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Ocean Science Discussions

Interactive comment on "Seawater capacitance – a promising proxy for mapping and characterizing drifting hydrocarbon plumes in the deep ocean" *by* J. C. Wynn and J. A. Fleming

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We very much appreciate the thoughtful and encouraging reviews we have received for this paper.

Referee #2 specifically addresses three concerns or issues:

(1) "...the influence of other substances on the registered signal..."

(2) "...but also that the response is not a linear function of the concentration" and

(3) "The influence of the experimental approach considering the unstable oil emulsion generated by a martini stirrer should be further assessed and discussed. More specif-

ically, does it only influence the low frequency noise?"

Issue #1 mainly involves the addition of solvents, specifically Corexit 9527 and Corexit 9500, to the Gulf of Mexico to act as a dispersant. Between 3,000,000L and 3,800,000L of Corexit were eventually dropped into the Gulf of Mexico during the Deepwater Horizon blowout episode. Unfortunately, the different versions of Corexit contain proprietary components that we know little about. In addition, there is little published on the effect the Corexit had on the Deepwater Horizon hydrocarbons. While this is an interesting variable in the process, the Corexit used in the Deepwater Horizon spill was delivered by aircraft and surface ships against a hydrocarbon release that began at 1,260 m water depth. Consequently, the Corexit impacted only the more volatile components of oil that quickly reached the surface, but it had little or no effect on the larger component drifting south from the wellhead with the Gulf Loop Current. The objective of our paper was to propose a deep mapping system for the non-surface oil using a variant on the principle of induced polarization ("IP"). This is applicable in areas and depths where we believe the Corexit thus had little if any effect.

Issue #2 concerns the linear or nonlinear response of the marine IP system as a function of concentration. In fact, the response we observed in the laboratory appeared to be approximately linear until the concentration fell below a certain minimum noise threshold. We did not test for concentrations above 3% oil/seawater because that appeared to be an outside limit to the maximum percentage encountered in Rosette sampling distal to the wellhead. Our lower detection limit of 0.1% derives from the noise threshold of the marine IP systems that we have deployed in the past for different (i.e., sub-seafloor) investigations. In our response to Referee #1 we addressed this issue in more detail. There is an apparent shift in the frequency response peak to the IP signal depending on the droplet size, but this is difficult to assess precisely without a substantial augmentation of our laboratory system. As suggested by Referee #1, one way to deal with this would be to substantially increase the volume of our sampling cell from approximately 800 cc to several cubic meters.

Issue #3 concerns the stability of the emulsion and our preparation of the mixture. Experience suggests that without the addition of emulsifiers it would be difficult to prepare a stable mixture that would be more than approximately quantifiable in terms of droplet size. This is due to steady recombination of oil droplets in a bounded sample container. We are aware of optical approaches to assess sediment load in river water, but this would require some confidence that the emulsion would be at least metastable. There are other considerations, including refraction and partial transparency. Going back to issue #1, and what one of our references (Camilli et al, 2010) suggests, we believe that in the open sea the oil-water mixture would be metastable, with droplet size changing slowly as a function of biodegradation over time, after the more volatile components reached the surface.

The low-frequency components of the laboratory IP measurements are the most unstable, with fairly quick recombination taking place even after extended mixing. This is apparent in our figure #4. The finer droplet sizes appear to be more stable over time, but the higher gravity components of the multivis oil we used will still eventually float to the surface and combine into a laboratory equivalent of an oil slick. Our proposed 3D/4D IP system is designed primarily to map and characterize the higher viscosity, lower gravity component of releases like the Deepwater Horizon spill that were not readily visible (and accessible) on the surface of the Gulf of Mexico.

Interactive comment on Ocean Sci. Discuss., 9, 2679, 2012.