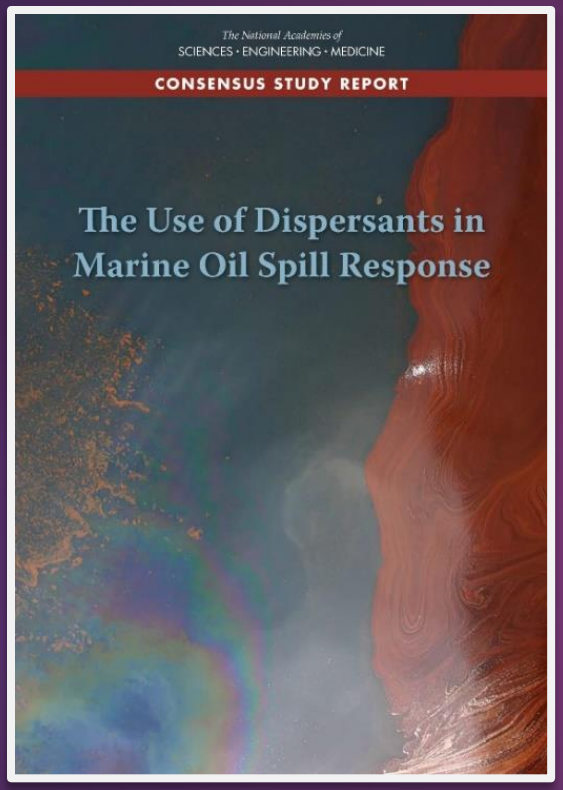
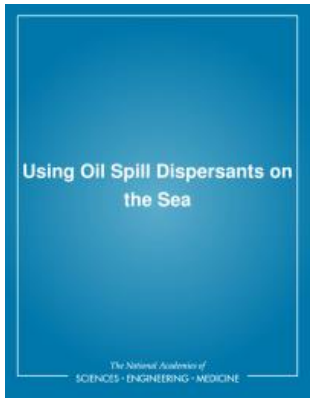


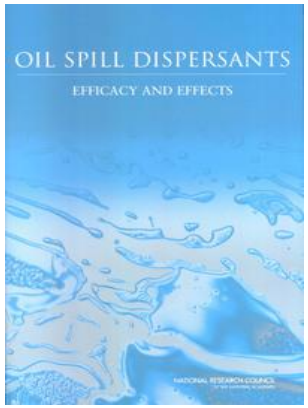
The Use of Dispersants in Marine Oil Spill Response

THE NATIONAL ACADEMIES
Advisers to the Nation on Science, Engineering, and Medicine

Previous Reports on Dispersants



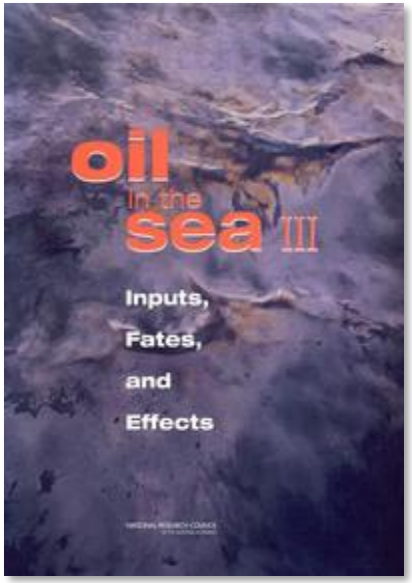
1989: *Using Oil Spill Dispersants on the Sea*
(https://www.nap.edu/catalog/736/using-oil-spill-dispersants-on-the-sea)

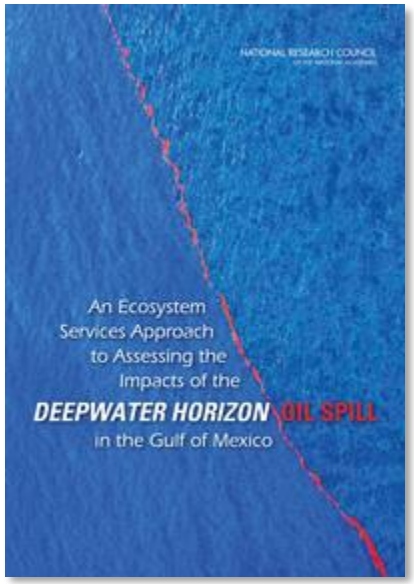


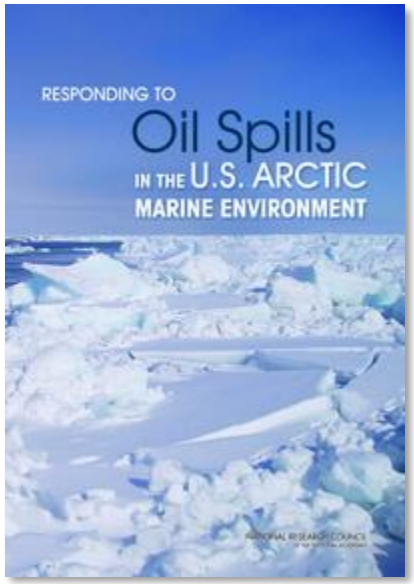
2005: *Oil Spill Dispersants: Efficacy and Effects*

(https://www.nap.edu/catalog/11283/oil-spill-dispersants-efficacy-and-effects)

Other Oil Spill Reports







Part 2: The Study
Abbreviated Statement of Task

This study will assess the effects and efficacy of dispersants as an oil spill response tool through review and evaluation of research reports and results. The study will evaluate trade-offs associated with dispersant use, in part through use or review of net environmental benefit analyses conducted for past oil spills. This evaluation will include comparison of chemically dispersed oil with the fate and effects of untreated oil.

Part 2: The Study
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Tasks

- Assess the state of our knowledge about dispersant effectiveness and the fate of untreated oil, chemical dispersants, and chemically dispersed oil;
- Evaluate and summarize research on toxicity of chemical dispersant formulations, chemically dispersed oil, and untreated oil at realistic environmental exposure levels;
- Compare the benefits and limitations of dispersant application to the use of other clean-up methods;
- Compare the relative human health risks;
- Identify the research protocols and standards that would increase the applicability of lab-based measurements to the field and improve the comparability of research findings from different laboratories;
- Assess the adequacy of the existing information to support risk-based decision-making.

Committee Roster

MARY E. LANDRY, Chair
(Retired) U.S. Coast Guard, Belmont, Massachusetts
STACEE KARRAS, Study Director

E. ERIC ADAMS, Massachusetts Institute of Technology, Cambridge

ADRIANA BEJARANO, Research Planning Inc., Columbia, South Carolina

MICHEL BOUFADEL, New Jersey Institute of Technology, Newark

GINA COELHO, (Retired) Sponson Group Inc., Mansfield, Texas

THOMAS S. COOLBAUGH, ExxonMobil, Spring, Texas

CORTIS COOPER, (Retired) Chevron Corporation, Kensington, California

DOMINIC DI TORO, University of Delaware, Newark

JULIA GOHLKE, Virginia Polytechnic Institute and State University, Blacksburg

BERNARD D. GOLDSTEIN, University of Pittsburgh, Pennsylvania

TERRY C. HAZEN, University of Tennessee, Knoxville

KENNETH LEE, Fisheries and Oceans Canada, Dartmouth, Nova Scotia

STEVE MURAWSKI, University of South Florida, St. Petersburg

W. SCOTT PEGAU, Prince William Sound Science Center, Cordova, Alaska

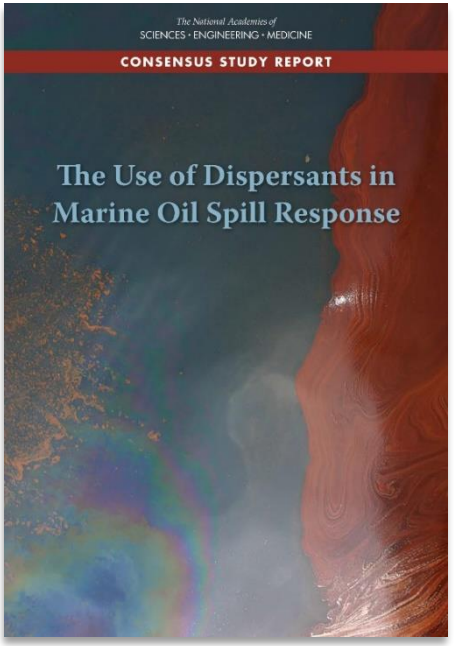
RON TJEERDEMA, University of California, Davis

DAVID L. VALENTINE, University of California, Santa Barbara

HELEN WHITE, Haverford College, Pennsylvania

Report Roadmap

- **Chapter 1:** Introduction
- **Chapter 2:** Fate and Transport
- **Chapter 3:** Aquatic Toxicology and Biological Effects
- **Chapter 4:** Human Health Considerations
- **Chapter 5:** Tools for Decision-Making
- **Chapter 6:** Comparing Response Options
- **Chapter 7:** Research and Decision-Making Protocols



1. Introduction

- A variety of response options are required to address the diversity of circumstances, oil types, and environmental conditions under which oil spills occur.
- Dispersants promote formation of small droplets that become suspended in the water column; droplets promote dilution, dissolution, and degradation.
- Much of the literature since the 2005 report focuses on the DWH; however, ***this report is not a retrospective evaluation of that event.***

Dispersants
Fate and Transport

- Modern dispersants are a mixture of solvents and surfactants.
- Physicochemical properties determine fate of components in the environment.
- Dispersant components are generally subject to rapid dilution, dissolution, and degradation.
- Components of dispersants differentially dilute, dissolve, and degrade, influencing their relative concentrations in the water column.

Oil Fate and Transport

- Fate and transport of oil depends on the location of the source, oil type and composition, and environmental conditions.
- Action of dispersants depends on type of oil, degree of weathering, and mixing energy.

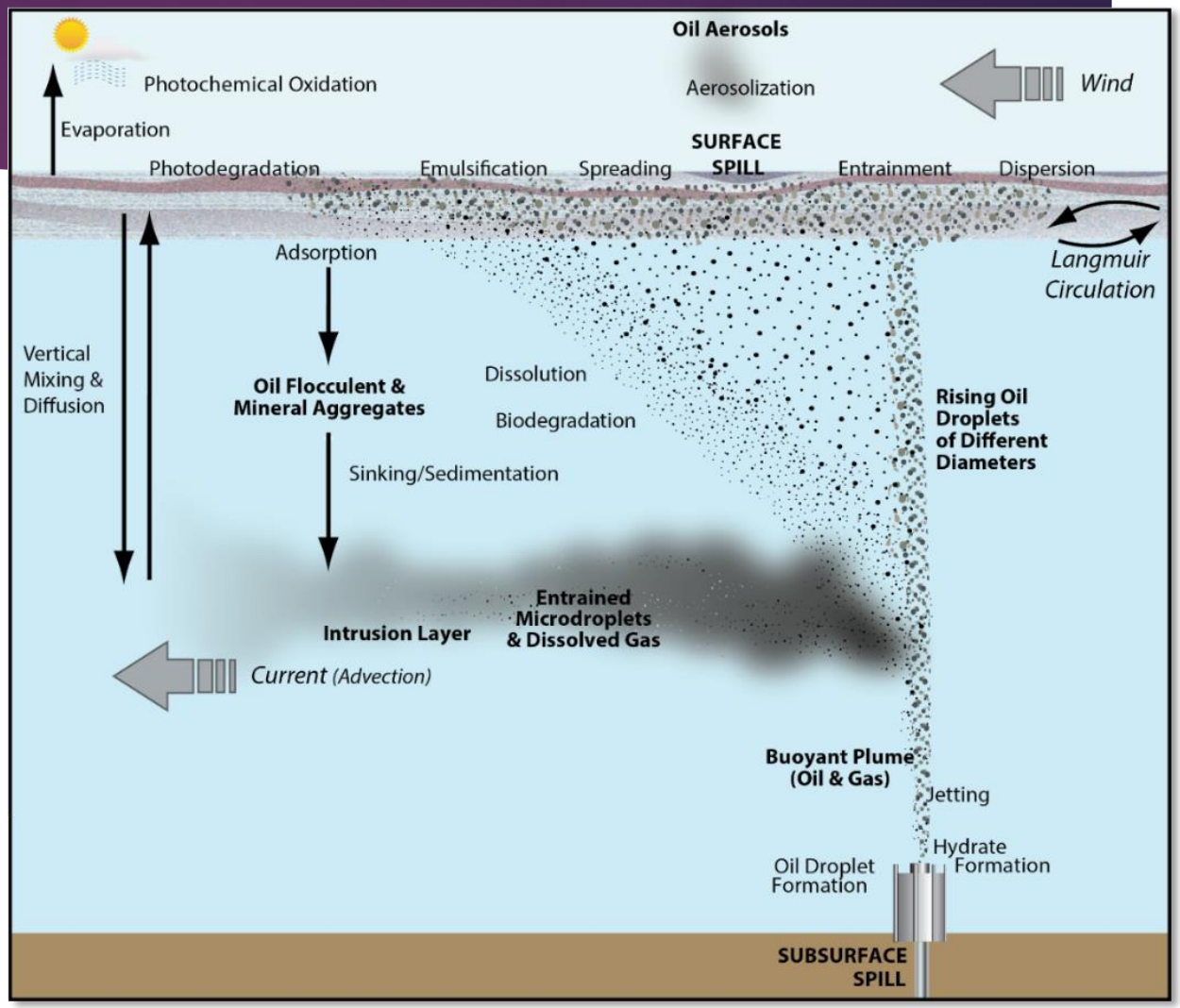


Figure 2.1; SOURCE: Modified from Hazen et al. (2016).

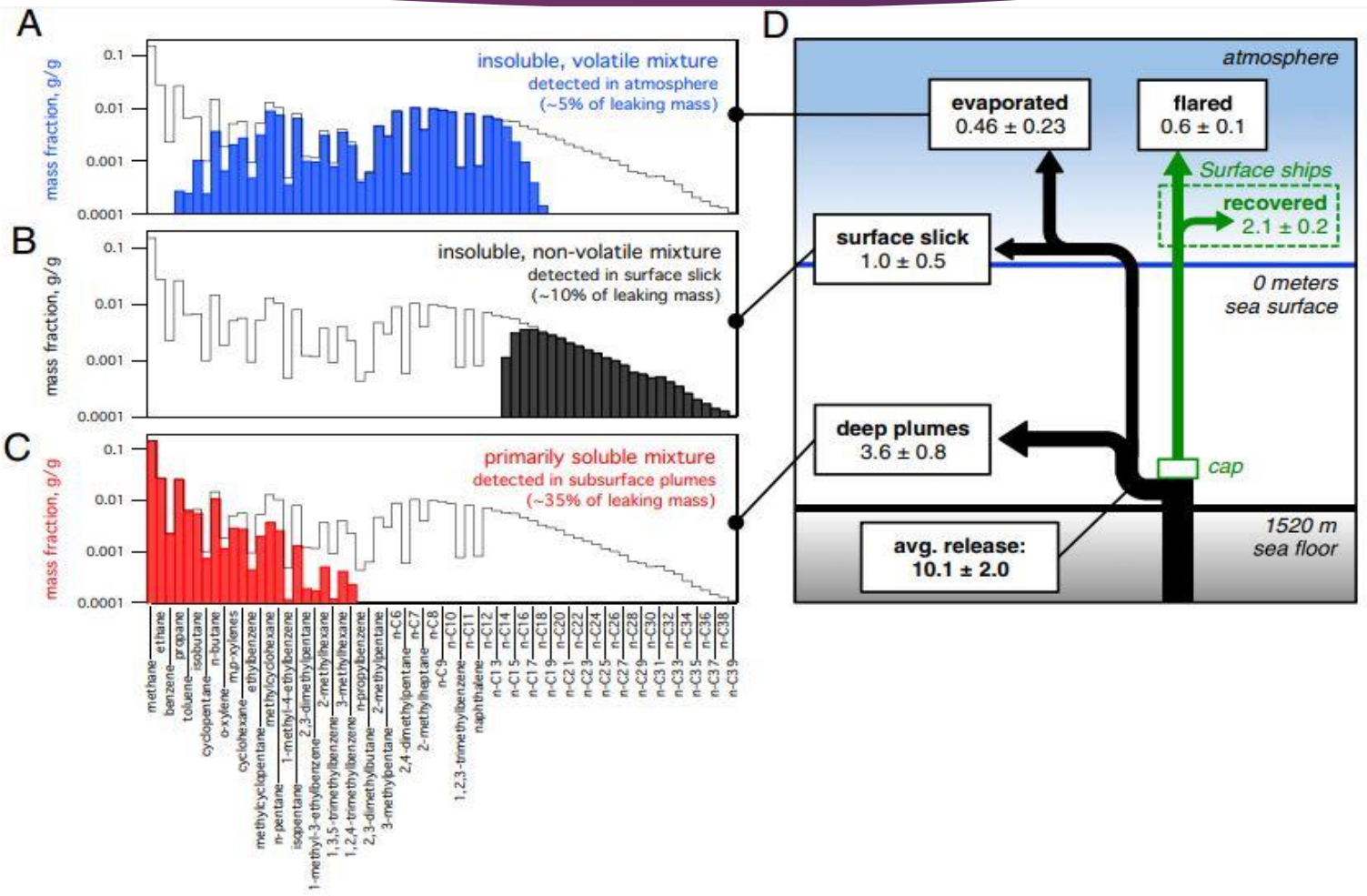
Oil Fate and Transport

- Oil droplet size is a major factor determining the fate and transport of spilled oil.
- Experimental systems and models provide insight on oil droplet formation and distribution; however, sources of uncertainty remain, such as tip-streaming, pressure gradients, and out-gassing.
- Additional observations of droplet formation are needed as close to field scale as possible.

Recommendation: A model hindcast of the VOCs generated around the Macondo Well should be performed to better validate models and understand processes affecting VOC concentrations.

Fractionation of Oil

Figure 2.5, from Ryerson et al. 2012



3. Aquatic Toxicity of Dispersants

A review of existing laboratory-based dispersant-only toxicity data showed that when compared to field conditions, dispersant concentrations would be well below toxic thresholds

As underscored in the previous NRC reports, the primary concern is whether dispersed oil is more toxic than untreated oil, not the toxicity of modern dispersant formulations.

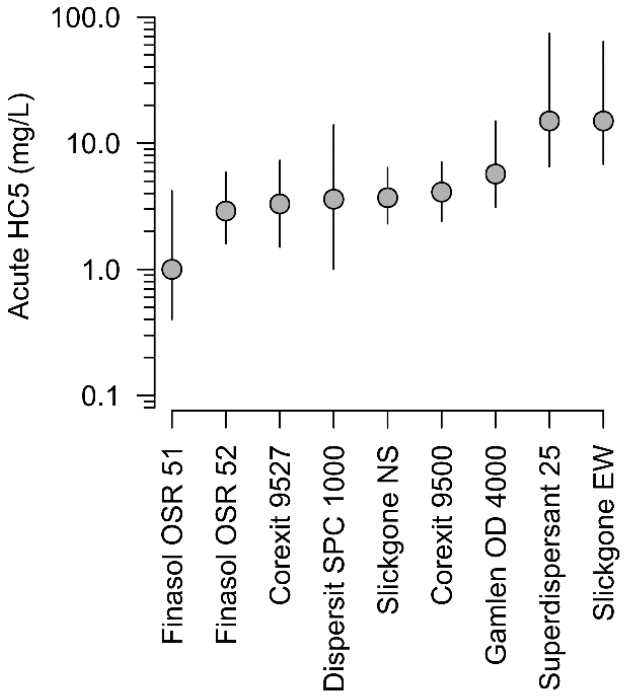


Figure 3.2; Data from Bejarano (2018)

Aquatic Toxicity

Variable loading used to compare WAF with CEWAF

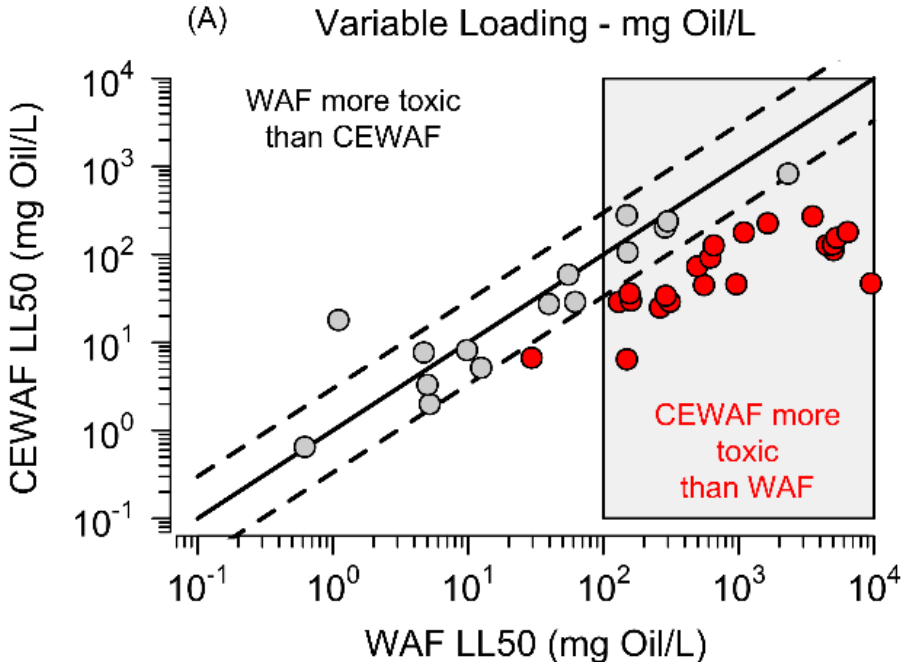


Figure 3.5a; Page 81; Data from Bejarano et al. (2014) and the Committee's meta-analysis (Appendix F).

Aquatic Toxicity and Biological Impacts

To determine the toxic effects of untreated and chemically dispersed oil on marine life, need to resolve four factors:

- Concentration exceeding known acute or chronic toxicity thresholds for the specific oil;
- Duration of exposure above toxic thresholds;
- Spatial and temporal distribution of marine life; and
- Species sensitivity to oil exposure above the acute or chronic toxicity thresholds.

Recommendation: The use of toxic units should be integrated into revised oil toxicity testing standards, evaluation criteria for models, and response option risk analysis. TUs make it possible to compare the toxicity of various mixtures of PAHs from different source oils and from mixtures that results from the differential solubility of oil constituents in seawater.

Aquatic Toxicity and Biological Impacts

Dispersants have been implicated in the formation of MOSSFA an aggregate that sediments and may affect benthic organisms.

Oiling and inhalation/aspiration of VOCs or oil droplets present hazards to surfacing animals (e.g., cetaceans, turtles, and birds) which may be reduced with effective chemical dispersion of surface slicks.

The hazard posed by dispersant use to wildlife under field conditions is not fully understood:

- Difficult to differentiate the impacts of chemically versus physically dispersed oil.
- Most research on oil impacts to wildlife has come from spills without dispersant use, or through controlled laboratory exposures.

Human Health

Primary oil constituents of concern: VOCs (benzene, toluene, ethylbenzene, and xylene [BTEX]) and PAHs.

Direct effect exposure pathways:

- Inhalational and dermal exposure to VOCs, dispersants or dispersed (aerosolized) oil for responders.
- PAHs and persistent dispersant components (DOSS) via seafood consumption.

Indirect effects

- Major oil spills are stressful to affected communities.
- Lack of transparency (e.g. dispersant formulation) enhances the stress levels and psychosocial situation.

Human Health

Epidemiological studies suggest consistent physical and psychological impacts of major oil spills; however studies examining direct effects of dispersants are limited. Two studies of DWH response workers reported effects associated with dispersant exposure; however these studies were protracted in initiation and relied on self-report of exposure.

- As part of planning efforts for future spills, biomarkers should be established for each dispersant formulation listed on the US EPA National Contingency Plan Product Schedule.
- In addition, reporting requirements should be improved to include details of injury and illness, with a focus on whether workers were exposed to dispersant.

Net Environmental Benefit Analysis (NEBA)

NEBA is a collection of tools to identify:

- Tradeoffs between response options
- Response option(s) most likely to minimize the net environmental impacts, given spill-specific conditions and potentially impacted resources.

NEBA can be used for:,

- Strategic planning during the initial stages of a spill response,
- Tactical decisions during the active phase of a response,
- Contingency plan development

Decision-making Tools

Various tools have been developed to support the NEBA approach for oil spills, such as:

- Consensus Ecological Risk Assessment (CERA)
- Spill Impact Mitigation Assessment (SIMA)
- Comparative Risk Assessment (CRA)

Recommendations: These tools should be expanded to address health (e.g., response personnel, community) and socioeconomic (e.g., beach closures) considerations. These tools should be used to gain stakeholder input on local/regional priorities, expand awareness, and gain trust in the decision-making process.

Comparing Response Options

Limited number of comparative studies have evaluated various response methods:

- TROPICS
- CRA SSDI Studies (CRA-1/CRA-2)
- Comparative VOC study
- Model of Gros et al. (2017)
- SIMA of Subsea Dispersant Injection

Report also highlights special considerations, such as:

- Regulatory approval process for dispersants
- Trans-boundary considerations
- Arctic conditions

Research and Decisionmaking

Methodologies, tools, and facilities for further research:

- Environmental Geochemistry Research
- Biodegradation Research and Modeling
- Meso-scale Test Facilities for Dispersant Studies
- Field Studies and Spills of Opportunity
- Droplet Model Validation
- Toxicity Testing
- Epidemiological Studies
- Risk Assessment Tools

Acknowledgments

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Reviewers of the report;

Meeting participants; and

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Continuing the Discussion

Report Briefings:

- NRT/RRT
- Clean Gulf 2019
- ICCOPR
- ITAC 2019
- GOMOSES 2020