Counter-Historical Study of Alternative Dispersant Use in the Deepwater Horizon Oil Spill Response

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Extended Abstract

Following unprecedented usage of subsea dispersant injection (SSDI) during the Deepwater Horizon (DWH) oil spill response, questions have arisen regarding the extent to which this action influenced the volatile organic carbon (VOC) emissions, ecological exposures, and effects of the oil. What if SSDI had not been conducted at all? What if it had been applied earlier and more consistently and/or at various doses throughout the spill period? Study authors recently completed validated modeling to develop a mass budget of the DWH oil spill as it occurred (French McCay et al. 2021a,b). The completion of this effort now allows for a counter-historical study of the exposures and effects of SSDI using a quantitative Comparative Risk Assessment (CRA) which weighs the relative risks of differing application scenarios.

A suite of six scenarios were modeled: three without SSDI (no intervention, in-situ burning (ISB) only, and ISB plus surface dispersant) and three with SSDI added (actual SSDI as it was applied, SSDI at 1:100 dispersant oil ratio (DOR), and SSDI at 1:20 DOR). The actual application of SSDI was discontinuous and inconsistent, which resulted in partial treatment of the oil, where some released oil was “dispersed” as smaller droplets, while much of the remainder continued to rapidly surface as large droplets, as it would have without SSDI. The two alternate SSDI scenarios represent continuous full treatment at various DORs, starting on day 3 of the spill.

Modeling of the fate and transport of oil components in the actual and five counter-historical scenarios was conducted using RPS’s integrated plume model (OILMAP DEEP) and farfield model (SIMAP), which included developing representative droplet size distributions (DSDs) released into the farfield environment and tracking 18 pseudo-components of oil as they were subject to differing fate processes, importantly including dispersion and dissolution in the water column during the ~1.2 km ascent to the sea surface. During the actual event when SSDI was applied in June to July 2010, ~89% of the oil surfaced, with the remainder staying in the deep plume at depths between 900 m and 40 m, where it dissolved and biodegraded. Actual SSDI was estimated to reduce surface oil by 7% and evaporation of volatiles and semi-volatiles (VOCs) by 26% during that period. Therefore, another important feature of SSDI was not only that it kept some oil from surfacing entirely, but also that it dispersed oil into smaller droplets that rose more slowly allowing oil to weather, reducing VOC emissions.

The CRA approach applied here was the same as that previously developed for a hypothetical subsea blowout in the Gulf of Mexico (French McCay et al., 2018, 2021c; Bock et al., 2018, 2021; Walker et al., 2018). Potential effects on, and risks to, Valued Ecological Components (VECs) residing in different Environmental Compartments (ECs) within the Gulf of Mexico ecosystem were modeled and compared.

The CRA methodology was particularly suited to evaluating SSDI because of the complexity of modeling SSDI's effect on oil droplet size and the need to calculate how oil fate model results would affect VECs in a variety of depth zones and shore proximities. Relative exposure indices (representing the portion of each EC exposed above a threshold of concern) were calculated for each unique VEC: EC combination, then multiplied by a population index and a relative recovery index to estimate the fraction of the VEC population exposed and its recovery potential. For all VECs, two exposure thresholds were selected to assess the potential for greater sensitivity and lower sensitivity upon exposure. All exposure indices were calculated as a time-weighted area (as km^2-days) or time-weighted volume (as m^3-days), over which aquatic biota moving through the spill environment were exposed to doses above the threshold.

On-Line Tool: Exposure indices and CRA scores were calculated for each EC and the VECs residing within them to assess the relative exposures and risks in the six examined scenarios. These results are presented as a series of comparative graphs and in an online tool that allows for stakeholder weighting of scores and investigation of specific VECs or ECs of interest. Risk reductions (from reduced exposures at the surface and shoreline) and risk tradeoffs (from greater exposures of the deep water column and benthos) can be assessed and compared. Actual SSDI applied during DWH reduced net risks to varying degrees, dependent on the type of VEC and its relative density and recovery time. Exposures and relative risks across the ecosystem would have been substantially reduced with more effective SSDI.

References:

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