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Submersible Optical Sensors Exposed to Chemically Dispersed Crude Oil: Wave Tank Simulations for Improved Oil Spill Monitoring

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Supporting Information

ABSTRACT: In situ fluorometers were deployed during the Deepwater Horizon (DWH) Gulf of Mexico oil spill to track the subsea oil plume. Uncertainties regarding instrument specifications and capabilities necessitated performance testing of sensors exposed to simulated, dispersed oil plumes. Dynamic ranges of the Chelsea Technologies Group AQUAtracka, Turner Designs Cyclops, Satlantic SUNA and WET Labs, Inc. ECO, exposed to fresh and artificially weathered crude oil, were determined. Sensors were standardized against known oil volumes and total petroleum hydrocarbons and benzene-toluene-ethylbenzene-xylene measurements—both collected during spills, providing oil estimates during wave tank dilution experiments. All sensors estimated oil concentrations down to 300 ppb oil, refuting previous reports. Sensor performance results assist interpretation of DWH oil spill data and formulating future protocols.

INTRODUCTION

SMART (special monitoring of applied response technologies) protocols use real-time fluorescence monitoring in decision-making during oil spill dispersant operations[1] to determine efficacy of chemically enhanced dispersion and dispersed oil transport.[2] Chemical dispersants applied to oil slicks (in the presence of mixing energy) reduce the oil−water interfacial tension, forming small oil droplets (<100 um) that are less likely to recoalesce,[3] removing oil from the water surface and suspending neutrally buoyant oil droplets as a subsurface plume. This reduces risk to shorelines and air−water interface biota and also increases microbial biodegradation rates of oil.[4−6] Under SMART, in situ monitoring of surface waters (<2 m) and below (2 - 10 m) evaluates efficacy. Monitoring requires rapid, reliable, easy-to-operate in situ fluorometers. Validation with oil/water samples yields oil mapping with finer temporo-spatial resolution not achieved through coarse discrete measurements alone.

Fluorescence has been an oil spill monitoring tool for more than 30 years.[7,8] Measurements are inherently sensitive, conducted without laborious extraction techniques, time

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