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Interactive Comment

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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General Comments The paper is well written and easy to understand. The phenomenon of IP is generally associated with the phenomenon of electrode polarization in which the mode of conduction must change from ionic to electronic at the boundary between a conductive solution and a metallic conductor. A second mechanism for IP is so-called membrane polarization wherein the ionic mobility of anions and cations in solution can differ markedly in the presence of fixed charge associated with broken bonds in platy silicates cause charge build-up in the presence of an applied electric field. The authors have observed a "complex resistivity" associated with an oil-water emulsion and postulate a “dielectric-like” mechanism similar to a capacitor. Purely from a phenomenological point-of-view this effect is perhaps associated with a third and, as yet, poorly understood mechanism for IP.

If the oil-water emulsions can indeed be characterized by observing the frequency-dependent behavior of the macroscopic conductivity of the two-phase emulsion then we certainly would have a useful method for mapping oil spills. So it seems that there are three important preliminary investigations that must be undertaken: 1. Establishment of the relationship between complex conductivity/resistivity and oil-water emulsions in terms of the oil emulsion particle size distribution and oil concentration. This can be done in the laboratory. 2. Establish a mechanism for this particular IP phenomenon. My understanding of dielectric polarization suggests that its effects occur at frequencies that are much higher than the frequencies typically employed for the measurement of IP (.01 $\leq$ f $\leq$ 100 Hz). It seems likely that this “capacitive” behavior of an oil-water emulsion has been observed and studied in other contexts. What is the mechanism here? Is it truly dielectric polarization? 3. Scale up the measurement to something larger than a laboratory cell. I feel uncomfortable with extrapolating from a laboratory scale of perhaps 10cm to an array that has a radius of investigation of 40m or more (order 10m). It would be nice to make measurements of IP in a volume of water on the scale of cubic meters.

Specific Comments 1. Noise Envelop: I was surprised that the authors estimate a noise envelop of $\pm$1mr. Based on the phase curve in Figure 5, I would think that the (phase) noise would be more on the order of ($\pm$0.1-0.2 mr). This is in line with my own experience with streaming IP in connection with UXO detection. If the noise is indeed of that order (i.e.,$\pm$0.1mr), then the minimum detectable concentration might be a factor of 2 or 3 lower than the 0.1% estimated in the paper. 2. Detection Level: In reference to detection levels, the authors seem to be using their estimated noise level as a threshold of detection. In my experience, one should be using a detection threshold of at least 2x or 3x the noise. Given their estimate of noise ($\pm$1mr) I would

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use 2-3mr as the threshold for detection. This implies that the minimum detectable concentration would be on the order of 0.2-0.3% rather than 0.1%. But if the phase noise level is as low as implied in Figure 5, detection of concentrations of 0.1% or even smaller might well be achievable. 3. Given the required radius of investigation (40m), I wonder whether a frequency domain measurement is the best way to go about measuring IP. In a conductive environment, the phase shifts introduced by electromagnetic coupling between the transmitter and the receiver dipoles will be appreciable when the electrode array is appropriately scaled. Over short profile distances the EM coupling will, of course, be constant unless the survey is conducted over shallow water with substantial bottom topography. In any case, I think that, for mapping (i.e., mapping the plume) at least, a time domain measurement would be more appropriate because such measurements avoid some of the EM coupling effect. Broadband measurements in the frequency domain are appropriate for the purpose of characterizing the nature of the plume and should be conducted at minimal speed in order to permit the transmission of low frequency waveforms and to allow stacking and averaging.

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

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