and O (SI Appendix, Fig. S19 A and B), which include the common aromatic hydrocarbons abundant in Macondo crude oil (39).

Oil-derived nitrogen-containing dissolved organic matter (DOM) compounds also decreased during the incubations (between 26% and 43% of the decreasing formulae, Fig. 4 A and B), agreeing with previous studies reporting that crude oil (40), including Macondo oil (39), contains numerous biodegradable polar and water-soluble organic nitrogen compounds. The WAF treatments exhibited the highest rates of degradation of oil-derived nitrogen-containing compounds (~8% vs. ~1% in the CEWAF treatment, Fig. 4 A and D) (38). In the WAF treatments, protein synthesis rates significantly exceeded those in the dispersant-amended treatments (T_4: $P = 0.0002$), and a 31% decrease of seawater- and oil-derived dissolved organic nitrogen (DON) concentrations showed that the generation of microbial biomass required significant rates of nitrogen assimilation (SI Appendix, Table S1). The enhanced uptake of oil-derived organic nitrogen illustrates that oil can serve as an important nitrogen source when oil-degrading microbial communities are nitrogen limited (41).

Organic sulfur compounds are abundant in Macondo oil (39). The FT-ICR-MS results imply complex processing of sulfur-containing oil-derived and dispersant-derived DOM, including degradation of oil-derived sulfur compounds and formation of new organic sulfur compounds (Fig. 4 C–E). The FT-ICR-MS detected DOSS (molecular formula $C_{20}H_{38}O_7S$; see arrow in Fig. 4 D and E) in all dispersant-amended treatments after 6 wk of incubation. The formation of new organic sulfur-compounds was particularly pronounced in the CEWAF (± nutrients) samples (circled area in Fig. 4 D and E), signaling that their formation was stimulated by dispersant addition. Elevated relative abundances of Colwellia in post-DWH discharge seawater along with enhanced expression of genes involved in the degradation of sulfur-containing organic matter (e.g., alkanesulfonate monooxygenase) (42) infer a role for Colwellia in organic sulfur cycling in situ during the DWH incident. The genome of C. psychrerythraea strain 34H has a remarkable potential for sulfur metabolism (43). Thus, we hypothesize that Colwellia played an important role in the observed turnover of DOSS-derived sulfur compounds as a result of their capability to metabolize the organic sulfur compounds in dispersants; they may have exhibited similar metabolic abilities in situ during the DWH incident.

Factors Regulating Microbial Activity. To further unravel factors that regulate activity of key bacterial taxa, we determined statistically significant relationships between experimental conditions (geochemistry, cell counts, and microbial activity) and oligotype abundances. Distinct trends were apparent for Colwellia, Marinobacter, Oceaniserpentilla, and Cycloclasticus, as were correlations for specific oligotypes (SI Appendix, Table S2). Of the 24 detected Colwellia oligotypes, many correlated positively with concentrations of DOC (88%), ammonium (50%), cell counts (46%), and bacterial production (79%) as well as peptidase, glucosidase, and lipase (38–79%) activities. The majority of Colwellia oligotypes correlated negatively with concentration of total n-alkanes, hexadecane, naphthalene, and phenanthrene (71–79%), supporting the hypothesis that oligotypes of this taxon are predominantly responsible for dispersant breakdown. A considerable number of the 24 Marinobacter oligotypes correlated positively with cell counts (79%), bacterial production (79%), as well as peptidase and lipase (67–71%) activities. In contrast to Colwellia,

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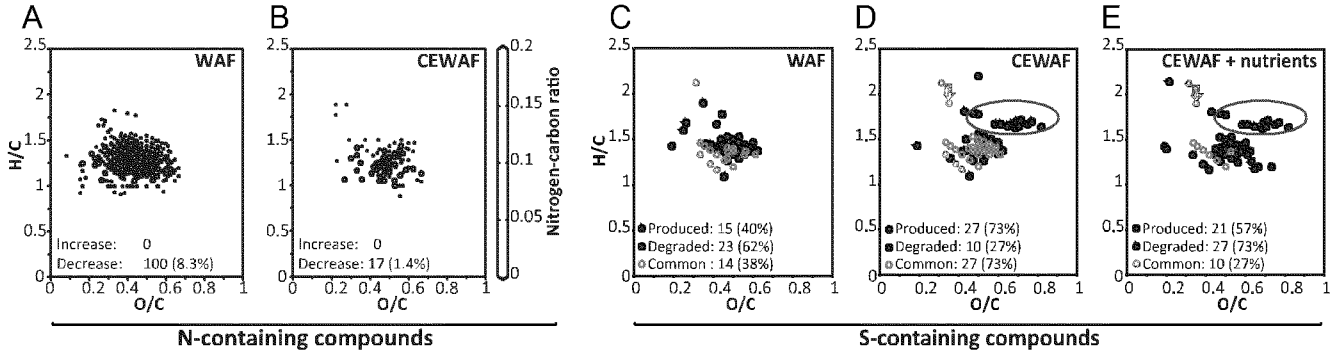

Fig. 4. Dispersants impact microbial turnover of dissolved organic matter. Analysis of molecular-level patterns in Van Krevelen diagrams (hydrogen-to-carbon, H/C, and oxygen-to-carbon, O/C ratios; each circle represents a molecular formula). (A and B) Van Krevelen diagrams showing nitrogen-containing formulae (color scale depicts N/C ratios; open circles, formula contained no nitrogen). (C–E) Van Krevelen diagrams presenting changes in the presence or absence of sulfur-containing compounds (red circles, produced compounds, i.e., absent at T_0 but present at T_4; blue circles, degraded compounds, i.e., absent at T_4 but present at T_0; open circles, common compounds present at T_0 and T_4). DOSS (molecular formula $C_{20}H_{38}O_7S$, marked by arrow) was present at T_0 and T_4. Several sulfur-containing compounds were exclusively produced in the dispersant-amended treatments (molecular formulae marked by an ellipse).

Marinobacter oligotypes correlated positively to total petroleum concentrations (83%) and hexadecane oxidation (71%), highlighting a key role for these microorganisms in hexadecane degradation in the absence of dispersants. Oceaniserpentilla and Cycloclasticus oligotypes (30 and 31 types, respectively) correlated positively with nitrate and total n-alkanes, hexadecane, naphthalene, and phenanthrene (71–80%) concentrations. In addition, Cycloclasticus abundance positively correlated with naphthalene oxidation (61%), supporting their involvement in PAH degradation.

Evaluating the Utility of Dispersants. Dispersants are used regularly as a response action after oil spills to disperse oil slicks, enhance the relative oil surface area in water, and to stimulate microbial hydrocarbon degradation. During the DWH incident, the deep-sea application of dispersants was unprecedented. Prior studies about microbial dispersant impacts generated confounding results (for review see ref. 25) most likely because nonspecific metrics were used, e.g., microbial cell counts or the production of CO_2. Though changes in these two metrics reflect changes in microbial growth or activity, they do not specifically signify changes in hydrocarbon degradation rates. Further, it is quite possible that microorganisms stimulated by dispersant addition may outcompete natural hydrocarbon degraders. Thus, a direct quantification of hydrocarbon oxidation, accomplished here by direct determination of hydrocarbon oxidation using radiotracer assays in tandem with hydrocarbon quantification by GC-MS, is necessary to elucidate the impacts of dispersants on microbial populations and activities. The data obtained do not support dispersant stimulation of oil biodegradation, questioning the utility of dispersant application to pelagic ocean ecosystems.

Dispersant impacts on pelagic environments that are not impacted by natural oil seepage remain largely unknown. However, it seems unlikely that dispersants would stimulate hydrocarbon degradation in a system that lacks a substantial population of hydrocarbon degraders when they had no stimulatory effect in samples from a system that was primed for oil degradation (e.g., oil degraders account for 7–10% of the natural microbial population at site GC600) (18). In fact, the presence of dispersant selected against the most effective hydrocarbon degrading microorganisms (i.e., Marinobacter). This multidisciplinary data set strongly suggests that dispersants did not stimulate microbial hydrocarbon-degradation rates, as maximal oil-degradation rates were observed in the WAF treatments. Though we quantified degradation rates of only two hydrocarbons, hexadecane and naphthalene, biodegradation of other n-alkanes and PAHs could be similarly affected by dispersants. Quantification of the total crude oil also showed that the highest levels of oil biodegradation occurred in treatments without dispersants.

Whereas microbial activities in CEWAF (± nutrients) microcosms were comparable for 1 wk, rates were stimulated by nutrients in the later time points (e.g., CEWAF + nutrient hydrocarbon oxidation rates after 4 and 6 wk), suggesting progressive nutrient limitation. Clearly, the Gulf's deepwater microbial community is able to degrade oil efficiently in the absence of dispersant. Therefore, caution is advised when considering dispersant applications as a primary response for future oil spills in deepwater environments similar to the Gulf. A full understanding of dispersant impacts on microbial populations requires immediate and careful evaluation of dispersant impacts across a variety of habitats.

Materials and Methods

Microcosm Setup and Sampling. Seawater (160 L) was sampled from 1,178 m at an active natural hydrocarbon seep in the northern Gulf on March 7, 2013 (site GC600, latitude 27.3614, longitude −90.6018; SI Appendix, Fig. S1). After sampling, seawater was transferred to 20 L carboys and stored at 4 °C onboard the ship for 3 d. The carboys were transported at 4 °C to the laboratory at University of Georgia where the experiment and sampling were conducted in an 8 °C cold room. Setup and sampling of microcosms are described in detail in SI Appendix, SI Materials and Methods. In brief, 72 2-L glass bottles (1.8-L sample per bottle) were incubated on a roller table (SI Appendix, Fig. S2). Treatments (WAF, dispersant-only, and CEWAF ± nutrients) and controls (abiotic and biotic) were run in triplicate for each time point. Sampling (except for the CEWAF + nutrients treatment) was performed after 0 d (T_0), 1 wk (T_1), 2.5 wk (16 d; T_2), 4 wk (T_3), and 6 wk (T_4); CEWAF + nutrients treatments were sampled at T_0, T_1, and T_4. CEWAFs were prepared by mixing pasteurized seawater with oil and/or dispersants for 48 h at room temperature and subsequently subsampling CEWAFs, excluding contamination by oil or dispersants phases (SI Appendix). In addition, hydrocarbon turnover was determined in oil-contaminated surface seawater samples obtained along a transect from the Taylor Energy oil platform to the Mississippi River plume. Oil-contaminated surface seawater samples were used directly (untreated samples) or amended with dispersants (SI Appendix). Hydrocarbon turnover was analyzed using the newly adapted radiotracer assays (SI Appendix).

Molecular, Microbiological, and Geochemical Analyses. Nutrients (nitrate, nitrite, phosphate, and ammonium), dissolved inorganic carbon, and oxygen as well as hydrocarbons (44) and dispersant concentrations were monitored during the course of the experiment (SI Appendix). Microbial community evolution and cell numbers were investigated for each sample using 16S rRNA amplicon Illumina sequencing (Bioproject accession PRJNA253405), computational oligotyping analysis (28), and total cell counts (SI Appendix). Activity measurements were performed using enzyme assays (peptidase, glucosidase, lipase) (45), ^{3}H-leucine incorporation analysis (46), as well as the newly developed method for the analysis of ^{14}C-hexadecane and ^{14}C-naphthalene oxidation (SI Appendix). TEP analyses were carried out for controls and oil-only treatments (47) and CARD–FISH analysis (48) were performed in particular for microbial-aggregate formations in nutrient treatments (SI Appendix). Oil-derived hydrocarbons were extracted from water samples using a mixture of

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hexane:dichloromethane (1:1, vol/vol). After concentration, hydrocarbon compounds were identified and quantified by GC/MSD using conditions described previously (49) (SI Appendix). Analysis of the surfactant components of the dispersant Corexit was performed by LC-MS/MS as described elsewhere (13), with minor modification (SI Appendix). FT-ICR-MS was carried out to analyze DOM (50) (SI Appendix). Statistical analyses were used to unravel factors that drive microbial community evolution and microbial activities (SI Appendix).

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Sent: Wed 11/25/2015 7:28:46 PM
Subject: State-of-Science: Public Health and Food Security follow-up and REPLY
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Wickcliffe response.pdf
2015.11.23_Public Health and Food Security.docx
Suggestions from John French_new concerns and references.docx

As follow-up to our call on 11/23, please find information below and attached:

•□□□□□□□ Here is the link for the Federal Registry for "Guidelines for Ensuring and Maximizing the Quality, Objectivity, Utility, and Integrity of Information Disseminated" https://www.whitehouse.gov/sites/default/files/omb/fedreg/reproducible2.pdf

•□□□□□□□ Attached are: D'Andrea paper 2013 ("Health Consequences among Subjects Involved in Gulf Oil Spill Clean-up Activities") and 2014 ("Health Risks Associated with Crude Oil Spill Exposure"); Two responses from Piacentino and Wickliffe; and the author's reply to these 2 comments.

•□□□□□□□ I am also attaching once again the latest draft of our document, along with the proposed wording & resources from John French.

And here is a doodle poll to select our next meeting>> http://doodle.com/poll/59ctafsri9zzgvzm Please fill out by Monday 11/30 for these potential December meeting dates. The doodle poll is time zone enabled for your convenience.

Kathy Mandsager

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CLINICAL RESEARCH STUDY

THE AMERICAN JOURNAL of MEDICINE

Health Consequences among Subjects Involved in Gulf Oil Spill Clean-up Activities

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ABSTRACT

BACKGROUND: Oil spills are known to affect human health through the exposure of inherent hazardous chemicals such as para-phenols and volatile benzene. This study assessed the adverse health effects of the Gulf oil spill exposure in subjects participating in the clean-up activity along the coast of Louisiana.
METHODS: This retrospective study included subjects that had been exposed and unexposed to the oil spill and dispersant. Using medical charts, clinical data including white blood cell count, platelets count, hemoglobin, hematocrit, blood urea nitrogen, creatinine, alkaline phosphatase (ALP), aspartate amino transferase (AST), alanine amino transferase (ALT), and somatic symptom complaints by the subjects were reviewed and analyzed.
RESULTS: A total of 247 subjects (oil spill exposed, n ¼ 117 and unexposed, n ¼ 130) were included. Hematologic analysis showed that platelet counts (┐ 10^3 per mL) were significantly decreased in the exposed group compared with those in the group unexposed to the oil spill (252.1 └ 51.8 vs 269.6 └ 77.3, P ¼ .024). Conversely, the hemoglobin (g per dL) and hematocrit (%) levels were significantly increased among oil spill-exposed subjects compared with the unexposed subjects (P ¼ .000). Similarly, oil spill-exposed subjects had significantly higher levels of ALP (76.3 └ 21.3 vs 61.2 └ 26.9 IU/L, P ¼ .000), AST (31.0 └ 26.3 vs 22.8 └ 11.8 IU/L, P ¼ .004), and ALT (34.8 └ 26.6 vs 29.8 └ 27 IU/L, P ¼ .054) compared with the unexposed subjects.
CONCLUSION: The results of this study indicate that clean-up workers exposed to the oil spill and dispersant experienced significantly altered blood profiles, liver enzymes, and somatic symptoms.
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KEYWORDS: Blood disorders; Chemical exposure; Crude oil spill; Dispersants; Health impact; Hematological toxicity; Hepatotoxicity; Somatic symptoms; Urinary phenol

Crude oil spills affect human health through exposure to inherent hazardous chemicals including para-phenols and volatile benzene.[1-3] The major health consequences of crude oil spill exposure include the abnormalities in hematologic, hepatic, respiratory, renal, and neurologic functions.[4,5] In addition, subjects exposed to oil spills often experience frequent asthmatic attacks, headache, diarrhea, dizziness, abdominal pain, back pain, and other symptoms.[4,6-9]

On April 20, 2010, the British Petroleum (BP) Deepwater Horizon offshore drilling rig located 50 miles off the Louisiana coast exploded and sank in the Gulf of Mexico (Figure 1).[5,10] Consequently over 200 million gallons of oil poured into the Gulf of Mexico,[11] thereby contaminating the Gulf coast. During the height of this disaster, BP used nearly 2 million gallons of dispersants such as COREXIT[12] (Nalco Energy Services, L.P., Sugar Land, Tex) to break down the oil slick.[11] This oil spill and use of massive amounts of dispersant has the potential to affect human health. It is estimated that up to 170,000 people worked in some capacity to clean up the Gulf oil spill.[13]

Previously, several studies have evaluated the health impact of other oil spills.[5,6,10,14-16] These studies primarily focused on physical effects and psychological sequelae. In addition, these studies point to potential adverse effects among oil spill clean-up workers. Earlier studies reported that benzene exposure is associated with hematological toxicity and increased cancer risk.[17-22] While such rare adverse outcomes may take years to develop, immediate health effects of

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oil spill exposure may be seen in hematological and hepatic parameters, indicating its toxic effects and potential for future health risk.[23]

To investigate the adverse health effects of the oil spill in the Gulf of Mexico, a retrospective analysis was performed on subjects participating in the oil spill clean-up activity along the coast of Louisiana. Specifically, we assessed the hematologic and hepatic markers in a cohort of oil spill clean-up workers, and the clinical findings were compared with the unexposed (control) subjects.

CLINICAL SIGNIFICANCE

- Human exposure to oil spill and dispersant use has a potential to alter both hematological and hepatic profiles.
- The hematological and hepatic alterations include decreased platelets and BUN, and increased creatinine, serum levels of ALP, AST, and ALT.
- The most reported somatic symptoms are headache, shortness of breath, skin rash, cough, fatigue, painful joints, and chest pain.

MATERIALS AND METHODS

Subjects

This study was approved by an Institutional Review Board. Using medical charts, demographic and clinical data were reviewed for the subjects who underwent clinical and laboratory evaluation between January 2010 and November 2012. The study was conducted according to the principles of the Declaration of Helsinki. The personal information of the subjects was redacted to maintain confidentiality.

Subjects included in this study were referred to the clinic for medical evaluation by the subjects' legal representatives. Written consent was obtained from the subjects' legal representatives. The subjects exposed to the oil spill and dispersant were identified as participants in the oil spill clean-up activities along the coast of Louisiana for a duration of over 3 months.

The unexposed subjects were living geographically at least 100 miles away from the Gulf coast of Louisiana. The unexposed subjects had visited the clinic for a routine wellness check-up. The subjects were selected randomly for the study by their primary care physicians.

Chart Review and Evaluation

Medical charts of exposed and unexposed subjects were reviewed by expert physicians and the data were processed for statistical analysis. Clinical data such as white blood cell (WBC) counts, platelet counts, hemoglobin, hematocrit, blood urea nitrogen (BUN), creatinine, serum beta-2-microglobulin, alkaline phosphatase (ALP), aspartate amino transferase (AST), and alanine amino transferase (ALT) levels were evaluated. Data on urinary phenol also was assessed as a benzene metabolite in oil spill-exposed subjects. Additionally, data on somatic symptoms were collected from the oil spill-exposed subjects and analyzed.

Statistics

Descriptive statistics were used to assess patient demographics and included means and standard deviations for each group. Variables included were WBC, platelets, hemoglobin, hematocrit, creatinine, BUN, ALP, AST, ALT, beta-2 microglobulin, and urinary phenol. Student's t test was used to assess the differences between exposed and unexposed groups. The significance level was predetermined at an alpha level of .05.

RESULTS

This study included a total of 247 subjects, 117 of which were involved in the clean-up activity of the oil spill. The outcomes of the oil spill-exposed subjects were evaluated and compared with the unexposed subjects (n ¼ 130). The subjects' demographics are shown in Table 1. Among the oil spill-exposed subjects (n ¼ 117), there were 104 (89%) males and 13 (11%) females. The median age of exposed and unexposed subjects was 34.0 (18-63) and 51.0 (15-90) years, respectively. The demographic characteristics such as sex and age groups differed significantly between the exposed and unexposed groups (P ¼ .000).

The data in Table 2 represents the differences in hematologic and hepatic markers between the subjects exposed to the oil spill and those unexposed. No significant differences were observed in the WBC count (¬ 10^3 per mL) among those exposed to the oil spill and those unexposed (6.9 └ 1.9 vs 6.5 └ 1.9, P ¼ .11). However, the platelet count (¬ 10^3 per mL) in subjects exposed to the oil spill was significantly decreased compared with the unexposed subjects (252.1 └ 51.8 vs 269.6 └ 77.3, P ¼ .024).

The hemoglobin (g per dL) levels were significantly increased among oil spill-exposed subjects compared with the unexposed subjects (14.9 └ 1.3 vs 13.6 └ 1.6, P ¼ .000). The hematocrit levels were significantly elevated in oil spill-exposed subjects compared with the unexposed subjects (44.6 └ 3.4 vs 40.8 └ 5.0, P ¼ .000). Similarly, serum creatinine levels (mg/dL) also were significantly higher in the oil spill-exposed subjects compared with the unexposed subjects (1.0 └ 0.2 vs 0.9 └ 0.3, P ¼ .000). Conversely, the BUN (mg/dL) significantly decreased in the oil spill-exposed subjects compared with the unexposed subjects (13.4 └ 3.4 vs 15.4 └ 7.1, P ¼ .014).

Compared with the unexposed subjects, subjects exposed to the oil spill showed significantly elevated levels of ALP (76.3 └ 21.3 vs 61.2 └ 26.9 IU/L, P ¼ .000). The AST (IU/L) levels were significantly higher in the oil spill-exposed subjects compared with the unexposed subjects (31.0 └ 26.3 vs 22.8 └ 11.8, P ¼ .004). Similarly, the ALT (IU/L) levels were marginally but significantly increased in the oil spill-exposed group compared with the unexposed group (34.8 └ 26.6 vs 29.8 └ 27, P ¼ .054).

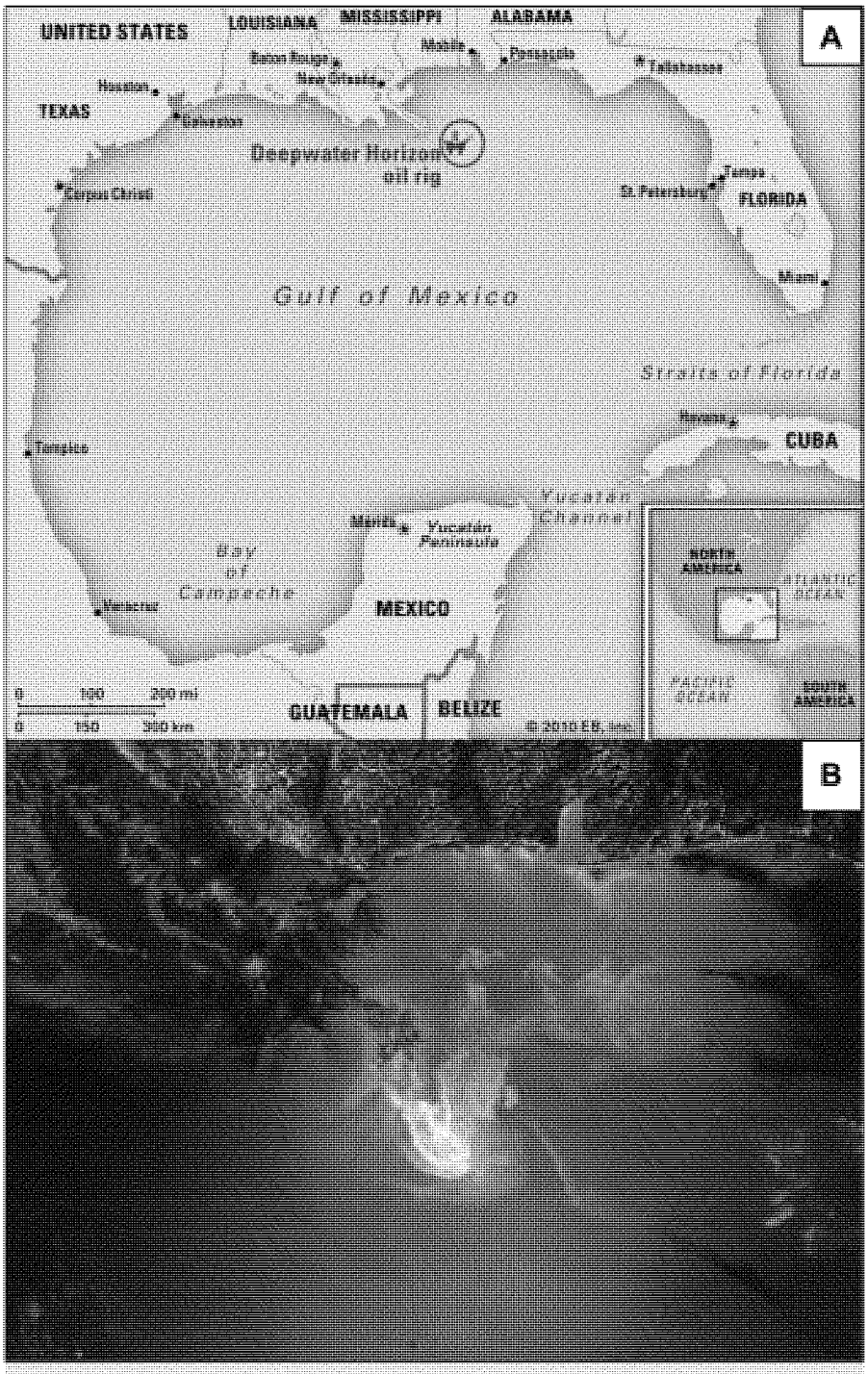

Figure 1 The Deepwater Horizon oil drilling rig. (A) The location of the Deepwater Horizon oil rig explosion in the Gulf of Mexico, 50 miles off the Louisiana coast (Source: http://www.britannica.com/blogs/2011/04/deepwater-horizon-oil-spill-year-picture-essay-day/ By courtesy of Encyclopedia Britannica, Inc., Copyright 2010; used with permission). (B) Satellite view of the Deepwater Horizon oil spill slick by the US National Aeronautics and Space Administration in the Gulf of Mexico (Source: http://www.nasa.gov/topics/earth/features/oilspill/index.html. Accessed January 15, 2013).

The results in Table 3 show the differences in hematologic and hepatic markers between exposed and unexposed subjects according to their age group. Specifically, subjects were grouped into <40-year and ≥ 40-year age groups, and clinical outcomes were compared. No differences were noted in the WBC count (≥ 10^3 per mL) between unexposed and exposed subjects in the <40-year age group; however, the WBC counts (≥ 10^3 per mL) were significantly higher in

Table 1 Demographics and Other Characteristics of the Subjects Included in the Study

Demographics	Unexposed	Exposed	P Value
Total subjects	130 (100%)	117 (100%)	-
Sex			.000*
Male	43 (33%)	104 (89%)	
Female	87 (67%)	13 (11%)	
Age, years			.000*
Mean	49.8	35.8	
Median	51	34	
Range	15-90	18-63	
Age group, years			.000*
<20	4 (3%)	0 (0%)	
20-<30	13 (10%)	31 (27%)	
30-<40	12 (9%)	42 (36%)	
40-<50	28 (22%)	35 (30%)	
50-<60	41 (32%)	8 (7%)	
60-<70	20 (15%)	1 (1%)	
70	12 (9%)	0 (0%)	

*Statistically significant at P ¼ .001.

oil spill-exposed subjects compared with the unexposed subjects in the 40-year age group (7.5 2.0 vs 6.5 1.9, P ¼ .007). Similarly, the platelet counts (10^3 per mL) were significantly higher in oil spill-exposed subjects compared with the unexposed subjects in the – 40-year age group (283.6 67.3 vs 251.8 51.7, P ¼ .006). However, no differences were noted in the platelet counts between exposed and unexposed subjects in the <40-year age group. Hemoglobin (g per dL) and creatinine (mg per dL) were increased significantly in oil spill-exposed subjects compared with the unexposed subjects, irrespective of age groups. Similarly, the serum levels of hepatic enzymes (ALP, AST, and ALT) were increased significantly in oil spill-exposed subjects compared with those unexposed subjects, irrespective of age groups (Table 3).

Table 2 Comparison of Hematologic and Hepatic Indices between the Unexposed and Exposed Subjects to Oil Spill

Variable	Unexposed (n ¼ 130)	Exposed (n ¼ 117)	P Value
WBC (10^3 per mL)	6.5 1.9	6.9 1.9	.108†
Platelets (10^3 per mL)	269.6 77.3	252.1 51.8	.024*
Hemoglobin (g per dL)	13.6 1.6	14.9 1.3	.000**
Hematocrit (%)	40.8 5.0	44.6 3.4	.000**
BUN (mg per dL)	15.4 7.1	13.4 3.4	.014*
Creatinine (mg per dL)	0.9 0.3	1.0 0.2	.000**
ALP (IU per L)	61.2 26.9	76.3 21.3	.000**
AST (IU per L)	22.8 15.1	31.0 26.3	.004**
ALT (IU per L)	29.8 27.0	34.8 26.6	.054*

ALP ¼ alkaline phosphatase; ALT ¼ alanine amino transferase; AST ¼ aspartate amino transferase; BUN ¼ blood urea nitrogen; WBC ¼ white blood cells.

*P ¼ 0.05.

**P ¼ 0.001.

†Did not reach statistical significance.

The results in Table 4 indicate the differences in hematologic and hepatic markers between the unexposed subjects and those exposed to the oil spill according to sex. No differences were noted in WBC counts (10^3 per mL) between unexposed and exposed male subjects; however, female subjects in the oil spill-exposed group had significantly elevated WBC counts (10^3 per mL) compared with the unexposed group (7.5 2.2 vs 6.4 1.7, P ¼ .022). No significant differences were detected by gender in the platelet counts between the unexposed and exposed subjects to the oil spill. Males in the oil spill-exposed group had significantly higher hemoglobin (15.1 1.5 vs 14.6 1.3 g/dL, P ¼ .022) and hematocrit (45.1 3.2 vs 42.9 5.4%, P ¼ .000) levels compared with the males in the unexposed group. BUN (mg per dL) was significantly decreased in males in the oil spill-exposed group compared with those in the unexposed group (13.4 3.4 vs 17.7 9.3, P ¼ .000).

The serum ALP levels (IU/L) were significantly elevated in male (76.9 21.0 vs 64.3 18.0, P ¼ .018) and female (71.3 23.1 vs 62.2 16.1, P ¼ .048) subjects in the oil spill-exposed group compared with the unexposed group. Similarly, the serum levels of AST and ALT (IU/L) were significantly elevated in both male and female subjects in the oil spill-exposed group compared with the unexposed group (Table 4).

The results in Table 5 represent the hematologic and hepatic changes according to the age group in oil spill-exposed subjects. The WBC (10^3 per mL) counts were significantly lower in the 20-29-year age group compared with the 30-39-year (6.2 1.6 vs 6.8 1.8, P ¼ .02) or over-40-year age group (6.2 1.6 vs 7.5 2.0, P ¼ .001). The WBC (10^3 per mL) counts were significantly lower in the 30-39-year age group compared with the over-40-year age group (6.8 1.8 vs 7.5 2.0, P ¼ .08). Although no differences were seen in beta-2-microglobulin (mg/L) levels between the 20-29-year and 30-39-year age groups, the 20-29-year age group had significantly lower levels of beta-2-microglobulin compared with the over-40-year age group (1.3 0.4 vs 1.4 0.3, P ¼ .02). Similarly, the 30-39-year age group had significantly lower levels of beta-2-microglobulin compared with the over-40-year age group (1.3 0.4 vs 1.4 0.3, P ¼ .05).

The principal somatic symptoms complained about by the oil spill clean-up workers are illustrated in Figure 2. Headache (77%) was the most frequently reported symptom, followed by shortness of breath (71%), skin rash (59%), cough (51%), dizzy spells (51%), fatigue (50%), painful joints (49%), night sweats (41%), and chest pain (38%).

The findings presented in Table 6 reveal the occurrence of somatic symptoms by sex among oil clean-up workers. Males had a lower frequency of headaches compared with females following exposure to the oil spill (75% vs 92%). Similarly, males experienced a lower frequency of painful joints (46% vs 69%), night sweats (38% vs 62%), ringing in the ears (32% vs 69%), fatigue (48% vs 62%), memory loss (20% vs 46%), and diarrhea (26% vs 38%) compared with

Table 3 Comparison of Hematologic and Hepatic Indices by Age Group between Subjects Unexposed and Exposed to the Oil Spill

Variable	Age Group	Unexposed‡	Exposed§	P Value
WBC (┐ 10^3 per mL)	<40 years	6.5 └ 1.9	6.6 └ 1.7	.461†
	│ 40 years	6.5 └ 1.9	7.5 └ 2.0	.007**
Platelets (┐ 10^3 per mL)	<40 years	283.6 └ 67.3	251.8 └ 51.7	.006**
	│ 40 years	249.5 └ 60.7	252.5 └ 52.4	.134†
Hemoglobin (g per dL)	<40 years	13.7 └ 1.8	14.9 └ 1.3	.000**
	– 40 years	13.6 └ 1.6	14.9 └ 1.4	.000**
Hematocrit (%)	│ 40 years	40.2 └ 5.9	44.7 └ 3.4	.000**
	│ 40 years	41.0 └ 4.8	44.4 └ 3.4	.000**
BUN (mg per dL)	<40 years	12.1 └ 3.8	13.6 └ 3.3	.039*
	│ 40 years	15.7 └ 5.6	14.5 └ 2.8	.389†
Creatinine (mg per dL)	<40 years	0.8 └ 0.2	1.1 └ 0.2	.000**
	│ 40 years	0.9 └ 0.3	1.0 └ 0.2	.044*
ALP (IU per L)	<40 years	65.0 └ 21.7	74.9 └ 20.9	.026*
	│ 40 years	67.5 └ 20.2	78.6 └ 22.0	.001**
AST (IU per L)	<40 years	20.9 └ 6.2	31.6 └ 9.0	.050*
	│ 40 years	23.5 └ 4.7	30.0 └ 5.8	.048*
ALT (IU per L)	<40 years	22.9 └ 12.5	33.8 └ 22.9	.050*
	│ 40 years	26.0 └ 13.8	40.1 └ 20.7	.054*

ALP ¼ alkaline phosphatase; ALT ¼ alanine amino transferase; AST ¼ aspartate amino transferase; BUN ¼ blood urea nitrogen; WBC ¼ white blood cells.
*P ¼ 0.05.
**P ¼ 0.001.
†Did not reach statistical significance.
‡Unexposed <40 years: n ¼ 28; unexposed │ 40 years: n ¼ 102.
§Exposed <40 years: n ¼ 73; exposed │ 40 years: n ¼ 44.

females, after exposure to the oil spill. Conversely, compared with females, males had a higher frequency of skin rash (61% vs 46%), chronic cough (55% vs 23%), and poor appetite (26% vs 8%).

The findings in Table 7 reveal the frequency of somatic symptoms according to the age group among oil spill clean-up workers. Subjects in the age group of 20-29 years reported higher frequency of painful joints compared with

Table 4 Comparison of Hematologic and Hepatic Indices by Sex between Unexposed and Exposed Subjects to Oil Spill

Variable	Sex	Unexposed‡	Exposed§	P Value
WBC (┐ 10^3 per mL)	Male	6.7 └ 2.2	6.8 └ 1.8	.343†
	Female	6.4 └ 1.7	7.5 └ 2.2	.022*
Platelets (┐ 10^3 per mL)	Male	234.6 └ 71.5	248.7 └ 52.0	.094†
	Female	287.0 └ 74.5	278.7 └ 42.5	.348†
Hemoglobin (g per dL)	Male	14.6└ 1.5	15.1 └ 1.3	.022*
	Female	13.1 └ 1.5	13.3 └ 0.9	.331†
Hematocrit (%)	Male	42.9 └ 5.4	45.1 └ 3.2	.000**
	Female	39.8 └ 4.5	40.5 └ 2.3	.293†
BUN (mg per dL)	Male	17.7 └ 9.3	13.4 └ 3.4	.000**
	Female	14.1 └ 5.1	13.0 └ 3.6	.228†
Creatinine (mg per dL)	Male	1.1 └ 0.3	1.1 └ 0.2	.381†
	Female	0.8 └ 0.2	0.8 └ 0.2	.202†
ALP (IU per L)	Male	64.3 └ 18.0	76.9 └ 21.0	.018*
	Female	62.2 └ 16.1	71.3 └ 23.1	.048*
AST (IU per L)	Male	21.6 └ 6.8	32.7 └ 7.5	.051*
	Female	18.6 └ 7.3	20.7 └ 5.0	.046*
ALT (IU per L)	Male	27.4 └ 13.5	38.2 └ 27.0	.054*
	Female	17.6 └ 12.0	26.1 └ 24.6	.039*

ALP ¼ alkaline phosphatase; ALT ¼ alanine amino transferase; AST ¼ aspartate amino transferase; BUN ¼ blood urea nitrogen; WBC ¼ white blood cells.
*P ¼ 0.05.
**P ¼ 0.001.
†Did not reach statistical significance.
‡Male unexposed: n ¼ 43; female unexposed: n ¼ 87.
§Male exposed: n ¼ 104; female exposed: n ¼ 13.

Table 5 Hematologic and Hepatic Changes by Age Group among Oil Spill Clean-up Workers

Variable	Age Group 20-29 Years (n ¼ 31)	Age Group 30-39 Years (n ¼ 42)	Age Over 40 Years (n ¼ 44)	P Value‡	P Value§	P Value¶
WBC (¬ 10^3 per mL)	6.2 └ 1.6	6.8 └ 1.8	7.5 └ 2.0	.02*	.001**	.08†
Hemoglobin (g per dL)	15.0 └ 1.3	14.8 └ 1.3	14.9 └ 1.4	.5†	.3†	.3†
Hematocrit (%)	45.0 └ 3.5	44.4 └ 3.3	44.4 └ 3.4	.5†	.2†	.5†
Platelets (¬ 10^3 per mL)	245.2 └ 50.1	256.6 └ 55.8	252.5 └ 52.9	.1†	.3†	.4†
BUN (mg per dL)	13.1 └ 3.2	13.4 └ 3.7	13.7 └ 3.3	.1†	.2†	.5†
Creatinine (mg per dL)	1.0 └ 0.2	1.1 └ 0.2	0.97 └ 0.2	.03*	.2†	.00**
b-2-microglobulin (mg per L)	76.1 └ 21.4	74.1 └ 20.5	78.6 └ 22.1	.3†	.3†	.1†
ALP (IU per L)	29.1 └ 29.0	33.4 └ 31	30.0 └ 21.4	.4†	.4†	.4†
AST (IU per L)	32.7 └ 32.1	34.5 └ 18.5	37.6 └ 29.9	.5†	.3†	.2†
ALT (IU per L)	1.3 └ 0.3	1.3 └ 0.4	1.4 └ 0.3	.5†	.02*	.05*
Urinary Phenol (mg per L)	8.7 └ 9.5	7.6 └ 9.9	5.3 └ 5.9	.47†	.03*	.09†

ALP ¼ alkaline phosphatase; ALT ¼ alanine amino transferase; AST ¼ aspartate amino transferase; BUN ¼ blood urea nitrogen; WBC ¼ white blood cells.
*P ¼ 0.05.
**P ¼ 0.001.
†Did not reach statistical significance.
‡Differences between age group of 20-29 years and 30-39 years.
§Differences between age group of 20-29 years and │40 years.
¶Differences between age group of 30-39 years and │40 years.

those in the 30-39-year or over-40-year age groups (65% vs 38% vs 48%). Similarly, the frequency of night sweats was higher in the 20-29-year age group compared with those in the 30-39-year or over-40-year age groups (52% vs 36% vs 39%). Conversely, subjects in the age group of 20-29 years reported the lowest frequency of chronic cough compared with those in the 30-39-year or over-40-year age groups (39% vs 52% vs 59%). The occurrence of other symptoms appeared to be similar among the 3 age groups.

DISCUSSION

Despite numerous oil spills that have affected the coastal populations, there have been very few studies that evaluated the health effects of these oil spills. Therefore, in this retrospective study we evaluated the health effects of the Deepwater Horizon oil spill and dispersant use in a cohort of oil spill clean-up workers. To our knowledge, no previous study has explored the effects of the oil spill specifically assessing the hematological and hepatic functions in oil spill clean-up workers.

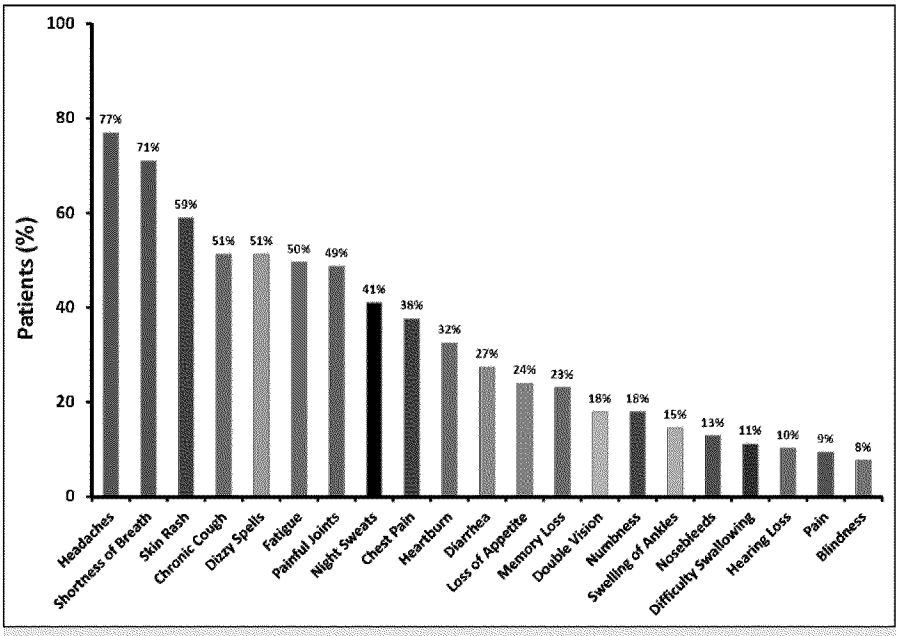

Figure 2 Major somatic symptoms experienced by the oil spill clean-up workers following exposure to oil spill and dispersant.

Table 6 Frequency of Somatic Symptoms by Sex among Oil Spill Clean-up Workers

Variable	Male (n ¼ 104)	Female (n ¼ 13)
Headaches	78 (75%)	12 (92%)
Shortness of breath	74 (71%)	9 (69%)
Skin rash	63 (61%)	6 (46%)
Chronic cough	57 (55%)	3 (23%)
Fatigue	50 (48%)	8 (62%)
Painful joints	48 (46%)	9 (69%)
Chest pain	40 (38%)	4 (31%)
Night sweats	40 (38%)	8 (62%)
Heartburn	33 (32%)	5 (38%)
Ringing in ears	33 (32%)	9 (69%)
Diarrhea	27 (26%)	5 (38%)
Poor appetite	27 (26%)	1 (8%)
Memory loss	21 (20%)	6 (46%)

The results of this study indicate that oil spill exposure appears to play a role in the development of hematologic and hepatic toxicity. While WBC levels remained similar, platelet levels were significantly decreased in oil spill-exposed subjects compared with the unexposed subjects. Similarly, the BUN and creatinine levels were significantly decreased in oil spill-exposed subjects compared with the unexposed subjects. Conversely, the hemoglobin and hematocrit levels were significantly increased among oil spill-exposed subjects compared with the unexposed subjects. Although the oil spill-exposed subjects had significant differences in various hematological and hepatic indices, our results indicate that exposure to the oil spill did not uniformly affect subjects who participated in oil spill clean-up activities.

The levels of ALP, AST, and ALT were increased among subjects exposed to the oil spill compared with those of the unexposed subjects. These serum enzyme levels have been considered indicators of hepatic damage. Phosphatases, amino transferases, and dehydrogenases play critical roles in biological processes. Specifically, these enzymes are involved in detoxification, metabolism, and biosynthesis of energetic macromolecules that are important for different essential functions. Alterations in the levels of these enzymes result in biochemical impairment and lesions in the tissue and cellular function. Thus, these enzymes are considered as specific markers for hepatic dysfunction and damage.[24] Similar increased levels of these enzymes have been reported in clinical and preclinical studies after benzene exposure.[25-27] The increase in the levels of these hepatic enzymes in the serum may be due to impairment in the function of hepatic tissues following exposure to toxic chemicals from an oil spill, such as benzene, thereby allowing liberation of these enzymes into the circulation. Furthermore, the serum ALP is often used as a marker to measure hepatic and biliary tract function.[28,29] The increase in the serum levels of ALP observed in this study suggest the possibility of biliary tract dysfunction in oil spill-exposed subjects.

Table 7 Frequency of Somatic Symptoms by Age Group among Oil Spill Clean-up Workers

Symptoms	Age Group 20-29 Years (n ¼ 31)	Age Group 30-39 Years (n ¼ 42)	Age Over 40 Years (n ¼ 44)
Headaches	25 (81%)	33 (79%)	32 (73%)
Painful joints	20 (65%)	16 (38%)	21 (48%)
Skin rash	19 (61%)	23 (55%)	27 (61%)
Shortness of breath	18 (58%)	34 (81%)	31 (70%)
Night sweats	16 (52%)	15 (36%)	17 (39%)
Fatigue	15 (48%)	20 (48%)	23 (52%)
Dizzy spells	15 (48%)	24 (57%)	21 (48%)
Chest pain	13 (42%)	20 (48%)	11 (25%)
Chronic cough	12 (39%)	22 (52%)	26 (59%)
Heartburn	11(35%)	13 (31%)	14 (32%)
Ringing in ears	11(35%)	13 (31%)	18 (41%)
Poor appetite	8 (26%)	11 (26%)	9 (20%)
Memory loss	8 (26%)	5 (12%)	14 (32%)
Diarrhea	7 (23%)	13 (31%)	12 (27%)

Traditionally, the excretion of phenol in the urine has been used as an index of benzene exposure, which is a principal component of crude oil.[30-32] In this study, we found that there were significant amounts of phenol (7.0 mg/L) in the urine of the oil spill-exposed subjects. However, in healthy subjects (not exposed to oil spill), only traceable or an undetectable amount of phenol is expected in the urine. Thus, these findings suggest that the subjects involved in the oil spill clean-up activity were inherently exposed to benzene.

The health complaints reported by those involved in the oil spill clean-up operations are consistent with the previously reported studies of other major oil spills.[6,7,9,33] However, the prevalence of symptoms appears to be higher in the present study compared with the earlier findings of other investigators. Lyons et al.[6] found that headache, shortness of breath, fatigue, cough, skin rash, and diarrhea occurred more frequently in subjects exposed to the Sea Empress oil spill. Similarly, Morita et al[33] observed headache, low back pain, leg pain, and jiggling of vision as major symptoms in subjects engaged in the clean-up activity of the Nakhodka oil spill. In the present study, the major symptoms observed were headache, shortness of breath, skin rash, cough, and fatigue in subjects involved in oil spill clean-up operations.

To understand the health consequences of oil spill exposure, a subgroup analysis was performed in subjects who participated in the oil spill clean-up activity. Specifically, the consequences of oil spill exposure were examined according to sex and age by subgroup analysis. Although the number of female clean-up workers was limited, we found no significant differences in the WBC count, BUN, beta-2-microglobulin, ALP, AST, ALT, and urinary phenol between the male and female subjects exposed to the oil spill. However, the platelet counts were significantly lower

in the male subjects compared with the female subjects exposed to the oil spill. Age appears to have minimal impact on various hematological and hepatic parameters in subjects exposed to the oil spill.

There were certain differences observed in the frequency of somatic symptoms between the male and female subjects involved in the oil spill clean-up activity. Compared with males, females experienced a higher rate of headaches, painful joints, fatigue, night sweats, and diarrhea following the exposure to the oil spill. Similarly, the age of the subjects appears to have a considerable impact on the frequency of somatic symptoms after the oil spill exposure.

Study Limitations

As with any cross-sectional study and most studies of oil spill disasters, our results should be considered in light of the following limitations. Foremost among these limitations is our lack of predisaster health data on the subjects involved in the clean-up activities. In addition, the demographic characteristics such as sex and age were significantly different between the exposed and unexposed groups and may have impacted the observed findings. Specifically, the median age of unexposed subjects was significantly higher when compared with the exposed group. Furthermore, data on somatic symptoms were self-reported by the oil spill-exposed group and may have influenced the findings of the study. Also, because the clinical outcomes were measured at one time point after the oil spill exposure, it was difficult to infer a causality using such a study design. Moreover, the effect of the oil dispersant may have contributed to the current findings. The COREXIT used as a dispersant is currently banned in the United Kingdom because of its potential health risks to clean-up workers.[5] Nonetheless, this study has shed light on the health effects of oil spill exposure and dispersant use in subjects participating in the clean-up activities.

CONCLUSION

The results of this study indicate that human exposure to the oil spill has a potential to induce both hematological and hepatic toxicity. The hematological alterations include depletion of platelets, decreased BUN, and increased creatinine in subjects exposed to a crude oil spill. In addition, headache, shortness of breath, skin rash, cough, fatigue, painful joints, and chest pain occurred more frequently in oil spill clean-up workers. However, additional long-term follow-up studies are required to understand the clinical significance of the oil spill exposure.

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Health Risks Associated with Crude Oil Spill Exposure

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ABSTRACT

BACKGROUND: Human exposure to crude oil spills is associated with multiple adverse health effects including hematopoietic, hepatic, renal, and pulmonary abnormalities. The purpose of this study was to assess the hematological and liver function indices among the subjects participating in the Gulf oil spill cleanup operations in comparison with the standardized normal range reference values.

METHODS: Using medical charts, clinical data (including white blood cell [WBC] count, platelet count, hemoglobin, hematocrit, blood urea nitrogen [BUN] creatinine, alkaline phosphatase [ALP], aspartate amino transferase [AST], alanine amino transferase [ALT], and urinary phenol) were gathered for the subjects who were exposed to the Gulf oil spill and analyzed.

RESULTS: A total of 117 subjects exposed to the oil spill were included. Over 77% of subjects had WBC counts in the midrange (6-10 10^3 per mL), while none of the subjects had the upper limit of the normal range (11 10^3 per mL). A similar pattern was seen in the platelet counts and BUN levels among the oil spill-exposed subjects. Conversely, over 70% of the subjects had creatinine levels toward the upper limit of the normal range and 23% of subjects had creatinine levels above the upper limit of the normal range (> 1.3 mg per dL). Similarly, hemoglobin and hematocrit levels were toward the upper limit of normal in more than two thirds of the subjects. AST and ALT levels above the upper limit of normal range (> 40 IU per L) were seen in 15% and 31% of subjects, respectively. Over 80% of subjects had urinary phenol levels higher than detectable levels (2 mg per L).

CONCLUSION: The results of this study support our earlier study findings in which we found that people who participated in oil spill cleanup activities are at risk of developing alterations in hematological profile and liver function.

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KEYWORDS: Chemical exposure; Health impact; Hematological toxicity; Hepatotoxicity; Urinary phenol

Crude oil spills are tragic environmental disasters that can affect human health through exposure to inherent toxic chemicals including para-phenols and volatile benzene.[1,2] Human exposure to crude oil spills can lead to deleterious effects on many biological systems, including changes in the hematologic, hepatic, respiratory, renal, and neurological functions.[3,4] Recently, we investigated the adverse health effects of the Deepwater Horizon oil spill exposure in subjects participating in oil spill cleanup activities along the coast of Louisiana.[5] Specifically, we assessed the hematologic and hepatic markers in a cohort of oil spill cleanup workers and the clinical findings were compared with a group of unexposed (control) subjects. The findings of the study revealed significant differences in blood profiles and liver enzymes between the oil spill exposed and unexposed cohorts, indicating health risks among subjects who participated in the oil spill cleanup operation.[5]

Because the most reported clinical biomarker findings for both hematological and liver function indices fell within the normal range values for exposed and unexposed groups, concerns were raised about the study design and interpretation of the study findings.[6,7] This prompted us to carry out an additional analysis of clinical data that has been recently reported.[5] In the analysis, we assessed the blood profile and liver function data in comparison with the standard normal range values among the subjects who participated in the

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Gulf oil spill cleanup operation. The resultant outcomes are summarized to further facilitate the understanding of the health impact of oil spill exposure among subjects observed previously.

MATERIALS AND METHODS

Subjects

The details of identification of the subjects exposed to the oil spill were described in our previous manuscript.[5] Briefly, the subjects exposed to the oil spill were identified as participants in the oil spill cleanup activities along the coast of Louisiana. Medical charts were reviewed by an experienced physician. Clinical data such as white blood cell (WBC) counts, platelet counts, hemoglobin, hematocrit, blood urea nitrogen (BUN), creatinine, alkaline phosphatase (ALP), aspartate aminotransferase (AST), and alanine aminotransferase (ALT) levels were collected and evaluated. In addition, data on urinary phenol was also assessed as a benzene metabolite in the oil spill-exposed subjects.

CLINICAL SIGNIFICANCE

- Crude oil spills are tragic environmental disasters that have high potential to affect human health.
- The results of this study indicate that humans exposed to crude oil spill have a risk of developing hepatic or blood-related disorders.
- The hematological and hepatic alterations include altered platelet counts, serum creatinine, urinary phenol, and liver function enzymes.

Analysis

As shown in Table 1, the average reference values were derived from the normal range values for various indices of hematological and liver functions and the clinical data were processed. In addition, the normal range values were divided into various categories and the clinical data were analyzed. The variables included WBC and platelet counts, as well as the levels of hemoglobin, hematocrit, creatinine, BUN, ALP, AST, ALT, and urinary phenol.

Table 1 Normal Range Values for Various Indices

Parameter	Normal Range Value	Optimal (Average) Normal Value
WBC (10^3 per mL)	4.0-10.5	7.25
Platelets (10^3 per mL)	140-415	276
Hemoglobin (g per dL)	12.6-17.7	15
Hematocrit (%)	37.5-51.0	44
BUN (mg per dL)	6-24	15
Creatinine (mg per dL)	0.76-1.27	1.0
ALP (IU per L)	25-150	88
AST (IU per L)	0-40	20
ALT (IU per L)	0-40	20
Beta-2 macroglobulin (mg per L)	0.6-2.4	1.5
Urinary phenol (mg per L)	0-trace	2

ALP ¼ alkaline phosphatase; ALT ¼ alanine aminotransferase; AST ¼ aspartate aminotransferase; BUN ¼ blood urea nitrogen; IU per L ¼ International Units per liter; WBC ¼ White blood cells.

RESULTS

This study included a total of 117 subjects who were involved in the cleanup operations of the oil spill. Of the 117 subjects, 104 (89%) were male and 13 (11%) were female. The median age of the subjects was 34.0 (18-63) years.

The findings presented in the Figure (panel A) indicate the outcomes of WBC, platelet counts, and BUN levels assessment in the oil spill-exposed subjects. Based on the normal range values, WBC count was averaged at 7.2 (10^3 per mL) and the total number of subjects who had WBC counts below and above the average value of normal range was determined. Of the 117 subjects, 71 (61%) had WBC counts below the average value of normal range. Similarly, 79 (68%) of the subjects had platelet counts below the average value of normal range when 276 (10^3 per mL) was considered as the average value of normal range. Assessment of BUN levels also indicated that 68% of the subjects had below the average value of normal range when the average value of normal range of BUN levels was considered to be at 15 mg per dL.

The results shown in the Figure (panel B) depict the outcomes of serum creatinine, hemoglobin, hematocrit, and urinary phenol levels assessment in the oil spill-exposed subjects. Based on the normal range values, serum creatinine levels averaged 1.0 mg per dL and the total number of subjects who had creatinine levels above and below the average value of normal range was determined. Of the 117 subjects, 57 (49%) had serum creatinine levels above the average. Similarly, 76 (65%) of the subjects had hemoglobin levels above the average when 15 mg per dL was considered as the average value of normal range. Assessment of hematocrit levels indicated that 65% of the subjects had levels above the average value of normal range when the average value of normal range of hematocrit levels was considered to be at 44 mg per dL. Similarly, 93 (79%) of the subjects had urinary phenol levels above the average value of the normal range when 2.0 mg per L was considered as the average value of the normal range.

The findings presented in the Figure (panel C) reveal the outcomes of liver function enzymes such as AST, ALT, and ALP levels assessment in the serum of oil spill-exposed subjects. Based on the normal range values, AST and ALT levels in the serum were averaged at 20 IU per L, and the total number of subjects who had AST or ALT levels above and below the average was determined. Of the 117 subjects, 84 (72%) had serum AST levels above the average of the normal range. Similarly, 89 (76%) subjects had serum

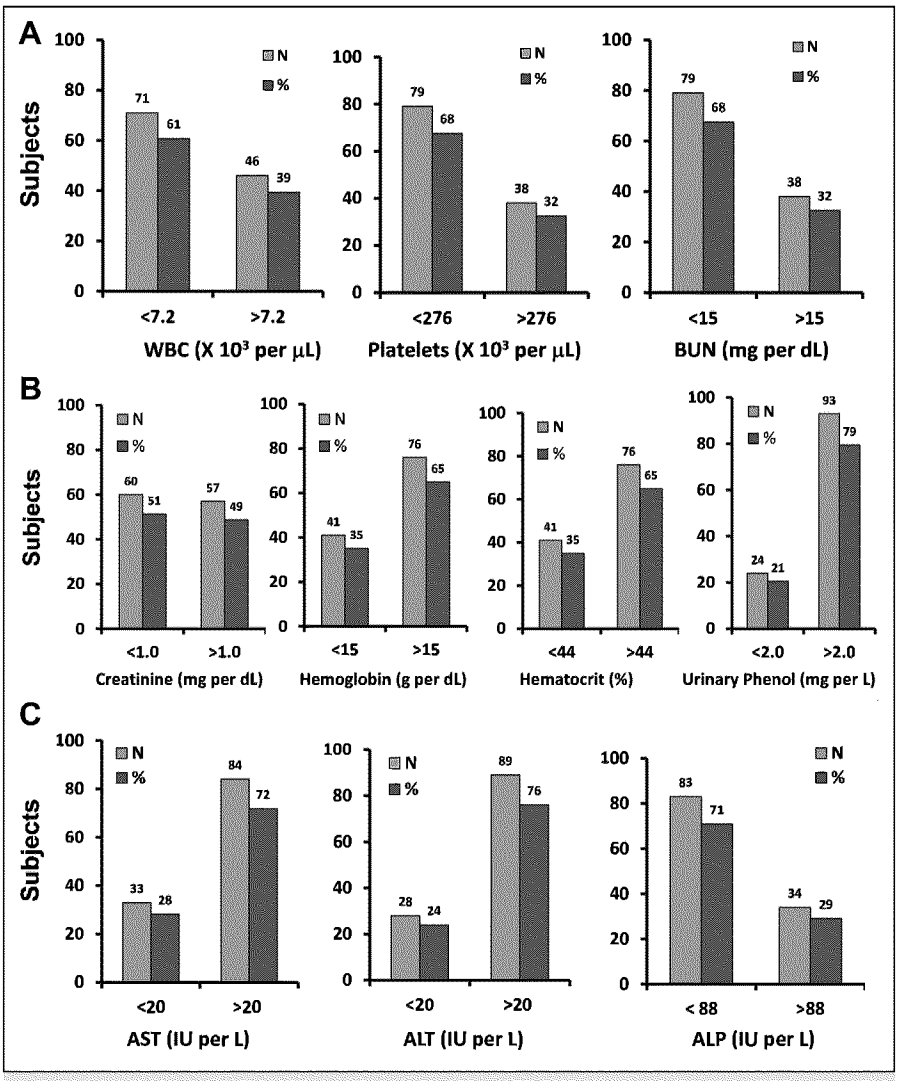

Figure Changes in biological markers in subjects involved in the Gulf oil spill cleanup operation. (A) Changes in white blood cell (WBC) counts, platelet counts, and blood urea nitrogen (BUN) levels. (B) Changes in serum creatinine, hemoglobin, hematocrit, and urinary phenol levels. (C) Changes in liver function enzymes such as aspartate aminotransferase (AST), alanine aminotransferase (ALT), and alkaline phosphatase (ALP) levels.

ALT levels above the average of the normal range. Conversely, only 29% of the subjects experienced serum ALP levels above the average when 88 IU per L was considered as the average value of the normal range.

The outcomes were compared with the normal range reference values that were grouped into lower-, middle-, and upper-limit ranges in addition to the above-normal range. The results presented in Tables 2 and 3 indicate the outcomes on

Table 2 Blood Profile with Various Indices in Subjects (n ¼117) Involved in Oil Spill Cleanup Activity

WBC (10^3 per mL)		Platelets (10^3 per mL)		BUN (mg per dL)	
Count	n	Count	n	Level	n
<5.0	14 (12.0%)	<200	23 (19.7%)	<11.0	33 (28.2%)
6.0-<8.0	50 (42.7%)	200-<250	36 (30.8%)	11.0-<15.0	46 (39.3%)
8.0-<10.0	40 (34.2%)	250-<300	35 (29.9%)	15.0-<20.0	32 (27.4%)
10.0 -<11.0	13 (11.1%)	300-<400	23 (19.7%)	20.0-<24.0	6 (5.1%)
┘ 11.0	0 (0.0%)	┘ 400	0 (0.0%)	┘ 24.0	0 (0.0%)

BUN ¼ blood urea nitrogen; WBC ¼ white blood cells.

Table 3 Blood Profile and Urinary Phenol in Subjects (n ¼117) Involved in Oil Spill Cleanup Activity

Creatinine (mg per dL)		Hemoglobin (g per dL)		Hematocrit (%)		Urinary Phenol (mg per L)	
Level	n	Level	n	Level	n	Level	n
<0.80	11 (9.4%)	<13.0	21 (17.9%)	<40	11 (9.4%)	0	10 (8.5%)
0.8-<0.9	22 (18.8%)	13.0-<15.0	20 (17.1%)	40-<45	42 (35.9%)	<2.0	13 (11.0%)
0.9-<1.0	27 (23.1%)	15.0-<16.0	60 (51.3%)	45-<50	56 (47.9%)	2.0-<5.0	38 (32.5%)
1.0-<1.3	30 (25.6%)	┘ 16.0	16 (13.7%)	┘ 50	8 (6.8%)	5.0-<10.0	31 (26.5%)
┘ 1.3	27 (23.1%)	N/A	N/A	N/A	N/A	┘ 10.0	25 (21.4%)

blood profiles and urinary phenol levels in subjects involved in the oil spill cleanup operations. Over 77% of the subjects had WBC counts in the mid range (6-10 10^3 per mL), while none of the subjects had upper limits of the normal range (11 10^3 per mL). A similar pattern was seen in the platelet counts and BUN levels among the oil spill-exposed subjects. However, nearly one third of subjects had BUN levels less than the lower limit (11 mg per dL) of the normal range. Conversely, over 70% of the subjects had creatinine levels toward the upper limit of the normal range and 23% of subjects had creatinine levels above the upper limits of the normal range (>1.3 mg per dL, Table 3). Similarly, hemoglobin levels were raised toward the upper limit of the normal range (>15 g per dL) in more than two thirds of the subjects. Hematocrit levels were also in the upper limit of the normal range in over 50% of the subjects. Over 80% of the subjects had urinary phenol levels more than detectable levels (2 mg per L) and 21% of the subjects had urinary phenol levels >10 mg per L (Table 3).

The findings presented in Table 4 show the levels of the hepatic enzymes such as AST, ALT, and ALP in the serum of the subjects involved in oil spill cleanup operations. AST levels above the normal range (>40 IU per L) were seen in approximately 15% of the subjects. Similarly, ALT levels above the normal range (>40 IU per L) values were seen in approximately 31% of the subjects. Conversely, none of the subjects had ALP levels above the normal range (>150 IU per L) values.

DISCUSSION

In a previous study, we evaluated the health effects of the Deepwater Horizon oil spill exposure in a cohort of oil spill cleanup workers.[5] The study found that the blood profiles and hepatic enzymes were significantly altered in subjects exposed to the oil spill compared with the unexposed subjects. Because the standard reference values have a wide range for the indices, a follow-up study was undertaken to assess the outcomes with respect to the standard reference values. Specifically, the outcomes were compared with the average value of the normal range values of each parameter. Further, the outcomes were compared with the normal range reference values that were grouped into lower-, middle-, and upper-limit ranges in addition to the above-normal range.

The findings of the study indicate that subjects who participated in the oil spill cleanup operations experienced changes in their blood profiles and hepatic enzymes. The study findings indicated that about 60%-70% of subjects exposed to the oil spill had WBC and platelet counts as well as BUN levels below the average normal reference value. Conversely, 50%-65% of subjects exposed to the oil spill had creatinine, hemoglobin, and hematocrit levels above the average normal reference value. Urinary phenol levels were also found to be above the average normal reference value in approximately 80% of oil spill-exposed subjects. Similarly, liver function enzymes such as AST and ALT were found to be above the average normal reference value in over 70% of oil spill-exposed subjects. Thus, these findings support our earlier study findings in which we found that subjects who participated in the oil spill cleanup activity are at an increased risk of developing hematological and liver function abnormalities.[5]

The abnormality of various biological markers in subjects who are involved in oil spill cleanup operations is further evidenced by the changes in various indices including creatinine, hemoglobin, hematocrit, liver function

Table 4 Liver Function Enzymes in the Serum of Subjects (n ¼117) Involved in Oil Spill Cleanup Activity

AST (IU per L)		ALT (IU per L)		ALP (IU per L)	
Level	n	Level	n	Level	n
<20	33 (28.2%)	<20	28 (23 .9%)	<60	27 (23.1%)
20-<30	49 (41.9%)	20-<30	38 (32.5%)	60-<80	48 (41.0%)
30-<40	18 (15.4%)	30-<40	15 (12.8%)	80-<100	23 (19.7%)
┘ 40	17 (14.5%)	┘ 40	36 (30.8%)	┘ 100	19 (16.2%)

ALP ¼ alkaline phosphatase; ALT ¼ alanine aminotransferase; AST ¼ aspartate aminotransferase.

enzymes (AST and ALT), and urinary phenol. The results show that over 15% of subjects experienced some of these biomarker indices over the upper limit of the normal reference range, and over 50% of subjects had the indices toward the upper limit.

Overall, the findings indicate that the subjects were not affected uniformly by the oil spill exposure. This could be due to the differences in duration and intensity of exposure, protective equipment, preexisting health conditions, use of medications, and the differential immunity to the toxic chemicals of the oil spill. In addition, subjects' age may have contributed to the variations in findings observed in the study. Nonetheless, the findings of the study suggest that subjects involved in oil spill cleanup operation are at an increased risk of developing health-related sequelae and support our earlier findings reported in the previous article.[5]

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18 October 2015

I. Direct Public Health Implications

A. New References

1. Devine, S. and Devine, T. Government Accountability Project (GAP) Report and Addendum
   a. Devine, S. and Devine, T. (2013) Deadly Dispersants in the Gulf: Are Public Health and Environmental Tragedies the New Norm for Oil Spill Cleanups? http://whistleblower.org/gulftruth . 323 pages with affidavits from 21 witnesses
   b. Devine, S. and Devine, T. (2015) Public Comments on EPA Proposed Rule to Subpart J of the National Oil and Hazardous Substances Pollution Contingency Plan that Governs the Use of Dispersants, Addendum to Deadly Dispersants in the Gulf: Are Public Health and Environmental Tragedies the New Norm for Oil Spill Cleanups? http://whistleblower.org/gulftruth . 65 pages with affidavits from 13 additional witnesses.
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B. Abstracts & Importance

1. The GAP reports are written by a whistleblower advocacy group with primarily a legal rather than a scientific perspective. However the reports are well annotated, and received external scientific review. The most important contributions of these reports are probably the affidavits documenting adverse effects to the health of oil spill workers.

   "GAP's evidence comes from those whistleblowers who experienced the cleanup's effects firsthand. For its original report, GAP investigators interviewed 25 whistleblowers from Alabama, Louisiana and Mississippi, conducted extensive Freedom of Information Act requests, and off-the-record interviews with government employees. GAPs latest evidence comes from more than one dozen whistleblowers impacted by Corexit. Witnesses range from cleanup workers and fishermen, to scientists and residents. Together, their accounts produce a frighteningly consistent picture of health and ecological devastation that is starkly at odds with

official BP and government statements that Corexit is no more dangerous than Dawn dishwashing soap. GAP worked closely with The ALERT Project and the Louisiana Environmental Action Network to conduct this investigation The updated evidence included in this addendum is consistent with, and in some cases more severe than, the following findings documented in 2013 –

Existing Health Problems

- *Coined "BP Syndrome," all GAP witnesses experienced spill-related health problems. Furthermore, 95% report that they continued to experience spill-related health problems as of April 2013, and more than 50% living in affected areas reported that their children and/or grandchildren's health has deteriorated.*
- *Select effects include: blood in urine; heart palpitations; kidney & liver damage; migraines; multiple chemical sensitivity, including hyper-allergies to common household cleaners; neurological damage resulting in severe IQ loss and memory loss; hyper-allergies to processed foods, causing extreme weight loss; exhaustion and loss of stamina for routine activities; respiratory system & nervous system damage; seizures; skin lesions throughout the body; and temporary paralysis.*
- *Victims also are extremely concerned about recognized long-term health effects from chemical exposure, such as reproductive damage and cancer.*
- *Blood test results from a majority of GAP interviewees showed alarmingly high levels of chemical exposure – to Corexit and oil – that correlated with experienced health effects. These chemicals include known carcinogens."* (I.A.1b: Introduction, p 1-2)

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2. *"ABSTRACT*
   BACKGROUND: Oil spills are known to affect human health through the exposure of inherent hazardous chemicals such as para-phenols and volatile benzene. This study assessed the adverse health effects of the Gulf oil spill exposure in subjects participating in the clean-up activity along the coast of Louisiana.
   METHODS: This retrospective study included subjects that had been exposed and unexposed to the oil spill and dispersant. Using medical charts, clinical data including white blood cell count, platelets count, hemoglobin, hematocrit, blood urea nitrogen, creatinine, alkaline phosphatase (ALP), aspartate amino transferase (AST), alanine amino transferase (ALT), and somatic symptom complaints by the subjects were reviewed and analyzed.
   RESULTS: A total of 247 subjects (oil spill exposed, n ¼ 117 and unexposed, n ¼ 130) were included. Hematologic analysis showed that platelet counts (_ 103 per mL) were significantly decreased in the exposed group compared with those in the group unexposed to the oil spill (252.1 _ 51.8 vs 269.6 _ 77.3, P ¼ .024). Conversely, the hemoglobin (g per dL) and hematocrit (%) levels were significantly increased among oil spill-exposed subjects compared with the unexposed subjects (P ¼ .000). Similarly, oil spill-exposed subjects had significantly higher levels of ALP (76.3 _ 21.3 vs 61.2 _ 26.9 IU/L, P ¼ .000), AST (31.0 _ 26.3 vs 22.8 _ 11.8 IU/L, P ¼ .004), and ALT (34.8 _ 26.6 vs 29.8 _ 27 IU/L, P ¼ .054) compared with the unexposed subjects.
   CONCLUSION: The results of this study indicate that clean-up workers exposed to the oil spill and dispersant experienced significantly altered blood profiles, liver enzymes, and somatic symptoms." (1.A.2, Abstract, p. 966)

3. *"ABSTRACT: The technology to recover natural gas depends on undisclosed types and amounts of toxic chemicals. A list of 944 products containing 632 chemicals used during natural gas operations was compiled. Literature searches were conducted to determine potential health effects of the 353 chemicals identified by Chemical Abstract Service (CAS) numbers. More than 75% of the chemicals could affect the skin, eyes, and other sensory organs, and the respiratory and gastrointestinal systems. Approximately 40-50% could affect the brain/nervous system, immune and cardiovascular systems, and the kidneys; 37% could affect the endocrine system; and 25% could cause cancer and mutations. These results indicate that many chemicals used during the fracturing and drilling stages of gas operations may have long-term health effects that are not immediately expressed. In addition, an example was provided of waste evaporation pit residuals that contained numerous chemicals on the CERCLA and EPCRA lists of hazardous substances. The discussion highlights the difficulty of developing effective water quality monitoring programs. To protect public health we recommend full disclosure of the contents of all products, extensive air and water monitoring, coordinated environmental/human health studies, and regulation of fracturing under the U.S. Safe Drinking Water"* (I A.3: Abstract, p. 1039)

C. Suggested New Language in Work Group Report
Under "Human Health & Toxicity, A. Human Exposure to Dispersants and Dispersed Oil, *Uncertainties*.
2. Self-reported adverse effects have been documented with changes in blood chemistry and liver enzymes consistent with exposure to oil. Reports are from studies which were not designed answer questions of frequency of occurrence or dose-response.

II. Petroleomics and Composition of Crude Oil

A. New References
1. McKenna, AM, Nelson, RK, Reddy, CM, Savory, JJ, Kaiser, NK, Fitzsimmons, JE, Marshall, AG and Rodgers, RP (2013) Expansion of the Analytical Window for Oil Spill Characterization by Ultrahigh Resolution Mass Spectrometry: Beyond Gas Chromatography. Environ. Sci. Technol., 47, 7530−7539.
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4. Marshall, AG. and Rodgers, RP. (2003) Petroleomics: The Next Grand

Challenge for Chemical Analysis. Acc. Chem. Res., 37, 53-59

B. Importance

1. *ABSTRACT: Traditional tools for routine environmental analysis and forensic chemistry of petroleum have relied almost exclusively on gas chromatography −mass spectrometry (GC-MS), although many compounds in crude oil (and its transformation products) are not chromatographically separated or amenable to GC-MS due to volatility. To enhance current and future studies on the fate, transport, and fingerprinting of the Macondo well oil released from the 2010 Deepwater Horizon disaster, we created an extensive molecular library of the unadulterated petroleum to compare to a tar ball collected on the beach of Louisiana. We apply ultrahigh resolution Fourier transform ion cyclotron resonance (FT-ICR) mass spectrometry to identify compositional changes at the molecular level between native and weathered crude oil samples and reveal enrichment in polar compounds inaccessible by GC-based characterization. The outlined approach provides unprecedented detail with the potential to enhance insight into the environmental fate of spilled oil, improved toxicology, molecular modeling of biotic/abiotic weathering, and comprehensive molecular characterization for petroleum-derived releases. Here, we characterize more than 30 000 acidic, basic, and nonpolar unique neutral elemental compositions for the Macondo well crude oil, to provide an archive for future chemical analyses of the environmental consequences of the oil spill.* (II.A.1, Abstract, p.7530)
2. *"Supporting Information: More than 16 000 unique molecular monoisotopic elemental compositions for the acidic, basic, and nonpolar components obtained by FT-ICR MS for parent Macondo well petroleum, catalogued as neutral elemental compositions and figures as mentioned in the text. This material is available free of charge via the Internet at http://pubs.acs.org."* (II.A.1, p. 7539)
3. *"...**The Petroleome.** We have, to date, resolved and identified >60,000 distinct elemental monoisotopic elemental compositions, $^{12}C_c{}^{1}H_h{}^{14}N_n{}^{16}O_o{}^{32}S_s$, from ions in positive- and negative ion ESI and APPI FT-ICR mass spectra of dozens of petroleum crude oil samples. [Species with one or more ^{13}C, ^{15}N, ^{34}S, etc. are not counted separately because they are chemically essentially identical. Moreover, a neutral composition based on observation of both $^{+\bullet}$ and $(M+H)^+$ ions is counted only once.] Fig. 6 is a distribution of DBE vs. carbon number for just the CcHhS1 members of the ''petroleome.'' The diagonal line represents the maximum possible DBE for each carbon number in a planar polycyclic aromatic molecule. Interestingly, over the tens of millions of years during which petroleum is formed, virtually all possible combinations of DBE and carbon number are generated up to DBE _ 25 and carbon number _ 40, and, with decreasing aromaticity, up to carbon number _ 80. Similar trends are found for other heteroatom classes.* (II.A.2, Results & Discussion, p.18093)
4. *"...Research on polar water-solubles primarily focuses on naphthenic acids (surfactant-like acyclic, monocyclic, and polycyclic acids) and pure hydrocarbons (2). Naphthenic acids are soluble at neutral pH and ionize*

under slightly basic solutions such as seawater (2). Upto_3%w/w of crude oil may be acids, of which naphthenic acids are most abundant (3). Crude oil heterocyclic/aromatic NSO compound characterization and monitoring is fundamentally necessary for environmental protection, because NSO-containing compound solubilities are orders of magnitude greater than those of purely aromatic hydrocarbons. For example, the aqueous solubility of phenanthrene, a neutral tri-aromatic hydrocarbon, is 1.1 mg L^{-1}, whereas acridine (a nitrogen-containing polar basic tri-aromatic) has a solubility of 46.6 mg L^{-1} (4). Identification of solubility patterns for organic-NSO-heteroatomic basic water-soluble species should not go ignored, because basic nitrogen species are generally more toxic than acidic nitrogen compounds (5).(II.A.3, Introduction, p. 2696)

5. *"...Petroleum crude oil is arguably the world's most compositionally complex organic mixture, in terms of the number of chemically distinct constituents within a dynamic abundance range of 10 000-100 000. For such mixtures, chemists have traditionally relied on multiple wet chemical separations (extraction, precipitation, distillation, chromatography, etc.) to reduce the number of components and thus simplify the determination of the various molecular elemental compositions and structures. Fortunately, each chemical element (more precisely, each isotope of each element) has a different mass defect (i.e., the difference between its exact mass and the nearest integer ("nominal") mass).3 Moreover, it is now possible to ionize virtually any organic molecule to produce a molecular (e.g., M+) or quasimolecular (e.g., $[M + H]^+$,$[M - H]^-$) ion. Thus, with sufficiently high mass resolving power, m/¢m50%, in which m is ion mass and ¢m50% is mass spectral peak full width at half-maximum height, it is in principle possible to resolve and identify the elemental composition (chemical formula) of virtually any organic molecule, even in a complex mixture. In this Account, we describe recent advances culminating in the resolution and identification of crude oil components of more than 10 000 different elemental compositions ($C_cH_hN_nO_oS_s$), with analogous extension to other complex mixtures (coal, humic and fulvic acids). We shall also discuss the three analytically useful molecular characteristics that derive directly from elemental composition: "class" (i.e., numbers of heteratoms, $N_nO_oS_s$), "type" (i.e., hydrogen deficiency or number of rings plus double bonds), and carbon distribution (number of -CH_2 groups)."* (II.A.4, Introduction, p. 53)

C. Suggested New Language in Work Group Report
   1. Whereas the actual composition of individual petroleum crude oils varies with source, all are compositionally complex organic mixtures, with the number of chemically distinct constituents within a dynamic abundance range of 10 000-100 000.
   2. Crude oil heterocyclic/aromatic NSO compound (nitrogen, oxygen, or sulfur containing) characterization and monitoring is fundamentally necessary for environmental protection, because NSO-containing compound solubilities are orders of magnitude greater than those of purely

aromatic hydrocarbons.

III. Toxicity of Crude Oil Fractions

A. New References

1. Toxicity shown in Human or Human Surrogate Systems
   a. Vrabie, CM., Sinnige, TL., Murk, AJ and Jonker, MTO. (2012) Effect-Directed Assessment of the Bioaccumulation Potential and Chemical Nature of Ah Receptor Agonists in Crude and Refined Oils. Environ. Sci. Technol., 46, 1572−1580.
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B. Abstracts & Importance
   1. The question can, and perhaps should be asked, why these references are important to the CRRC Public Health and Food Security Work Group when they do not directly involve humans or chemical dispersants. The biophysics of dispersants/surfactants and biological membranes dictate that the former

will increase the permeability of the latter. Thus at least in some cases one should expect the presence of the surfactants present in Corexit-brand chemical dispersants to cause additive or even synergistic toxicity with petroleum hydrocarbons. However, more than one group, including Hodson's, have demonstrated that at least for first approximations, that the increased toxicity of petroleum fractions seen in the presence of dispersants is primarily due to the increased bioavailability of petroleum hydrocarbons in the aqueous phase. Thus it is important to understand the toxicity of individual petroleum compounds and fractions before we can predict their toxicity in the presence of dispersants. These papers strongly suggest that some petroleum fractions may be toxic through direct interactions with cell-surface receptors; so they never have to enter the cell, while others, such as carcinogenic PAH must enter the cell and should be assisted by agents which increase permeability of cell membranes; such as the DMSO which is added during many in vitro carcinogenesis assays.

2. *ABSTRACT: Recent studies have indicated that in addition to narcosis certain chemicals in crude oils and refined petroleum products may induce specific modes of action, such as aryl hydrocarbon receptor (AhR) agonism. The risks these toxic compounds pose to organisms depend on internal exposure levels, as driven by the chemicals' bioaccumulation potential. Information on this potential however is lacking, as the chemicals' identity mostly is unknown. This study showed that AhR agonists bioaccumulate from oil-spiked sediments into aquatic worms and persist in the worms for at least several weeks. Chemical fractionations of eight pure oils into saturates, aromatics, resins, and asphaltenes (SARA), followed by effect-directed analyses using in vitro reporter gene assays revealed that the agonists predominantly are aromatic and resin-like chemicals. Some of the compounds were easily metabolized in vitro, while others were resistant to biotransformation. HPLC-assisted hydrophobicity profiling subsequently indicated that the AhR-active chemicals had a high to extremely high bioaccumulation potential, considering theirestimated logK_{ow} values of 4 to >10. Most of the AhR agonism, however, was assigned to compounds with logKow of 5−8. These compounds were present mainly in the mid to high boiling point fractions of the oils (C14−C32 alkane range), which are usually not being considered (the most) toxic in current risk assessment. The fractionations further revealed considerable oil and fraction-dependent antagonism in pure oils and SARA fractions. The results of this study clearly demonstrate that crude oils and refined petroleum products contain numerous compounds that can activate the AhR and which because of their likely persistence and extremely high bioaccumulation potential could be potential PBT (persistent, bioaccumulative and toxic) or vPvB (very persistent and very bioaccumulative) substance candidates. Many chemicals were identified by GC-MS, but the responsible individual compounds could not be exactly identified in the complex mixtures of thousands of compounds. Because this obstructs a classical PBT risk assessment, our results advocate an adapted risk assessment approach for complex mixtures in which low concentrations of very potent compounds are*

*responsible for mixture effects.(*III.A.1.a., Abstract, p.1572)

3. *Abstract—Current petroleum risk assessment considers only narcosis as the mode of action, but several studies have demonstrated that oils contain compounds with dioxin-like, estrogenic or antiestrogenic, and androgenic or antiandrogenic activities. The present study is the third in a series investigating the specific toxic effects of 11 crude oils and refined products. By employing recombinant mammalian cells stably transfected with the human estrogen receptor alpha (ERa) or beta (ERb), and expressing the luciferase protein (ERa-U2OSLuc and ERb-U2OS-Luc assay), the estrogenicity or antiestrogenicity of oils was studied. All oils, except for two refined oils and one crude oil, induced estrogenic responses. The calculated estrogenic potencies of the oils were six to nine orders of magnitude lower than the potency of 17b-estradiol (E2). Upon coexposure to a fixed concentration of E2 and increasing concentrations of oils, additive, antagonistic, and synergistic effects were revealed. One nautical fuel oil was tested in the human breast carcinoma cell line MCF-7, in which it induced cell proliferation up to 70% relative to the maximal induction by E2. At its minimum effect concentration of 25 mg/L, the oil was also capable of inducing mRNA expression of the estrogen-dependent protein pS2 by a factor of two. The present results indicate that oils naturally contain potentially endocrine-disrupting compounds that are able to influence the estrogenicity of other compounds and may cause biological responses beyond receptor binding.* (III.A.1.b, Abstract, p. 973)
4. *Abstract—The present study is the second in a series aiming at a systematic inventory of specific toxic effects of oils. By employing a recombinant yeast stably transfected with human estrogen receptor-a (ERa) or -b (ERb) or androgen receptor (AR) and expressing yeast enhanced green fluorescent protein, the (anti-)estrogenicity and (anti) androgenicity of 11 crude oils and refined products were studied. None of the oils tested had significant estrogenic effects in the ERa assay or androgenic effects in the AR assay. However, all oils were capable of inducing estrogenic responses in the ERb assay, with several responses being above even the maximal response of the standard 17b-estradiol (E2). Based on the lowest effect concentrations, the potencies of oils in all the assays were between four and seven orders of magnitude lower than those of the standards E2 or testosterone (T). The potencies of the actual individual petrochemical agonists may, however, be relatively high, considering the complex composition of oils. Additive effects, antagonistic effects, and a synergistic effect were measured in the assays upon coexposure to a fixed concentration of standard (E2 or T) and increasing concentrations of oils. To investigate whether the observed effects were receptor-mediated, coexposures to the synthetic inhibitors ICI 182,780 (ERb assay) or flutamide (AR assay), a fixed concentration of standard, and various concentrations of oils were performed. The results suggested that the androgenic effects were receptor mediated, whereas the estrogenic effects may be only partially mediated via the receptor. The present study indicates that oils contain compounds with possible endocrine-disrupting potential,*

some of them acting via the hormone receptors. (III.A.1.c, Abstract, p. 1529)

5. *Abstract—The present study is the first in a series reporting on in vitro toxic potencies of oils. The objective was to determine whether 11 crude oils and refined products activate the aryl hydrocarbon receptor (AhR) in a dioxin receptor–mediated luciferase assay. Cells were exposed for 6 and 24 h to different oil concentrations to screen for polycyclic aromatic hydrocarbon–like or dioxin-like activity. Moreover, cytotoxicity of the oils was determined using rat hepatoma cells. Except for one crude oil, none of the oils appeared cytotoxic up to 100 mg/L, but all oils activated the AhR. Strong AhR induction was observed for most oils after 6 h, and responses decreased after 24 h, indicating the presence of metabolizable agonists. However, several oils still caused high responses after 24 h, also demonstrating the presence of persistent agonists. The potencies (calculated based on comparisons of concentrations at which 50% of the maximal effect was observed) of oils were found to be approximately 40 to 106 times lower than the potency of the assay's standards benzo[a]pyrene and 2,3,7,8-tetrachlorodibenzo-p-dioxin. However, considering that oils contain thousands of chemicals, the potencies of petrochemical agonists may be very high. Among the most potent oils were bunker and crude oils. Induction up to 200% as compared to the maximum induction caused by benzo[a]pyrene was observed for these oils. Such supermaximal responses suggest mixture effects that may not be receptor-mediated. Experiments in which oils were tested in combination with the standards demonstrated that oils acted via an antagonistic or additive mode. The results of the present study may help improve risk assessment of petroleum products and judge the necessity or priority of oil spill cleanup activities.* (III.A.1.d, Abstract, 1995)
6. *Abstract: Heavy fuel oil (HFO) spills account for approximately 60% of ship–source oil spills and are up to 50 times more toxic tha medium and light crude oils. Heavy fuel oils contain elevated concentrations of polycyclic aromatic hydrocarbons (PAHs) and alkyl-PAHs, known to be toxic to fish; however, little direct characterization of HFO toxicity has been reported. An effects-driven chemical fractionation was conducted on HFO 7102 to separate compounds with similar chemical and physical properties, including toxicity, to isolate the groups of compounds most toxic to trout embryos. After each separation, toxicity tests directed the next phase of fractionation, and gas chromatography–mass spectrometry analysis correlated composition with toxicity, with a focus on PAHs. Low-temperature vacuum distillation permitted the separation of HFO into 3 fractions based on boiling point ranges. The most toxic of these fractions underwent wax precipitation to remove long-chain n-alkanes. The remaining PAH-rich extract was further separated using open column chromatography, which provided distinct fractions that were grouped according to increasing aromatic ring count. The most toxic of these fractions was richest in PAHs and alkyl-PAHs. The results of the present study were consistent with previous crude oil studies that identified PAH-rich fractions as the most toxic.* (III, A.2.a, Abstract, p.814)

7. *Abstract: The present study isolated and identified compounds in heavy fuel oil 7102 (HFO 7102) that are bioavailable and chronically toxic to rainbow trout embryos (Oncorhynchus mykiss). An effects-driven chemical fractionation combined the chemical separation of oil with toxicity testing and chemical analyses of each fraction to identify the major classes of compounds associated with embryo toxicity. Toxicity was assessed with 2 exposure methods, a high-energy chemical dispersion of oil in water, which included oil droplets in test solutions, and water accommodated fractions which were produced by oiled gravel desorption columns, and which did not contain visible oil droplets. Fractions of HFO with high concentrations of naphthalenes, alkanes, asphaltenes, and resins were nontoxic to embryos over the range of concentrations tested. In contrast, fractions enriched with 3- to 4-ringed alkyl polycyclic aromatic hydrocarbons (PAHs) were embryo-toxic, consistent with published studies of crude oils and individual alkyl PAHs. The rank order of fraction toxicity did not vary between the exposure methods and was consistent with their PAH content; fractions with higher–molecular weight alkyl PAHs were the most toxic. Exposure of juvenile trout to most fractions of HFO induced higher activities of cytochrome P450 enzymes, with a rank order of potency that varied with exposure method and differed somewhat from that of embryotoxicity. Induction reflected the bioavailability of PAHs but did not accurately predict embryo-toxicity.* (III. A.2.b, Abstract, 825)
8. *A b s t r a c t: Polycyclic aromatic hydrocarbons (PAH) are hydrophobic environmental contaminants with petrogenic, biogenic, and pyrogenic sources. Alkylated PAH predominate in crude oils, are found in sediment downstream of pulp and paper mills, and can be more toxic than their non-alkylated homologues. The enzymatic metabolism of alkyl phenanthrenes generates ring and chain hydroxylated derivatives. The main objective of this research was to estimate the potential role of hydroxylation in PAH toxicity and secondly to better understand the relative risk of different PAH in complex mixtures. This project assessed the toxicity of ring and chain hydroxylated 1-methylphenanthrenes to the early life stages of Japanese medaka (Oryzias latipes). Phenols were more toxic than benzylic alcohols, and some phenols were more than four times more toxic than their non-hydroxylated counterpart. Ring hydroxylation can increase PAH toxicity, and metabolism may enhance alkyl-PAH toxicity through the generation of such metabolites.This paper is the first to describe the relative toxicity of a suite of hydroxylated alkyl-PAH to the early life stages of fish, proposing an association between the preferential formation of para-quinones and enhanced toxicity.* (III.A.2.c., Abstract, p.56),
9. The region-specificity and differential toxicity of compounds such as alkyl-phenanthrenes and hydroxylated alkyl-phenanthrenes are considered strongly indicative of either specific receptor-toxin, or metabolic activation required in the toxicity of the compounds in question.

C. Suggested New Language in Work Group Report

1. Although the connection between pyrogenic-PAH and cancer has been well studied, most of the human toxicity from exposure to crude oil and its fractions has focused on acute effects. More recent studies in *in vitro* systems and non-human species have elucidated possible long term Sublethal adverse effects in humans from short-term exposures to crude oil at levels many considered very low concentrations (<300 ppb TPAH).
2. Most aspects of Phase I metabolism of toxic substances is common to all eukaryote species, including humans, For many toxic substances this Phase is the branch point for toxification and detoxification of many substances including PAH and nitrogen, oxygen or sulfur (NOS) containing polycyclic compounds. The predominant metabolic reactions in Phase I are those catalyzed by the cytochrome P-450 monooxygenases (CYP gene products); including CYP-1A and the Arylhydrocarbon receptor (AhR). Thus both AhR and CYP-1A expression is a good indicator of toxic substance metabolism in both humans and other species.
3. Varbie and coworkers (III.A.1 a&d), and Hodson and coworkers (III.A.2.a&b), have both shown that low-level exposures to polar water soluble oil fractions increase the expression of both AhR, CYP-1A, and the associated EROD enzyme activity. Although the tests were not done on humans, the tests used are broadly accepted as surrogates for toxicity in humans.
4. Hodson and coworkers (III.A.2.a&b) have clearly shown that the impairment of cardiac function measured in fish is caused by more polar PAH fractions. They interpret their findings as a causative link to alkyl three or four ring PAH.
5. Varbie and coworkers (III.A.1.b&c) have measured estrogen and androgen-mediated responses following exposure to low-level exposures to oil fractions. The *in vitro* test systems used are consistent with the EPA's protocols for screening for endocrine disrupting chemicals.

IV. Northern Gulf of Mexico Cetacean Unusual Mortality Event (UME); 2010-2015

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PLOS ONE DOI:10.1371/journal.pone.0126538 May 20, 2015

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PLOS ONE | DOI:10.1371/journal.pone.0117248 February 11, 2015

B. Abstracts & Importance

1. This Unusual Mortality Event (UME) and the related findings are important to the CRRC Public Health and Food Security Work Group for two reasons. First. bottlenose dolphins are the closest human surrogate used in in any of the scientifically rigorous studies coming out of the Deepwater Horizon oil spill. Second, marine mammals fill critical spiritual and nutritional roles in the traditional and coustomary lives of most Arctic Peoples.
2. *Abstract: A northern Gulf of Mexico (GoM) cetacean unusual mortality event (UME) involving primarily bottlenose dolphins (Tursiops truncatus) in Louisiana, Mississippi, and Alabama began in February 2010 and continued into 2014. Overlapping in time and space with this UME was the Deepwater Horizon (DWH) oil spill, which was proposed as a contributing cause of adrenal disease, lung disease, and poor health in live dolphins examined during 2011 in Barataria Bay, Louisiana. To assess potential contributing factors and causes of deaths for stranded UME dolphins from June 2010 through December 2012, lung and adrenal gland tissues were histologically evaluated from 46 fresh dead non-perinatal carcasses that stranded in Louisiana (including 22 from Barataria Bay), Mississippi, and Alabama. UME dolphins were tested for evidence of biotoxicosis, morbillivirus infection, and brucellosis. Results were compared to up to 106 fresh dead stranded dolphins from outside the UME area or prior to the DWH spill. UME dolphins were more likely to have primary bacterial pneumonia (22% compared to 2% in non-UME dolphins, P = .003) and thin adrenal cortices (33% compared to 7% in non-UME dolphins, P = .003). In 70% of UME dolphins with primary bacterial pneumonia, the condition either caused or contributed significantly to death. Brucellosis and morbillivirus infections were detected in 7% and 11% of UME dolphins, respectively, and biotoxin levels were low or below the detection limit, indicating that these were not primary causes of the current UME. The rare, life-threatening, and chronic adrenal gland and lung diseases identified in stranded UME dolphins are consistent with exposure to petroleum compounds as seen in other mammals. Exposure of dolphins to elevated petroleum compounds present in coastal GoM waters during and after the DWH oil spill is proposed as a cause of adrenal and lung disease and as a contributor to*

increased dolphin deaths. (IV.A.2., Abstract, p. 1-2)

3. *Abstract: A multi-year unusual mortality event (UME) involving primarily common bottlenose dolphins (Tursiops truncates) was declared in the northern Gulf of Mexico (GoM) with an initial start date of February 2010 and remains ongoing as of August 2014. To examine potential changing characteristics of the UME over time, we compared the number and demographics of dolphin strandings from January 2010 through June 2013 across the entire GoM as well as against baseline (1990-2009) GoM stranding patterns. Years 2010 and 2011 had the highest annual number of stranded dolphins since Louisiana's record began, and 2011 was one of the years with the highest strandings for both Mississippi and Alabama. Statewide, annual numbers of stranded dolphins were not elevated for GoM coasts of Florida or Texas during the UME period. Demographic, spatial, and temporal clusters identified within this UME included increased strandings in northern coastal Louisiana and Mississippi (March-May 2010); Barataria Bay, Louisiana (August 2010-December 2011); Mississippi and Alabama (2011, including a high prevalence and number of stranded perinates); and multiple GoM states during early 2013. While the causes of the GoM UME have not been determined, the location and magnitude of dolphin strandings during and the year following the 2010 Deepwater Horizon oil spill, including the Barataria Bay cluster from August 2010 to December 2011, overlap in time and space with locations that received heavy and prolonged oiling. There are, however, multiple known causes of previous GoM dolphin UMEs, including brevetoxicosis and dolphin morbillivirus. Additionally, increased dolphin strandings occurred in northern Louisiana and Mississippi before the Deepwater Horizon oil spill. Identification of spatial, temporal, and demographic clusters within the UME suggest that this mortality event may involve different contributing factors varying by location, time, and bottlenose dolphin populations that will be better discerned by incorporating diagnostic information, including histopathology.* (IV.A.3., Abstract, p.1-2)

C. Suggested New Language in Work Group Report

1. The closest surrogate to humans which was exposed to oil and dispersed oil in the northern Gulf of Mexico, and whose toxic response is currently being studied is the bottlenose dolphin. The exposure to oil coincides with an increase in lethal strandings. Cluster group analysis (IV.A.3) has separated those demographic clusters those fatalities to oil exposure during the time of the BP/Deepwater Horizon response from those apparently un related. Venn-Watson and coworkers (IV.A.2) has identified lung and adrenal lesions among the strandings which are consistent with known toxic effects from oil exposure. The metabolic similarities between humans and bottlenose dolphins suggest humans are probably susceptible to these adverse effects. Whether the adverse consequences of exposure to oil or dispersed oil are due to continuing exposure to lingering oil, or are

long-term consequences to short-term exposures is impossible to ascertain from the existing data.

THE AMERICAN JOURNAL of MEDICINE

The Reply

We appreciate Piacentino et al for their interest in our recent article about the health consequences among subjects involved in Gulf oil spill cleanup activities published in The American Journal of Medicine.[1] We strongly disagree with their opinion about the findings of our published study. This is a retrospective analysis, which is not based on epidemiological analysis, as Piacentino et al have attempted to argue, using several uncontrollable compounding factors. Unlike prospective clinical studies, retrospective studies are limited to the existing data that have been recorded for reasons other than research.[2] The outcomes generated using retrospective data serve as basis for future prospective studies. In our study, a very well-established standard study design was used to compare the variables (clinical biomarkers) between the 2 groups. The study findings were interpreted and discussed appropriately with existing literature.

The selection of subjects both unexposed and exposed to the oil spill was described clearly in the published article. Because it was a retrospective study, data on lifestyle characteristics, medical history, or employment status were not available for all the subjects included in the study. As argued by Piacentino et al, this study did not use recruitment of subjects to control the variables. As this research was unfunded, it was not feasible to obtain corresponding hematological and liver function data from an appropriately matched external reference group for comparison through the National Health and Nutrition Examination Survey cohort, as was suggested. As was pointed out by Piacentino et al, the additional limitations such as lifestyle exposures, race, ethnicity, chronic medical conditions, medication use, smoking, and alcohol may have played some role, but it is important to know that the subjects in both groups were considered using these variables equally.

Blood and urine samples were collected and stored using standard clinical methods and were subsequently analyzed by independent accredited clinical laboratories. Based on those laboratory findings, physicians routinely diagnose and treat medical conditions. Because samples for both exposed and unexposed groups were collected using these standard methods for analysis by the nationally accredited laboratories, we believe that the impact on the outcomes is insignificant.

Our study was the first of its kind to report changes in hematological and hepatic functions in the oil spill-exposed subjects. Several investigators have used similar study designs for the evaluation of their subjects exposed to the oil spill in relation to control or unexposed groups.[3-6] We believe that our study is hypothesis driven, with clear objectives, and the conclusions drawn were valid. Thus, the findings of our study form a basis for future prospective clinical studies in this area of research.

In order to further clarify issues raised by Piacentino et al, additional analysis of the clinical data was performed for the oil spill-exposed subjects. In this analysis, we assessed the blood profiles and liver function data of the subjects who participated in the Gulf oil spill cleanup operation and compared them with the standard normal range values. In brief, the results of this analysis indicate that a considerable number of exposed subjects exhibited altered biomarkers above the upper limits of the normalized range.[7] Thus, these results support our earlier published findings. These details can be found in this issue of the Journal.

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The Reply

We appreciate the comments of Wickliffe et al[1] on our article published recently in The American Journal of Medicine.[2] We strongly disagree with both their opinion and conclusions. We followed very well-established standard study designs for clinical research and the outcomes (clinical biomarkers). The results were subsequently interpreted and discussed appropriately with existing literature. With regard to their criticisms, we have serious concerns about their analysis of the data presented in our published article. More specifically, there are inconstencies in the data presented in Table 1 by Wickliffe et al. For instance, their data do not reflect the actual data of Table 2 in our article published in The American Journal of Medicine.[2] It appears that these authors derived the low and high values by subtracting or adding the standard deviations from or to the mean values of Table 2, producing completely erroneous values from the actual data that we used in our analysis. In addition, more errors were made in calculating values for some variables that they presented in Table 1. Moreover, there are no data that correspond to males or females in Table 2 of our article. Assuming that the source of data for male and female (hemoglobin, hematocrit, and creatinine levels) was from Table 4 of our published article, we noticed inconsistencies in calculating low and high values. Further, the reference links provided by Wickliffe et al in support of their data presented in Table 1 could not be accessed. Thus, we believe that these authors based their criticism on their flawed data used in Table 1 and are not valid to derive any accurate conclusions about our published work.

It should be noted that our study is not based on epidemiological analysis, as Wickliffe et al have attempted to argue, to deal with convenience sampling and case-control matching. It is a retrospective clinical study that has been carried out using a well-accepted clinical research study design. The selection of subjects both unexposed and exposed to the oil spill was described clearly in the study. In ideal situations, the best control for our study would have been the same subjects whose health analysis was made before and after the oil spill exposure so that the evaluation of their clinical biomarkers could provide a better understanding of the effect of the oil spill exposure on their health. Unfortunately, we lacked the data before their exposure to the oil spill and therefore, an unbiased control group of subjects was included in the study.

As noted by Wickliffe et al, the clinical biomarker values do fall within a range of normalized values, however, several biomarker values differ significantly between the oil-exposed and -unexposed (control) groups, indicating potential health risks in subjects exposed to the oil spill. Our study was the first of its kind to analyze the hematological and hepatic effects in the oil spill-exposed subjects. There exist a number of other studies that have evaluated hematological and other functions in subjects exposed to benzene in relation to control or unexposed subjects.[3-6] Significant differences were seen in various clinical biomarkers despite values of these markers falling under the range of normalized values. We believe that the study is hypothesis driven with clear objectives, and the conclusions drawn were valid. These findings can serve as a basis for future prospective studies that can explore the health effects of the oil spill exposure. Thus, the findings of our study provide valuable information on the health consequences among subjects exposed to the oil spill.

In order to further clarify issues raised by Wickliffe et al, we performed additional analysis of the clinical data of the oil spill-exposed subjects. In this second analysis, we assessed the blood profiles and liver function data of the subjects who participated in the Gulf oil spill clean-up operations and compared them with the standard normalized range values. In brief, the results of this analysis indicate that a considerable number of exposed subjects exhibited altered biomarkers above the upper limits of the normal range. Thus, these results support our earlier study findings published in the Journal.[7] The details of the outcomes can be found in the accompanying article.

It should be noted that unlike Wickliffe et al, who disclosed direct or indirect sponsored grants from several agencies including British Petroleum, our study was not supported by any outside funding agencies. It was a self-supported and self-motivated study with no bias, and based on the actual data gathered from medical records. The strengths and weaknesses of the study were discussed in detail and the conclusions drawn from the study are valid.

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Sent: Fri 10/30/2015 7:30:18 PM
Subject: State-of-Science: Public Health Group
2015.10.09_Public Health and Food Security.docx
Suggestions from John French_new concerns and references.docx

Dear Public Health panel:

John French has submitted additional publications for the panel to review. To view these additional publications please go to this link >> https://unh.box.com/s/nzispucuqrlh7snbm0fqen647l3uo7gp. Attached you will find John's proposed suggestions and comments to be addressed by this panel.

I've also attached the latest version of our working document for your perusal.

And finally, we would like to schedule another meeting to discuss these documents. Please use this doodle poll (by 11/3) to select all available time slots you could be available to meet next. This doodle poll is time zone enabled. http://doodle.com/poll/q8w35yd5ad4kvs9k

Please let me know how you would like your name and affiliation noted at the end of this document. Thanks to each of you for your assistance in preparing this thorough document!

Kathy Mandsager

Program Coordinator

Coastal Response Research Center

Center for Spills and Environmental Hazards

234 Gregg Hall, Colovos Rd

University of New Hampshire

Durham, NH 03824

603.862.1545

To: 'sarah.allan@noaa.gov'[sarah.allan@noaa.gov]; Barron, Mace[Barron.Mace@epa.gov]; 'abejarano@researchplanning.com'[abejarano@researchplanning.com]; 'jewel_bennett@fws.gov'[jewel_bennett@fws.gov]; 'DFrenchMcCay@asascience.com'[DFrenchMcCay@asascience.com]; 'peter.hodson@queensu.ca'[peter.hodson@queensu.ca]; sharon.hook@csiro.au[sharon.hook@csiro.au]; 'rrhopcroft@alaska.edu'[rrhopcroft@alaska.edu]; John Incardona - NOAA Federal[john.incardona@noaa.gov]; 'Angela_Matz@fws.gov'[Angela_Matz@fws.gov]; 'Teri.Rowles@noaa.gov'[Teri.Rowles@noaa.gov]; mathijs.smit@shell.com[mathijs.smit@shell.com]; Sprenger, Mark[Sprenger.Mark@epa.gov]; 'Robert.Suydam@north-slope.org'[Robert.Suydam@north-slope.org]; 'rstjeerdema@ucdavis.edu'[rstjeerdema@ucdavis.edu]; 'dana@mote.org'[dana@mote.org]; 'john.wise.sr@gmail.com'[john.wise.sr@gmail.com]; 'BGardiner@environcorp.com'[BGardiner@environcorp.com]; 'mhziccardi@ucdavis.edu'[mhziccardi@ucdavis.edu]
Cc: Ian Gaudreau[iangaudreau@gmail.com]; Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Mandsager, Kathy
Sent: Fri 9/18/2015 6:44:19 PM
Subject: RE: State-of-Science dispersant use in Arctic water: TOXICITY group - doodle poll for next meeting
2015.08.17_Toxicity and Sublethal Impacts.docx

Just a friendly reminder of our meeting on Monday beginning at 2ET.

Attached is latest draft of our document. I will need to know your name, title and affiliation exactly as you would like it listed at the end of this document.

From: Mandsager, Kathy
Sent: Friday, September 11, 2015 12:07 PM

We have a majority! Please mark your calendars for **Monday 9/21 beginning at 2pm ET**.

Attached is the latest version of the document for your review prior to this call.

I will send all of this information in a calendar request as well. WebEx instructions here>>

State-of-Science: Toxicity Group
Monday, September 21, 2015
2:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 3 hrs

Join WebEx meeting

Meeting number: 736 235 319

Join by phone
1-855-244-8681 Call-in toll-free number (US/Canada)
1-650-479-3207 Call-in toll number (US/Canada)
Access code: 736 235 319
Global call-in numbers | Toll-free calling restrictions

Can't join the meeting? Contact support.

From: Mandsager, Kathy
Sent: Tuesday, September 08, 2015 11:36 AM
To: 'sarah.allan@noaa.gov' <sarah.allan@noaa.gov>; 'Barron.Mace@epa.gov' <Barron.Mace@epa.gov>; 'abejarano@researchplanning.com' <abejarano@researchplanning.com>; 'jewel_bennett@fws.gov' <jewel_bennett@fws.gov>; 'DFrenchMcCay@asascience.com' <DFrenchMcCay@asascience.com>; 'peter.hodson@queensu.ca' <peter.hodson@queensu.ca>; sharon.hook@csiro.au; 'rrhopcroft@alaska.edu' <rrhopcroft@alaska.edu>; 'John Incardona - NOAA Federal' <john.incardona@noaa.gov>; 'Angela_Matz@fws.gov' <Angela_Matz@fws.gov>; 'Teri.Rowles@noaa.gov' <Teri.Rowles@noaa.gov>; 'mathijs.smit@shell.com'

<mathijs.smit@shell.com>; Sprenger, Mark <Sprenger.Mark@epa.gov> (Sprenger.Mark@epa.gov) <Sprenger.Mark@epa.gov>; 'Robert.Suydam@north-slope.org' <Robert.Suydam@north-slope.org>; 'rstjeerdema@ucdavis.edu' <rstjeerdema@ucdavis.edu>; 'dana@mote.org' <dana@mote.org>; 'john.wise.sr@gmail.com' <john.wise.sr@gmail.com>; 'BGardiner@environcorp.com' <BGardiner@environcorp.com>; 'mhziccardi@ucdavis.edu' <mhziccardi@ucdavis.edu>
Subject: State-of-Science dispersant use in Arctic water: TOXICITY group - doodle poll for next meeting

Dear Toxicity Group:

I would like to schedule yet another WebEx to continue the discussion on this paper. Although we are nearing the end, we do need to have **a fish and mammals** discussion. Please fill out the doodle poll as soon as possible so we can confirm a date for a potential 3-hour call this month. All are invited to participate in this discussion, but we must have the fish and mammals folks on the call for this discussion.

Doodle poll (time zone enabled) for dates in September>>
http://doodle.com/poll/t5h37gydqctcm5mf

Thank you!

Kathy Mandsager

Program Coordinator

Coastal Response Research Center

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Cc: Ian Gaudreau[iangaudreau@gmail.com]; Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]
From: Mandsager, Kathy
Sent: Fri 9/11/2015 4:07:25 PM
Subject: RE: State-of-Science dispersant use in Arctic water: TOXICITY group - doodle poll for next meeting
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State-of-Science: Toxicity Group
Monday, September 21, 2015
2:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 3 hrs

Join WebEx meeting

Meeting number: 736 235 319

Join by phone
1-855-244-8681 Call-in toll-free number (US/Canada)
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Subject: State-of-Science dispersant use in Arctic water: TOXICITY group - doodle poll for next meeting

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Thank you!

Kathy Mandsager

Program Coordinator

Coastal Response Research Center

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To: Ian Gaudreau[iangaudreau@gmail.com]; Mandsager, Kathy[kathy.mandsager@unh.edu]
Cc: chris.barker@noaa.gov[chris.barker@noaa.gov]; Barth, Edwin[Barth.Ed@epa.gov]; Conmy, Robyn[Conmy.Robyn@epa.gov]; thomas.s.coolbaugh@exxonmobil.com[thomas.s.coolbaugh@exxonmobil.com]; fingasmerv@shaw.ca[fingasmerv@shaw.ca]; ali.khelifa@ec.gc.ca[ali.khelifa@ec.gc.ca]; ken.lee@csiro.au[ken.lee@csiro.au]; jrpayne@sbcglobal.net[jrpayne@sbcglobal.net]; wspegau@pwssc.org[wspegau@pwssc.org]; crescent.moegling@noaa.gov[crescent.moegling@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]
From: CJ Beegle-Krause
Sent: Fri 8/21/2015 6:30:34 PM
Subject: RE: State-of-Science dispersant in Arctic: Transport & Behavior group - next call on 8/21
FuGongZhaoOReillyZhao_2014.pdf

Hi Ian, Please check that this is the correct Fu et al reference. - CJ

From: Ian Gaudreau [mailto:iangaudreau@gmail.com]
Sent: 20. august 2015 18:59
To: Mandsager, Kathy
Cc: chris.barker@noaa.gov; barth.ed@epa.gov; CJ Beegle-Krause; Conmy, Robyn; thomas.s.coolbaugh@exxonmobil.com; fingasmerv@shaw.ca; ali.khelifa@ec.gc.ca; ken.lee@csiro.au; jrpayne@sbcglobal.net; wspegau@pwssc.org; crescent.moegling@noaa.gov; doug.helton@noaa.gov; Gary Shigenaka - NOAA Federal; wilson.gregory@epa.gov; principe.vanessa@epa.gov
Subject: Re: State-of-Science dispersant in Arctic: Transport & Behavior group - next call on 8/21

Friendly reminder that our next Physical Transport & Chemical Behavior meeting will be **Friday, August 21 at 1:00pm EDT**. Attached is the most recent version of the document, as well as the Aman et al. 2015 paper, which we will be discussing tomorrow.

WebEx instructions below.

See you then!

Ian

On Wed, Aug 5, 2015 at 2:11 PM, Mandsager, Kathy <kathy.mandsager@unh.edu> wrote:

Confirming our next call for **Friday 21 August** beginning at 1:00 pm ET via WebEx (instructions below). I will also send this information via calendar request.

Tasks:

- Please review the attached Aman 2015 paper in order to include appropriate conclusions
- There are still a few references needed (or clarified) in order for Ian to include them in the database
- Please review for any specific notations with your name and also advise us on how you would like your name, title and affiliation listed at the bottom of this document

We look forward to what we think will be our final document. Thank you!

State-of-Science for dispersants: Transport & Behavior Group
Friday, August 21, 2015
1:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

Join WebEx meeting

Meeting number: 736 793 006

Join by phone
1-855-244-8681 Call-in toll-free number (US/Canada)

1-650-479-3207 Call-in toll number (US/Canada)
Access code: 736 793 006
Global call-in numbers | Toll-free calling restrictions

Can't join the meeting? Contact support.

--

Ian Gaudreau

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Environmental Science & Technology

Article

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Effects of Oil and Dispersant on Formation of Marine Oil Snow and Transport of Oil Hydrocarbons

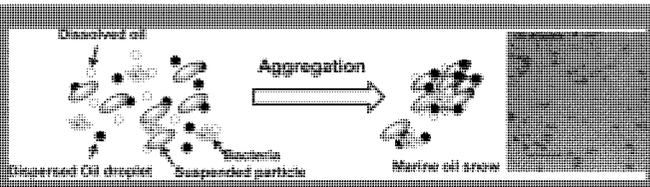
Jie Fu,[†] Yanyan Gong,[†] Xiao Zhao,[†] S. E. O'Reilly,[‡] and Dongye Zhao*,[†]

[†]Environmental Engineering Program, Department of Civil Engineering, Auburn University, Auburn, Alabama 36849, United States

[‡]U.S. Department of the Interior, Gulf of Mexico OCS, Office of Environment, New Orleans, Louisiana 70123, United States

* Supporting Information

This work explored the formation mechanism of marine oil snow (MOS) and the associated transport of oil hydrocarbons in the presence of a sweetype oil dispersant, Corexit EC9500A. Roller tube experiments were carried out to simulate natural marine processes that lead to formation of marine snow. We found that both oil and the dispersant greatly promoted the formation of MOS, and MOS flocs as large as 1.6–2.1 mm (mean diameter) were developed within 3–6 days. Natural suspended solids and indigenous microorganisms play critical roles in the MOS formation. The addition of oil and the dispersant greatly enhanced the bacterial growth and extracellular polymeric substance (EPS) content, resulting in increased flocculation and formation of MOS. The dispersant not only enhanced dissolution of n-alkanes (C9–C40) from oil slicks into the aqueous phase, but facilitated sorption of more oil components onto MOS. The incorporation of oil droplets in MOS resulted in a two-way (rising and sinking) transport of the MOS particles. More lower-molecular-weight (LMW) n-alkanes (C8–C18) were partitioned in MOS than in the aqueous phase in the presence of the dispersant. The information can aid in our understanding of dispersant effects on MOS formation and oil transport following an oil spill event.



INTRODUCTION

Marine snow (MS) refers to a class of organic and inorganic particles or aggregates (≥0.5 mm) naturally formed in the ocean, consisting of minerals, detritus, bacteria mucus, phytoplankton, and zooplankton feces.[1,2] Marine snow is ubiquitous in the ocean, and plays an important role in downward transport of materials and energy by gravitational settling.[3] Marine snow can be an important food source for organisms living in the aphotic zone.[4] While the exact formation mechanism of MS is quite complex, it is believed that both physicochemical processes (e.g., coagulation and flocculation) and microbial actions are involved.[2]

The 2010 Deepwater Horizon (DwH) oil spill incident gushed approximately 4.9 million barrels (779 million liters) of South Louisiana Sweet Crude oil into the Gulf of Mexico.[5,6] To mitigate the environmental impacts, ~2.1 million gallons (7.9 million liters) of chemical dispersants (Corexit EC9500A and Corexit 9527A) were applied at the sea surface and near the 1500 m deep wellhead.[7] In May 2010, shortly after the onset of the DwH oil spill, oil-associated marine snow (hereafter referred to as marine oil snow, MOS) of very large floc size (>1 cm) was observed at the surface in the vicinity of the spilled oil slicks near the oil platform.[1] During the spill, a continuous oil plume was reported about 10 miles long, 3 miles wide (16.9 × 4.83 km^2), and up to 400 ft (122 m) in depth, and the plume persisted for months without appreciable biodegradation.[8] While the mechanisms of plume formation are complex and largely unknown, the following factors have been cited to have a role: the interplay of gas and oil in multiphase flow, preferential solubility of each oil constituent, and potential gas hydrate formation.[8,9] However, the role of oil, the dispersants and dispersed oil in the oil plume formation or formation of MOS has not been addressed.

We hypothesize that oil and oil dispersants will interact with suspended particulate matter (SPM), and thus impact the formation of MOS. Furthermore, MOS will play an important role in transporting oil components in different environmental compartments.[10] Many investigations have indicated that accumulation of oil aggregates, dispersant components, minerals, and biologically derived solids on the seafloor is associated with the DwH oil spill.[11,12] Researchers[13] observed that some brown flocculent (likely MOS) induced widespread signs of stress for seafloor coral colonies following the DwH incident. Yet, the role of MOS in the material transport process remains unexplored.

The most important factors that can affect formation of MOS include the hydrodynamic conditions, collision rate of suspended mineral particles, biologically derived mucus and biopolymer, interactions of oil components with SPM, particle coagulation/flocculation characteristics, and interactions of oil components with microorganisms.[1] In addition, based on our recent work,[5,6] oil dispersants can significantly facilitate uptake of oil components on sediment particles, and dispersed oil is likely more adsorbable to SPM. However, detailed information remains lacking on how oil and dispersants impact the formation rate and characteristics of MOS. Moreover, it is not clear whether

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Revised: November 16, 2014
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Published: November 24, 2014

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ED_001324_00007043-00001

Table 1. Observations of Marine Snow Formation during Roller Table Experiments

case	formation of MS[a]	aggregates type	maximum D_m	aggregation rate[c]	sinking behavior	floating behavior
I: untreated seawater only	no	/	0.48 mm (day 25)	24.9 d^{-1}	7.68 mm/s[d] (day 28)	no
II: untreated seawater + oil	yes (day 2[b])	flocs, strips (day 6)	2.10 mm (day 6)	31.8 d^{-1}	15.76 mm/s (day 9)	day 6[e], 9.34 mm/s (day 14)
III: untreated seawater + dispersant	yes (day 1)	flocs	1.65 mm (day 3)	32.2 d^{-1}	14.81 mm/s (day 3)	no
IV: untreated seawater + oil and dispersant	yes (day 2)	flocs	1.55 mm (day 4)	26.3 d^{-1}	5.90 mm/s (day 2)	day 3, 4.98 mm/s (day 19)
V: microfiltered seawater + oil	no	/	/	/	/	/
VI: sterilized seawater only	no	/	0.34 mm (day 26)	9.6 d^{-1}	3.61 mm/s (day 28)	no
VII: sterilized seawater + oil	no	/	0.39 mm (day 12)	21.8 d^{-1}	3.14 mm/s (day 28)	no

[a]A D_m of >0.5 mm indicates formation of MS [b]Appearance time [c]Aggregation rate = (particle number at Day 28 − initial particle number)/28 [d]Maximum V_{ms} or V_{mf} [e]Time of first appearance

or how MOS facilitates uptake and transport of important oil components.

The overall goal of this work was to investigate the effects of oil and oil dispersants on the formation of MOS. The specific objectives were to (1) investigate the formation of artificial marine snow through roller table experiments in the presence of oil and a prototype oil dispersant (Corexit EC9500A), (2) evaluate the role of natural suspended solids, especially indigenous microorganisms, in the formation of MOS, (3) characterize physical properties (number, size, and sinking/rising velocity) of MOS, and (4) examine the influence of MOS on the fate and transport of spilled oil.

MATERIALS AND METHODS

Materials. Seawater samples were collected from the top water column (30 cm) at Grand Bay, AL (30°37′45″ N, 88°18′25″ W) in October 2012. Key physicochemical properties of the seawater include pH = 7.6 ± 0.1, dissolved organic carbon (DOC) = 0.70 ± 0.2 mg/L, total dissolved solid (TDS) = 30 ± 1 g/L, suspended solids (SS) = 34.2 ± 0.8 mg/L, Cl^- = 16.79 g/L, Na^+ = 9.87 g/L, SO_4^{2-} = 2.48 g/L, Mg^{2+} = 1.13 g/L and ionic strength (IS) = 0.60 M. A surrogate Louisiana Sweet Crude oil (LSC) was acquired through the courtesy of BP in America (Houston, TX), which mimics the BP Macondo well oil.[14] Corexit EC9500A was acquired through the courtesy of Nalco Company (Naperville, IL). All chemicals used in this study were of analytical or higher grade and obtained from Sigma-Aldrich (St. Louis, MO) or Fisher Scientific (Fair lawn, NJ).

Roller Table Experiments. Roller table experiments were conducted using 755 RMV Jar Mills (45.0 cm × 28.6 cm × 34.9 cm, U.S. Stoneware, East Palestine, OH) and 250 mL Boston round glass bottles (6 cm × 13.6 cm). Experiments were designed to test MS/MOS formation under seven scenarios: (I) untreated seawater only; (II) untreated seawater + oil; (III) untreated seawater + dispersant; (IV) untreated seawater + oil and dispersant; (V) microfiltered seawater + oil; (VI) sterilized seawater only; and (VII) sterilized seawater + oil. The doses of oil and dispersant were set at 0.06% (v/v, oil/seawater) and 1:20 (dispersant/oil), respectively. Oil was injected into the upper water column and there was no headspace in the bottles. In selected cases, microfiltration was exercised using 0.45 μm cellulose nitrate membranes to remove the SPM from the seawater, and seawater sterilization was carried out by autoclaving the seawater at 121 °C for 35 min. In each scenario, the bottles were incubated for 28 days at room temperature (22 ± 1 °C). The rotation speed was set at 20 rpm to keep MS/MOS suspended. On a daily basis, the bottles were removed from the roller tables and placed up-right to allow the MS/MOS to sink/rise to the bottom/top. Then, the bottles were gently turned over to initiate resinking/rising of the flocs. The morphology and motion of the MS/MOS flocs were then recorded through photographic imaging and video recording with a Canon EOS 600D camera and a Digital IXUS 80 IS camera (Tokyo, Japan). All tests were carried out in duplicate.

Characterization of Marine Snow Particles. Four parameters were used to characterize the MS/MOS particles, that is, particle number (N), mean diameter (D_m, mm), total volume (TV, mm^3), and mean sinking/rising velocity (V_{ms} or V_{mf}, mm/s). D_m is defined as the average particle size measured at 2 degree intervals and passing through the particle's centroid. TV is calculated from the equivalent spherical volume. A smaller particle size or higher number density favors incorporation of more oil into the particles; and a larger TV is associated with a looser and less stable structure of the flocs. Details on the characterization of MS/MOS particles are described in Section S1 of the Supporting Information (SI).

Total Bacteria Counting and Determination of Extracellular Polymeric Substance. The total bacteria numbers (TBN) in cases I−IV (with untreated seawater) after predetermined incubation times (0, 2, 14, and 28 days) were estimated following the fluorochrome staining method.[15] In addition, the extracellular polymeric substance (EPS) in Cases I−IV incubated for 0, 2, 14, and 28 days were extracted and determined through the gravimetric method. Details on the methods for quantifying TBN and EPS are described in Section S2 of the SI.

Analytical Methods. Section S3 in the SI gives methods for the seawater analysis. n-Alkanes (C9−C40) in the aqueous phase and in MS/MOS were determined using gas chromatography−mass spectrometry (GC-MS) by modifying the method by Liu et al.[12] The seawater or MS/MOS samples were first extracted with dichloromethane/n-hexane (1:1, v/v), concentrated and then analyzed by GC-MS. Details on the extraction method and GC-MS programing are described in Section S4 of the SI.

RESULTS AND DISCUSSION

Formation of MS/MOS. Table 1 summarizes the observations on the MS/MOS formation during the roller table experiments for the aforementioned seven cases. In Case I, the suspended particles in the raw water gradually aggregated over

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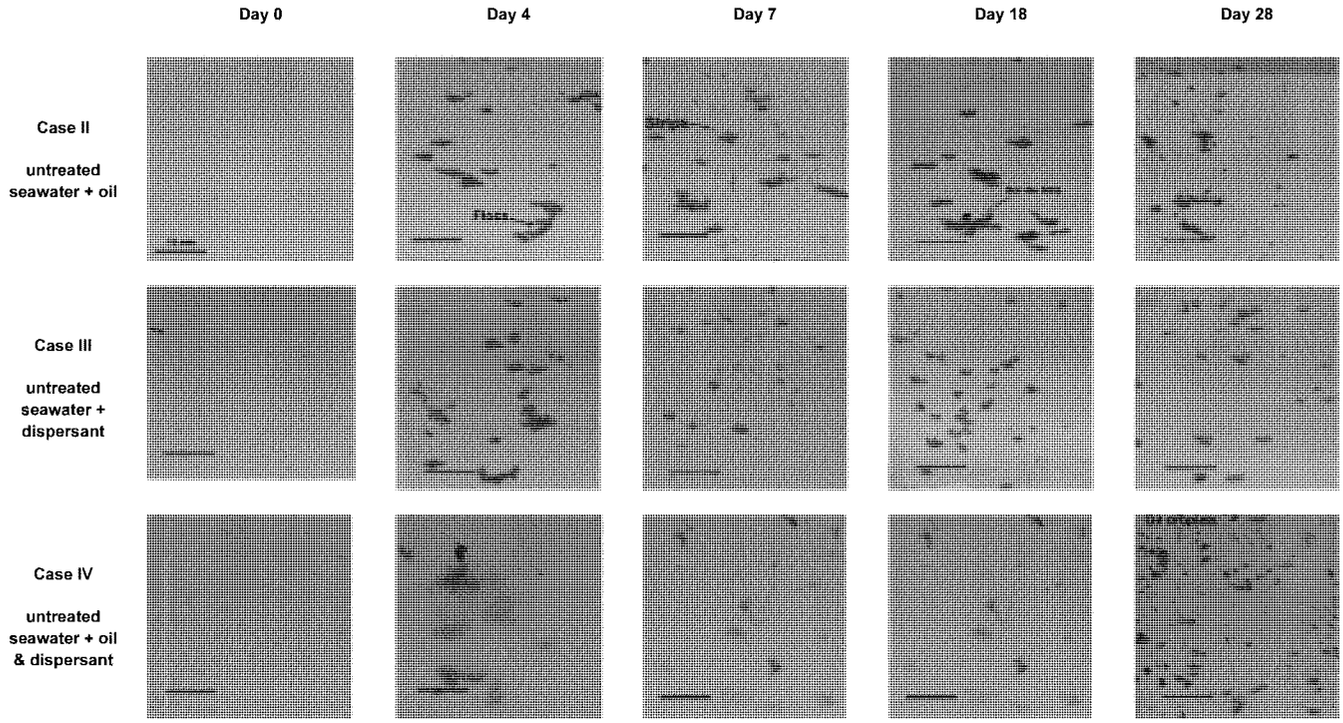

Figure 1. Morphological change of particle aggregates in Cases II−IV during 28-day roller table experiments. Case II: seawater + LSC oil (0.06%, v/v); Case III: seawater + Corexit EC9500A (0.003%, v/v); and Case IV: sweater + LSC oil (0.06%, v/v) + Corexit EC9500A (0.003%, v/v). All bottles (250 mL) were incubated at room temperature (22 ± 1 °C) at a rotation speed of 20 rpm. Scale bar = 10 mm.

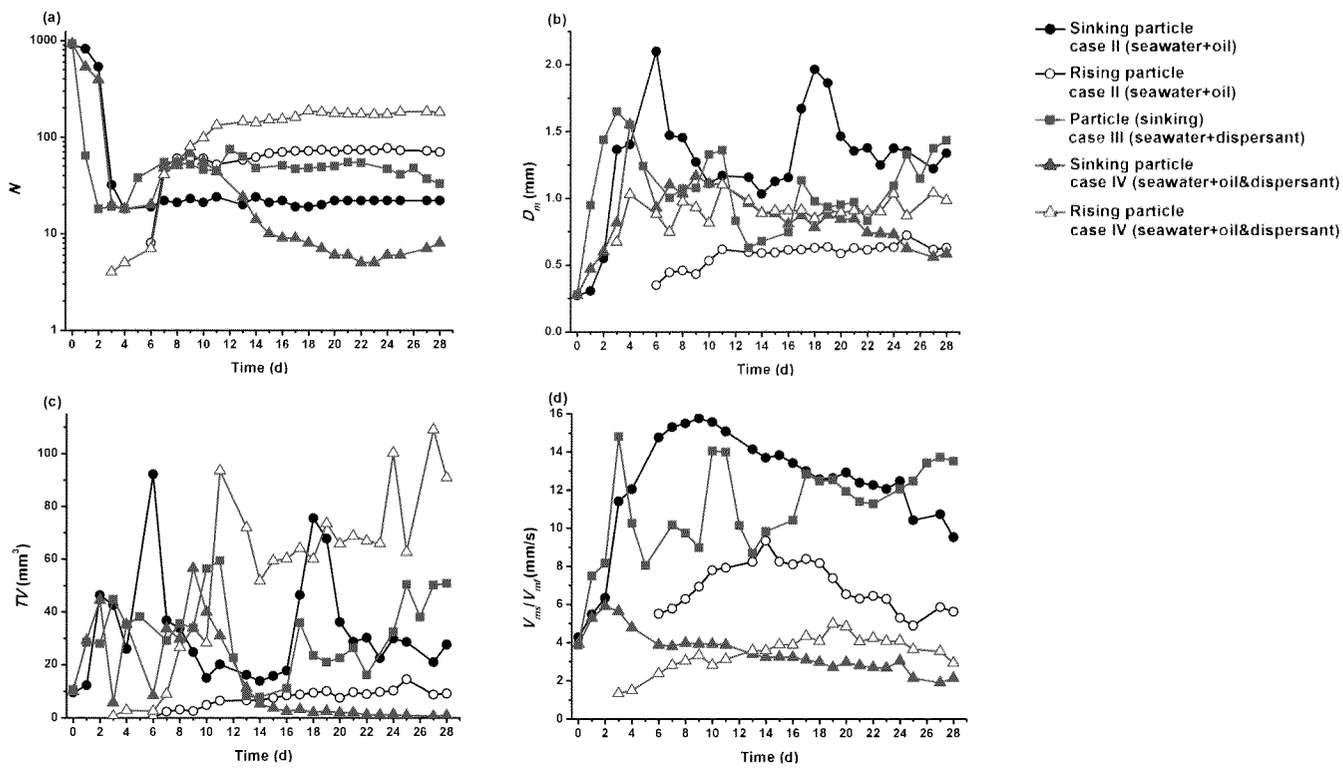

Figure 2. Changes of marine snow characteristics in Cases II−IV during 28-day roller table experiments: (a) particle number (N), (b) mean diameter (D_m), (c) total volume (TV), and (d) mean sinking and rising velocity (V_{ms} and V_{mr}).

the experimental period (N reduced from 956 ± 32 to 258 ± 25). While aggregates were observed with a maximum D_m of 0.48 mm, which is slightly smaller than the threshold of 0.5 mm.[2,16] As such, no typical MS was formed in Case I.

In Case II, the presence of oil greatly speeded up particle aggregation, and large MS flocs were formed in 2 days (Table 1). At Day 6, the smallest N (19 ± 3), and the largest D_m (2.10 mm) and TV (92.17 mm^3) were obtained (Figures 1, 2a−c). The

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formed MS flocs appeared relatively elongated, though largely irregular, and showed a high V_{ms} (15.76 mm/s) (Table 1 and Figure 2d). Afterward, the flocs number remained stable at approximately 22. From Day 6 on, some oil droplets were formed (due to mechanical dispersion and bacterial activities) and became incorporated into the MS flocs and smaller SPM seeds, resulting in more fine strip-like particles (N > 70) with a relatively bigger head of oil droplet (approximately 0.5 mm in diameter) and a mineral tail (1−2 mm in length) (Figure 1). The MS/MOS particles formed during the initial stage (≤6 d) tended to settle by gravity, whereas those strips with sufficient oil incorporated were lighter than water, and thus, ascended at a relatively high V_{mr} (9.34 mm/s) (Figure 2d). From day 16 to 18, an interesting phenomenon was observed · a large oil droplet of approximately 2 mm in diameter was incorporated into a floc and further became interwoven with several flocs to form a large star-like MOS (Figure 1). After day 19, with the dissipation of the oil droplet, this large MOS gradually disassembled.

The addition of the dispersant (Case III) resulted in rapid formation of MS in 1 day (Table 1). The resulting flocs were generally smaller with a lower V_{ms} (14.81 mm/s) than in Case II (Figures 1, 2b, 2d). On Day 3, the largest D_m (1.65 mm) and lowest N (19 ± 2) were observed. The flocs were then split into smaller ones gradually. On Day 12, the particle number grew to 75 ± 2, and subsequently, the MS flocs slowly reaggregated (Figures 1, 2a, 2b).

In the presence of both dispersant and oil (Case IV), the natural suspended particles aggregated rapidly to form large flocs within 2 days (Table 1). At Day 4, the largest flocs (D_m = 1.55 mm) were formed and the liquid appeared translucent with a sandy color (Figures 1, 2b). After Day 4, these large flocs were broken into many smaller ones with the incorporation of oil droplets. The formed oil droplets in Case IV were mostly less than 0.1 mm, which were much smaller than those in Case II. It is noteworthy that from Day 3 on, the previously sinking flocs gradually began to rise due to the incorporation of oil droplets or oil components of lower density. On Day 28, only a few small particles sank (Figure 2), while most MOS either floated at the surface or suspended in the water column. Compared with Cases II and III, more and smaller flocs (N = 190 ± 10, D_m = 0.58−0.98 mm) were formed in the presence of the dispersed oil at the end of incubation with a slower V_{ms} or V_{mr} (2.14 and 2.93 mm/s, respectively), and the TV of these flocs was much higher (90.9 mm^3) (Figure 2c). The sinking velocity of collected MS in the Gulf of Mexico ranged from 68 to 553 m/d.[1] In our study, the sinking velocities in Cases II−IV were 369−1361, 332−1280, and 164−510 m/d, respectively. The faster velocities from this can be attributed to the relatively higher turbulence in the experiments, leading to formation of denser MS/MOS. A sample video is provided in SI (Video S1) to demonstrate the motion of MS flocs in Cases II−IV.

No MS was generated in the microfiltrated seawater even in the presence of oil (Case V) (Table 1). The particles aggregation in sterilized seawater (Cases VI and VII) was quite slow compared with Cases I−IV and no MS was formed (Table 1).

Formation Mechanism of MOS and Effects of Oil and Dispersant. Proper turbulence can induce suspension of the particles and facilitate particle collisions.[17] Based on our preliminary work and work by others, the roller table approach provided sufficient rotational turbulence, which kept the particles in suspension, increased the collision rate between suspended particles and facilitated the particle aggregation,[18] while simulating conditions near the sea surface.

No MS was formed under the particle-free conditions even in the presence of oil (Case V, Table 1), indicating that the particulate matters were essential for the formation of MS. The lack of sufficient sticky particulate matters may account for the reported observation that there was no MOS formed in situ in the deepwater−oil plumes following the 2010 DWH oil spill,[1] i.e., the plumes are likely composed of mostly dispersed oil droplets.

As most particles in marine system carry net negative charges, the classical Derjaguin−Landau−Verwey−Overbeek (DLVO) theory can be used to interpret the collision and adhesion of these like-charged particles.[19] According to this theory, the forces governing the particle interactions are the van der Waals attraction (WA) and the electrostatic repulsion (ER).[20] When the collision energy overcomes the primary maximum energy barrier to reach the primary minimum, aggregation will occur; alternatively, when it falls in the secondary minimum domain, flocculation takes place. In this work, the breakup of the initially formed large MS/MOS flocs suggested that the flocculation was at least partially reversible, that is, the secondary minimum was an important mechanism in the formation of MS/MOS. The total volume of MS/MOS in cases II−IV increased from 9.5 to 27.6 mm^3, 10.0 to 91.7 mm^3, and 10.6 to 50.8 mm^3, respectively, during the 28 day incubation (Figure 2c). The TV of sinking flocs in case IV fluctuated remarkably in the initial 7 days, indicating the instability of the young MOS structure.

Due to the presence of the organic substances (i.e., oil hydrocarbons, dispersants and EPS), the non-DLVO forces (e.g., hydrophobic force and Lewis acid−base interactions) also play important roles in the formation of MS/MOS. The organic substances increase the surface friction or stickiness, leading to sticky collisions, which are more effective than elastic collisions. Consequently, not only more MS/MOS flocs are formed, but the flocs are likely bulkier because of the heat effect due to the transfer of more kinetic energy into the internal energy.

The experimental results also revealed that the indigenous microbes play a critical role in the particle aggregation and formation of MS/MOS. Of the seven cases, the lowest particle aggregation rate was found in Cases VI and VII (9.6 and 21.8 d^{-1}, respectively, Table 1), where the seawater was sterilized. This observation reveals that the bacteria activity plays a critical role in the formation of MS. In fact, bacteria are known to produce sticky matters, that is, EPS, which can be incorporated in the suspended particles to form mucus matrices that facilitate particle aggregation and MS formation.[1] The main contents of EPS are carbohydrate, protein and nucleic acid, and these macromolecules can cause aggregation of particles through sweep flocculation and bridging effect.[21] The functional groups of EPS include carboxylic, hydroxyl, and amino ions,[22] which can mediate particle aggregation through electrostatic and Lewis acid−base interactions.[23] Figure 3 shows that both TBN and EPS in Cases I−IV rapidly increased with the particle aggregation from day 1 to 14, indicating the important role of EPS in the MS/MOS formation process.

The much enhanced MS/MOS formation in Cases II−IV (Table 1) indicated the important role of oil and the dispersant. Dissolved/dispersed oil hydrocarbons in aqueous solutions can compress the diffuse layer surrounding the particles and reduce the repulsive energy, and thus, promoting the aggregation of particles.[24] In addition, the incorporation of the oil/dispersant hydrocarbons can enhance the hydrophobic interactions between SPMs, leading to the accelerated aggregation rates.[25] Such a snowballing effect continues until a dynamic steady state

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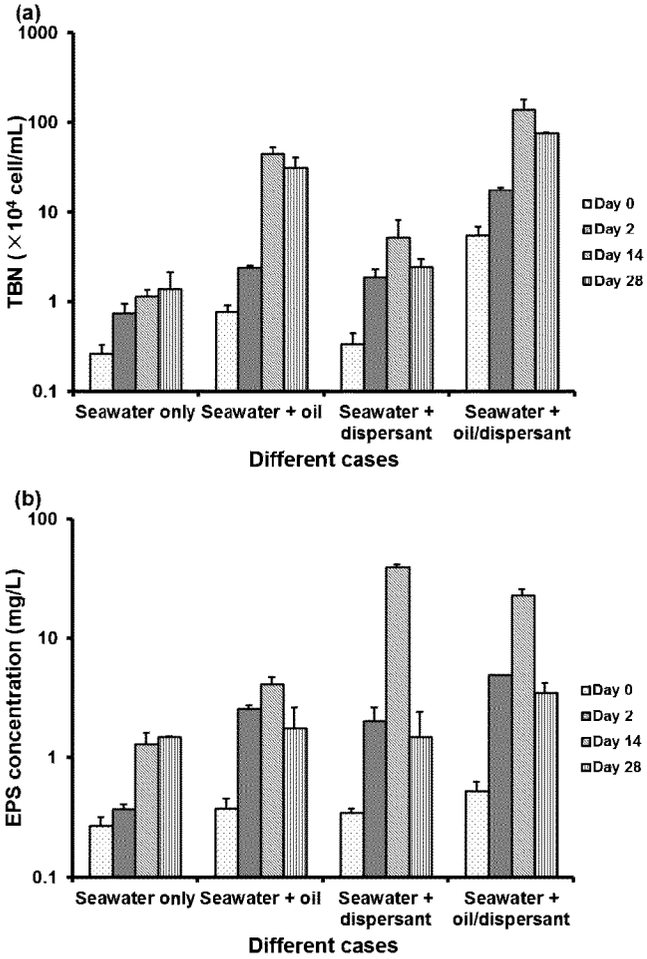

Figure 3. (a) Total bacterial number (TBN) and (b) extracellular polymeric substances (EPS) concentration in Cases I−IV at days 0, 2, 14, and 28, respectively.

is reached, where the particle growth is counterbalanced by the shearing forces.

The results also enunciate the profound role of the interactions between oil and indigenous bacteria/EPS in promoting the formation of MOS. In the initial 4 days, N in Case II was reduced from 912 ± 28 to 18 ± 3 with an aggregation rate of 223.5 d^{-1} (Figure 2a). Several factors are responsible for the effect. First, the dissolved/dispersed oil hydrocarbons enhanced the bacteria growth by serving as additional carbon and energy sources, which in turn resulted in more EPS or mucus substances. For instance, TBN and EPS in Case II at Day 2 were 2.38 ± 0.14 × 10^4 cells/mL and 2.59 ± 0.17 mg/L, respectively, which were 3.2- and 7-fold higher than those in Case I (Figure 3). Second, the biosurfactants produced by bacteria can emulsify the oil to increase bioavailability of the hydrocarbons[26] and enhance interactions between the hydrocarbons and suspended particles. This is supported by the observation that fine oil droplets were formed in Case II from Day 6 on until Day 28 (50−60 oil droplets at Day 28). However, in Case VII without the bacteria, only a few oil droplets were discernible in the end of the incubation.

Case III reveals that the dispersant alone was able to accelerate the formation of MS (Table 1). The N value was reduced from 934 ± 99 to 18 ± 4 in the first 2 days with an aggregation rate of 458 d^{-1} (Figure 2a), which was even faster than the oil-facilitated MOS formation (Case II). Corexit EC9500A consists of both nonionic and anionic surfactants, and organic solvent (including kerosene).[27] Therefore, the aforementioned oil-facilitated aggregation mechanisms remain operative due to the presence of hydrophobic tails and kerosene. Moreover, the uptake of the surfactants renders the particle surface more hydrophobic, promoting the attractive hydrophobic interactions between particles.[28] Surfactants also promote the adsorption of hydrocarbons and EPS by suspended particles.[6,29] Furthermore, the dispersant components are biodegradable and may serve as carbon and energy sources that stimulate the microbial activities.[30] Figure 3 shows that the dispersant greatly elevated the TBN and especially EPS levels. At Day 14, TBN in Case III increased by 15.3-fold compared with the initial level, while TBN in Case I increased by only 4.3-fold; At Day 14, the EPS content in Cases III increased by 115.0-fold, compared to only 4.8- and 11.0-fold respectively for Cases I and II.

Interestingly, the combination of oil and the dispersant (Case IV) did not show an additional or synergistic effect in terms of aggregation rate. In the first 3 days, N in Case IV was reduced from 925 ± 126 to 23 ± 4 with an aggregation rate of 301 d^{-1} (Figure 2a), which is between those in Cases II (oil only) and III (dispersant only). This is possible because the interactions between oil and the dispersant prevent either oil or the dispersant from fully exerting its individual role. Compared with Cases II and III, the flocs in Case IV were more abundant in number, larger in volume, but relatively smaller in size. After the 28-day incubation, most of the flocs in the presence of the dispersed oil showed positive or neutral buoyancy while those formed in the presence of oil alone or dispersant alone all sank (Figure 2). The different characteristics of flocs resulted from the incorporation of different types and amounts of oil components. The application of a chemical dispersant to an oil slick increases the formation of much smaller oil droplets and disperses much more oil in the water column, compared to naturally/mechanically dispersed oil.[31] These fine oil droplets not only facilitate formation of more MOS flocs, but resulted in much higher oil content in the resulting MOS. On Day 28, approximately 200 small oil droplets (<0.1 mm) were observed in the bottle of Case IV (Figure 1) and much more were incorporated into the MOS flocs. On the other hand, the coadsorbed dispersant molecules may orient themselves in the head-out fashion, which acts as a repulsive energy barrier, confining further growth of the MOS.

Distribution of n-Alkanes in Aqueous and MS/MOS Phases. The amounts of n-alkanes in seawater and MS/MOS particles were determined after the 28-day incubation. Figure 4 summarizes the results. The concentration of total n-alkanes (C9−C40) in the LSC oil was 34.61 mg/mL and the oil mass added in each bottle was 5.19 mg. The raw seawater (Case I) and sterilized seawater (Case VI) contained 0.05 and 0.06 mg of total n-alkanes, respectively. The addition of the dispersant (Case III) elevated the content to 0.09 mg (Figure 4a), which accords with the petroleum compositions in Corexit EC9500A.[27] In Case II, the total mass of n-alkanes dissolved in seawater was 0.40 mg (7.7% of the total mass of n-alkanes added). The application of the dispersant to the oil (Case IV) escalated the dissolved n-alkanes to 1.25 mg (24.1%). In addition, relatively high levels of n-alkanes were detected in Cases V (0.98 mg, 18.9%) and VII (1.06 mg, 20.4%), where oil was added in microfiltered and sterilized seawater, respectively.

Total n-alkanes in the natural suspended particles without addition of oil or dispersant were very low, 0.001 and 0.002 mg in Cases I and VI, respectively. In the presence of the dispersant (Case III), 0.11 mg of n-alkanes was detected in the formed MS

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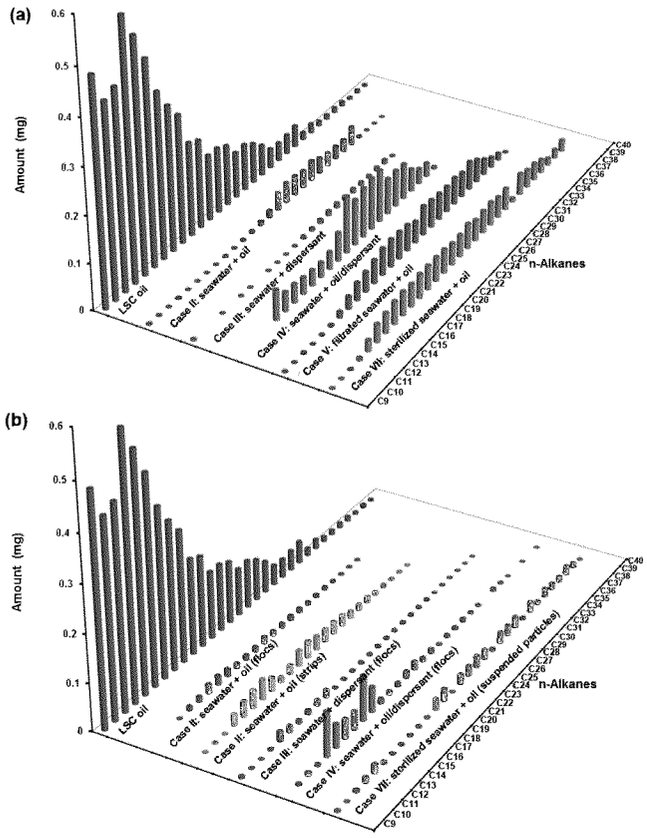

Figure 4. Mass distribution of of n-alkanes (C9−C40) in seawater (a) and in particle aggregates (MS/MOS) (b) after 28-day roller table experiments. The amount of n-alkanes in LSC oil was determined in 0.15 mL of the crude oil, which was the amount added in each testing bottle.

(Figure 4b). MOS flocs in the oil-dispersant system (Case IV) contained nearly three times more n-alkanes (0.48 mg, 9.2%) than in the oil-only system (Case II, 0.17 mg, 3.3%). However, more n-alkanes (0.42 mg, 8.1%) were detected in the "strips" (Case II) where rather distinctive oil droplets were incorporated in the particles (Figure 4). The addition of oil in sterilized seawater (Case VII) resulted in 0.34 mg (6.6%) of n-alkanes in the suspended solids.

Of the n-alkanes, the lower molecular weight (LMW) species (C9−C18) tended to partition more favorably in the MS/MOS particles than in the aqueous phase. The LMW n-alkanes in the MS/MOS flocs of Cases II−IV were 0.08, 0.07, and 0.38 mg, respectively, accounting for 7.9%, 39.9%, and 22.1% of the total n-alkanes in seawater and MS/MOS; whereas the LMW n-alkanes in the aqueous phase were only 0.8%, 1.4%, and 14.4%, respectively (Figure 4). However, for sterilized seawater (Case VII), the solid-retained mass of LMW n-alkanes was 4.1%, while leaving 24.2% in the aqueous phase. In the natural seawater without oil or dispersant (Cases I and VI), the LMW n-alkanes were low in both the aqueous and particle phases (0−3.8%).

MS/MOS-Facilitated Uptake and Transport of Oil Hydrocarbons. The Crude oil contains approximately 81 vol % alkanes and 19 vol % aromatics.[32] Therefore, it is of great significance to evaluate the transport of alkanes during the formation of MOS. Both dispersed oil droplets and dissolved oil can interact with SPMs and become associated with MS/MOS. Consequently, MS/MOS can affect the transport and fate of the oil components (Figure S1, SI).

The dispersant and bacterial activity greatly impact the formation, oil content, and fundamental properties (e.g., size, shape and density) of MS/MOS. The chemical dispersant reduces the interfacial tension between the oil and seawater, and hence promotes the formation of oil droplets.[6,33] When the dispersant concentration exceeds its critical micelle concentration (CMC) (22.5 mg/L),[6] micelles will be formed, which results in more oil dispersed in the water column and transfers more oil in MS/MOS.[34] In this work, the dispersant dose was 32 mg/L. Therefore, micelles are expected in the systems. In fact, the dispersant increased the total "dissolved" n-alkanes in Case IV by 191% than in Case II (excluding n-alkanes from the dispersant). With respect to uptake of oil hydrocarbons on particle aggregates or MS/MOS, the dispersant can exert a number of competing effects. First, the dispersant molecules reduce the stickiness of oil droplets and inhibit their adhesion to particles.[33] On the other hand, the dispersant generate more and smaller oil droplets,[31] which are favorable for incorporating more oil into the particles. Furthermore, the surfactant molecules can form hemimicelles at the particle surface, which also promote uptake of more hydrocarbons.[35] Conversely, interactions between hydrocarbons and aqueous dispersant micelles/molecules tend to disperse more oil in the aqueous phase. In our case, the dispersant increased the total n-alkanes adsorbed on the MS/MOS flocs by 1.23-fold, suggesting a net positive effect of the dispersant on the incorporation of more hydrocarbons into the MOS.

The biosurfactants/EPS from indigenous bacteria can also facilitate oil dispersion and dissolution in a similar fashion.[26,36] The bacteria could take up and degrade oil hydrocarbons dispersed or dissolved in the aqueous phase (Figure S1, SI). The presence of indigenous bacteria (Case II) reduced the aqueous n-alkanes from 1.06 mg (Case VII) to 0.40 mg, indicating remarkable biouptake/biodegradation of the hydrocarbons. Our findings also suggested that the indigenous microbes in seawater rather than those from the oil played the major roles in degrading the hydrocarbons, which was consistent with Baelum et al.'s report.[37] In terms of facilitating oil-particle interactions and formation of MS/MOS, bacteria can play a number of important roles. First, the bacteria-produced EPS enhances transferring more oil into the EPS matrix,[38] and the biodispersed oil droplets are also in favor of interacting with the solid particles. On the other hand, bacteria increase the aggregation of particles that may reduce the particle surface area and hinder the interactions between the particles and oil droplets. Lastly, biodegradation of oil hydrocarbons reduces the concentration and species distribution of the oil hydrocarbons in both the aqueous and particle phases. The biodegradation effect was manifested by the observation that the n-alkanes level in particles without indigenous bacteria (Case VII) was 2-fold higher than that in Case II where the bacteria were active.

Effects of chemical dispersants on biodegradation of petroleum hydrocarbons have been studied for decades. It is generally agreed that chemical dispersants increase bioavailability of oil slicks and accelerates biodegradation of oil. Figure 4 shows that n-alkanes in both the aqueous phase and the particles are approximately 3-fold higher in Case IV (with dispersant) than in Case II (without dispersant). This is because the effect of the dispersant on oil dispersion and dissolution is more apparent than its enhancement on the biodegradation of oil.

It is known that LMW hydrocarbons are more prone to oil weathering such as evaporation, dissolution and biodegradation.[12,39] Strong biodegradation of the LMW oil fraction was

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evident from the observation that the aqueous content of LMW n-alkanes (0.8% of the total n-alkanes sum in seawater and particle aggregates) in Case II (with bacteria) was much lower that (24.2%) in Case VII (without bacteria). Figure 4 shows that the LMW n-alkanes content in MOS (Cases II and IV) is higher than that in the aqueous phase, which can be attributed to incorporation of the dispersed oil droplets into the MOS. In contrast, no conspicuous incorporation of oil droplets was observed in Case VII (without bacteria), resulting in the low LMW n-alkanes percentage (4.1%) in the particles.

Environmental Significance and Implications. The information is valuable for aiding our understanding of the mechanisms of MS/MOS formation and MOS-facilitated transport of oil hydrocarbons, which has been largely ignored in estimating the oil budget following major oil spills, such as the 2010 DwH oil spill. The oil dispersant results in much more and smaller MOS and transfers more LMW oil in MOS, which may reverse the transport direction. Increasing the MOS residence time in the water column may promote the oil degradation in the euphotic zone and alleviate the impact of MOS on the benthos ecosystem. On the other hand, the MOS-facilitated oil transport may partially account for the reported oil accumulation at the seafloor following the DwH oil spill, while the observed deepwater−oil plumes are less likely to be associated with MS/MOS. Given the critical role of indigenous bacteria in facilitating the MS/MOS formation, further investigations are warranted into the mechanisms of EPS-producing bacteria and dispersant-stipulated MS formation.

ASSOCIATED CONTENT

* Supporting Information

Characterization of MS/MOS (Section S1); total bacteria counting and determination of EPS (Section S2); analysis of seawater (Section S3); analysis of n-alkanes (Section S4); a sample video illustrating motion of MS (Video S1); and a schematic diagram on fate and transport of oil during the formation of MOS (Figure S1). This material is available free of charge via the Internet at http://pubs.acs.org.

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Notes

The authors declare no competing financial interest.

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Cc: chris.barker@noaa.gov[chris.barker@noaa.gov]; Barth, Edwin[Barth.Ed@epa.gov]; Conmy, Robyn[Conmy.Robyn@epa.gov]; thomas.s.coolbaugh@exxonmobil.com[thomas.s.coolbaugh@exxonmobil.com]; fingasmerv@shaw.ca[fingasmerv@shaw.ca]; ali.khelifa@ec.gc.ca[ali.khelifa@ec.gc.ca]; ken.lee@csiro.au[ken.lee@csiro.au]; jrpayne@sbcglobal.net[jrpayne@sbcglobal.net]; wspegau@pwssc.org[wspegau@pwssc.org]; crescent.moegling@noaa.gov[crescent.moegling@noaa.gov]; doug.helton@noaa.gov[doug.helton@noaa.gov]; Gary Shigenaka - NOAA Federal[gary.shigenaka@noaa.gov]; Wilson, Gregory[Wilson.Gregory@epa.gov]; Principe, Vanessa[Principe.Vanessa@epa.gov]
From: CJ Beegle-Krause
Sent: Fri 8/21/2015 6:22:24 PM
Subject: RE: State-of-Science dispersant in Arctic: Transport & Behavior group - next call on 8/21
GongEtAl 2014.pdf

Hi Ian,

Please check that this is the correct Gong Et Al paper discussed today.

CJ

From: Ian Gaudreau [mailto:iangaudreau@gmail.com]
Sent: 20. august 2015 18:59
To: Mandsager, Kathy
Cc: chris.barker@noaa.gov; barth.ed@epa.gov; CJ Beegle-Krause; Conmy, Robyn; thomas.s.coolbaugh@exxonmobil.com; fingasmerv@shaw.ca; ali.khelifa@ec.gc.ca; ken.lee@csiro.au; jrpayne@sbcglobal.net; wspegau@pwssc.org; crescent.moegling@noaa.gov; doug.helton@noaa.gov; Gary Shigenaka - NOAA Federal; wilson.gregory@epa.gov; principe.vanessa@epa.gov
Subject: Re: State-of-Science dispersant in Arctic: Transport & Behavior group - next call on 8/21

Friendly reminder that our next Physical Transport & Chemical Behavior meeting will be **Friday, August 21 at 1:00pm EDT**. Attached is the most recent version of the document, as well as the Aman et al. 2015 paper, which we will be discussing tomorrow.

WebEx instructions below.

See you then!

Ian

On Wed, Aug 5, 2015 at 2:11 PM, Mandsager, Kathy <kathy.mandsager@unh.edu> wrote:

Confirming our next call for **Friday 21 August** beginning at 1:00 pm ET via WebEx (instructions below). I will also send this information via calendar request.

Tasks:

- Please review the attached Aman 2015 paper in order to include appropriate conclusions
- There are still a few references needed (or clarified) in order for Ian to include them in the database
- Please review for any specific notations with your name and also advise us on how you would like your name, title and affiliation listed at the bottom of this document

We look forward to what we think will be our final document. Thank you!

State-of-Science for dispersants: Transport & Behavior Group
Friday, August 21, 2015
1:00 pm | Eastern Daylight Time (New York, GMT-04:00) | 2 hrs

Join WebEx meeting

Meeting number: 736 793 006

Join by phone
1-855-244-8681 Call-in toll-free number (US/Canada)
1-650-479-3207 Call-in toll number (US/Canada)
Access code: 736 793 006
Global call-in numbers | Toll-free calling restrictions

Can't join the meeting? Contact support.

--

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