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Comparative risk assessment of oil spill response options for a deepwater oil well blowout: Part II. Relative risk methodology

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ABSTRACT

Subsea dispersant injection (SSDI) was a new oil spill response (OSR) technology deployed during the Deepwater Horizon accident. To integrate SSDI into future OSR decisions, a hypothetical deepwater oil spill to the Gulf of Mexico was simulated and a comparative risk assessment (CRA) tool applied to contrast three response strategies: (1) no intervention; (2) mechanical recovery, in-situ burning, and surface dispersants; and, (3) SSDI in addition to responses in (2). A comparative ecological risk assessment (CRA) was applied to multiple valued ecosystem components (VECs) inhabiting different environmental compartments (ECs) using EC-specific exposure and relative VEC population density and recovery time indices. Results demonstrated the added benefit of SSDI since relative risks to shoreline, surface wildlife and most aquatic life VECs were reduced. Sensitivity of results to different assumptions was also tested to illustrate flexibility of the CRA tool in addressing different stakeholder priorities for mitigating the impacts of a deepwater blowout.

1. Introduction

The goal of oil spill response (OSR) is to mitigate the impacts of spilled oil on valued resources while limiting the negative effects of the response. As such, OSR seeks to strike a balance between reducing injury to some resources without unacceptably increasing the injury to other resources. By necessity, OSR planning is a predictive process that depends upon evaluating (1) the oil release conditions, (2) the fate and transport of the released oil, (3) exposure of humans, biological and socioeconomic resources to oil hydrocarbons and response activities, (4) the potential effects on valued resources, and (5) how different oil spill response strategies influence the factors listed above. OSR response planning requires consideration of these factors by the stakeholders.

Subsurface dispersant injection (SSDI) is a promising recent innovation in oil spill response. The use of SSDI in a deepwater oil and gas well blowout can have many benefits including improving the effectiveness of dispersant treatment over that achievable at the water surface; reducing the volume of oil that reaches the water surface; reducing human and wildlife exposure to volatile organic compounds (VOCs); dispersing the oil over a large water volume at depth; reducing the persistence of any oil that does surface; enhancing oil biodegradation; and reducing surface, nearshore and shoreline exposures to oil. Potential negative effects include increased water column and benthic resource exposures to oil at depth.

To better understand the implications of SSDI use, work was conducted to model a hypothetical well blowout in the northern Gulf of Mexico (GOM) to predict oil fate and compare the environmental exposure for no intervention to various combinations of four response options - mechanical recovery, in-situ burning (ISB), surface dispersant application (MBSD), and SSDI. Probabilistic modeling was used to evaluate the influence of variable metocean conditions (i.e., winds, currents and temperature) on oil trajectory and fate. Using individual runs representative of specific metocean conditions (e.g., Fig. 1, worst case for oiling of shorelines), several different modeling simulations and combinations of response options were compared to quantify oil fate, the amount of surfaced as opposed to dispersed oil, and the area or volume of different surface and subsurface environmental compartments in which predicted exposure concentrations exceeded screening thresholds for potential effects. A comparative risk assessment methodology was used to compare the various OSR options. This work was undertaken in consultation with a large group of stakeholders who provided input and guidance on all aspects of the modeling, input

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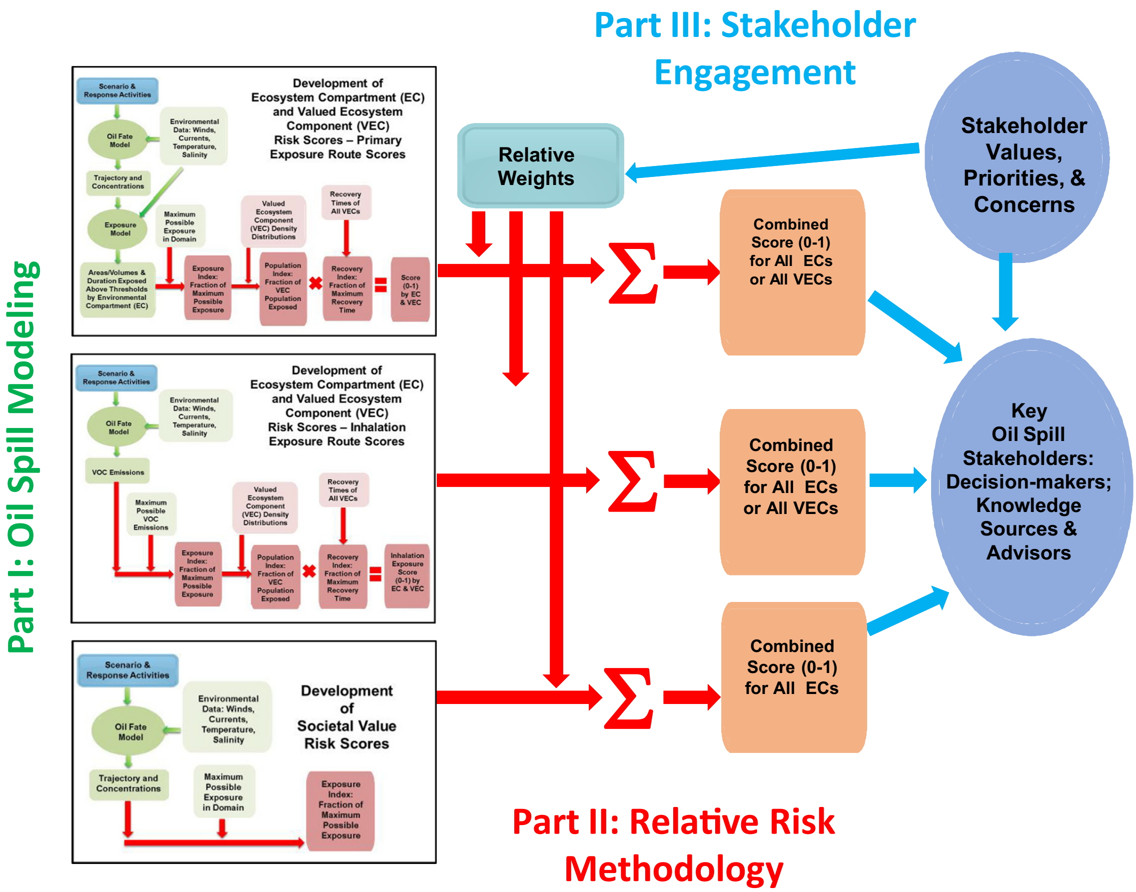

Fig. 1. Schematic of the Comparative Risk Assessment (CRA) methodology. The relative risk methodology is describe herein as Part II. The oil spill fate and exposure modeling (green boxes) is described by French-McCay et al. (2018b). The stakeholder engagement process is described by Walker et al. (2018). (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

assumptions and assessment. This process and the connections between the modeling, the comparative risk assessment, and stakeholder engagement are depicted in Fig. 1. The work is described in a series of three papers on "Comparative Risk Assessment of Oil Spill Response Options for a Deepwater Oil Well Blowout" and this paper is the second in the series "Part II: Relative Risk Methodology".

The objective of this paper in the series is to describe a comparative risk assessment (CRA) approach for evaluating the influence of various response alternatives on relative risks, with a focus on using SSDI in combination with other response strategies namely, mechanical recovery, in situ burning (ISB), and surface dispersant application. In Part I, French-McCay et al. (2018b) conducted trajectory and fate modeling of a hypothetical deepwater well blowout in the Gulf of Mexico (GOM) to predict oil-related exposures in different ECs following deployment of various response options. In this paper, Part II, we develop an approach whereby risks of spills to ecological and socioeconomic resources, as modified by different spill response activities, may be compared. The approach utilizes (1) the surface areas or water volumes and days of exposure above threshold concentrations, which are estimated by the oil spill modeling; (2) the relative density distributions of valued ecosystem components (VECs) across environmental compartments (ECs), which determines the fraction of the VEC in the domain evaluated that would be exposed; (3) the relative ability of the VECs to recover; and (4) the ability to vary the relative weights implicitly or explicitly given to VECs and ECs that are applied by the decision-maker or his/her advisor when comparing the modeled exposures. In Part III, Walker et al. (2018) described the stakeholder engagement process and how stakeholder engagement was used to guide all aspects of the work.

2. Evolution of decision analysis for oil spill response

While it is recognized that the prevention of oil spills, particularly during offshore drilling, is of utmost importance, the Deepwater Horizon (DWH) oil spill heightened awareness of the possibility of deepwater well blowouts and associated consequences. Detailed contingency planning is an important part of the regulatory and response planning process to minimize risks from these types of oil spill events (Leschine et al., 2015). Planning and preparedness work needs to account for scenarios considered to be "reasonable worst case" in terms of oil volumes, seasonal environmental sensitivities, and oceanographic and weather conditions. Planning also requires an understanding of the likely environmental consequences and trade-offs associated with different plausible oil spill response (OSR) countermeasures. Typically, the first considerations in an OSR are to quickly remove visible oil from the water surface either mechanically, by burning, or use of dispersants to prevent spilled oil from reaching the shoreline (Tamis et al., 2012). Regardless of the trajectory of the spilled oil, removal of oil from the water's surface before water-in-oil emulsification occurs is paramount because the removal of such emulsions becomes exceedingly difficult (Prendergast and Gschwend, 2014) and emulsified oil amounts to over twice the volume of unemulsified oil. Adding to these considerations is the recognition that changes to the behavior of oil prompted by response actions may direct the oil from one environmental compartment to another, thus affecting the nature and persistence of oil exposures (John et al., 2016). Thus, identifying response strategies that reduces risks to the environment as a whole, while considering the specifics of the spill event, is of key interest to decision-makers and ultimately society.