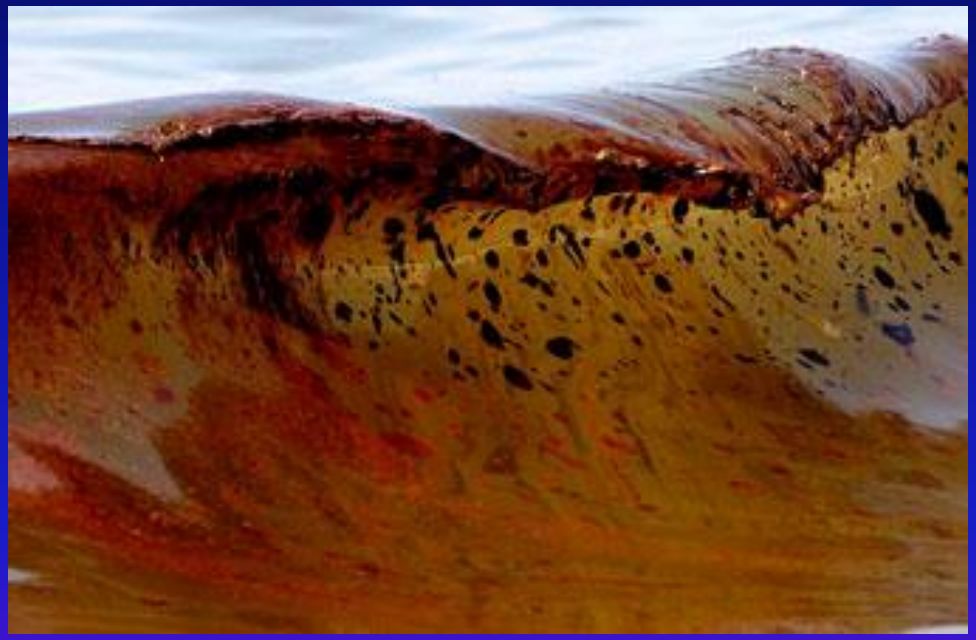
Marine Induced Polarization Technology

Rapid Oil Spill Detection and Mapping

Jeff Wynn and Curtis Clement



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USGS science for a changing world

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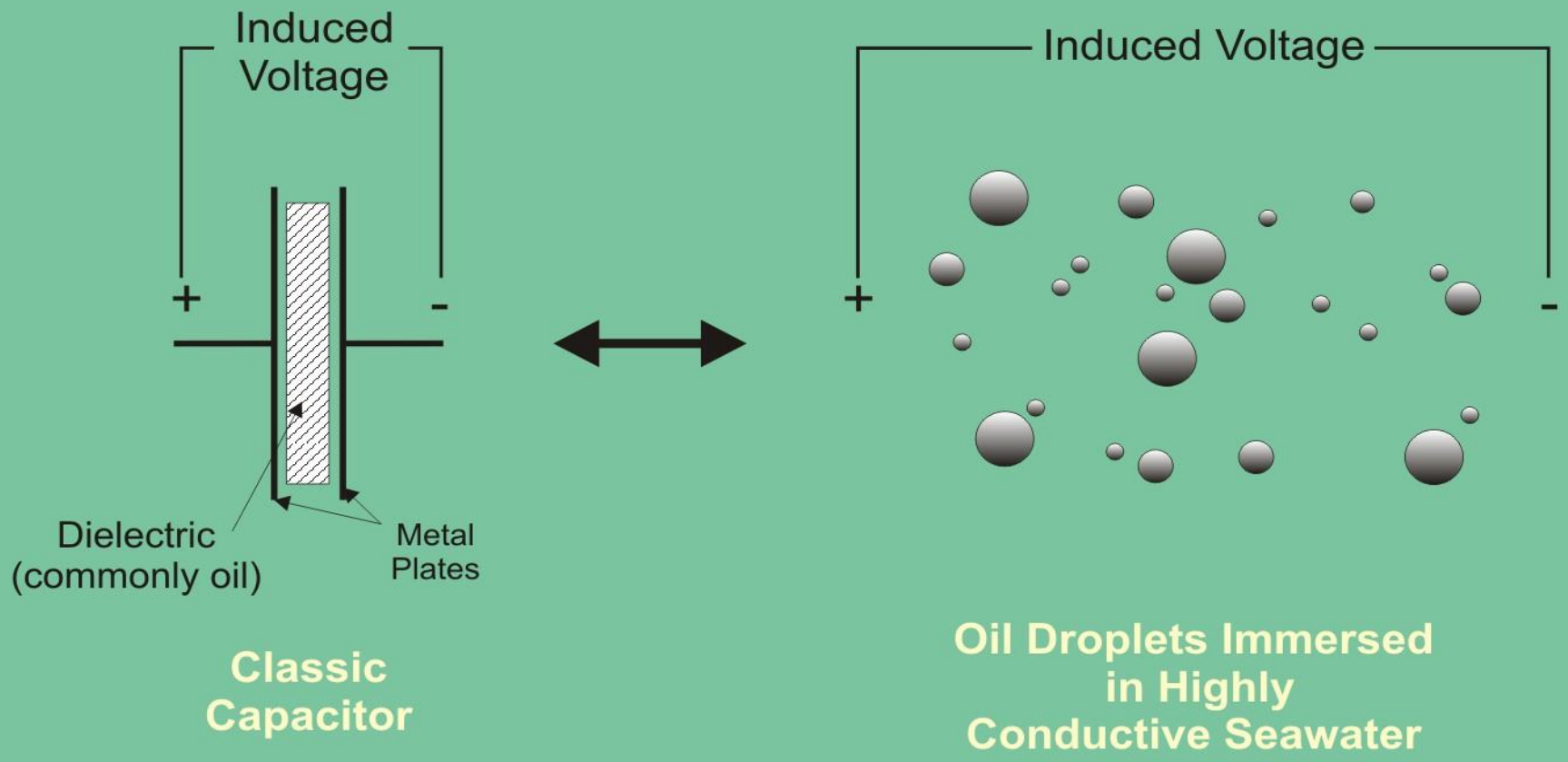
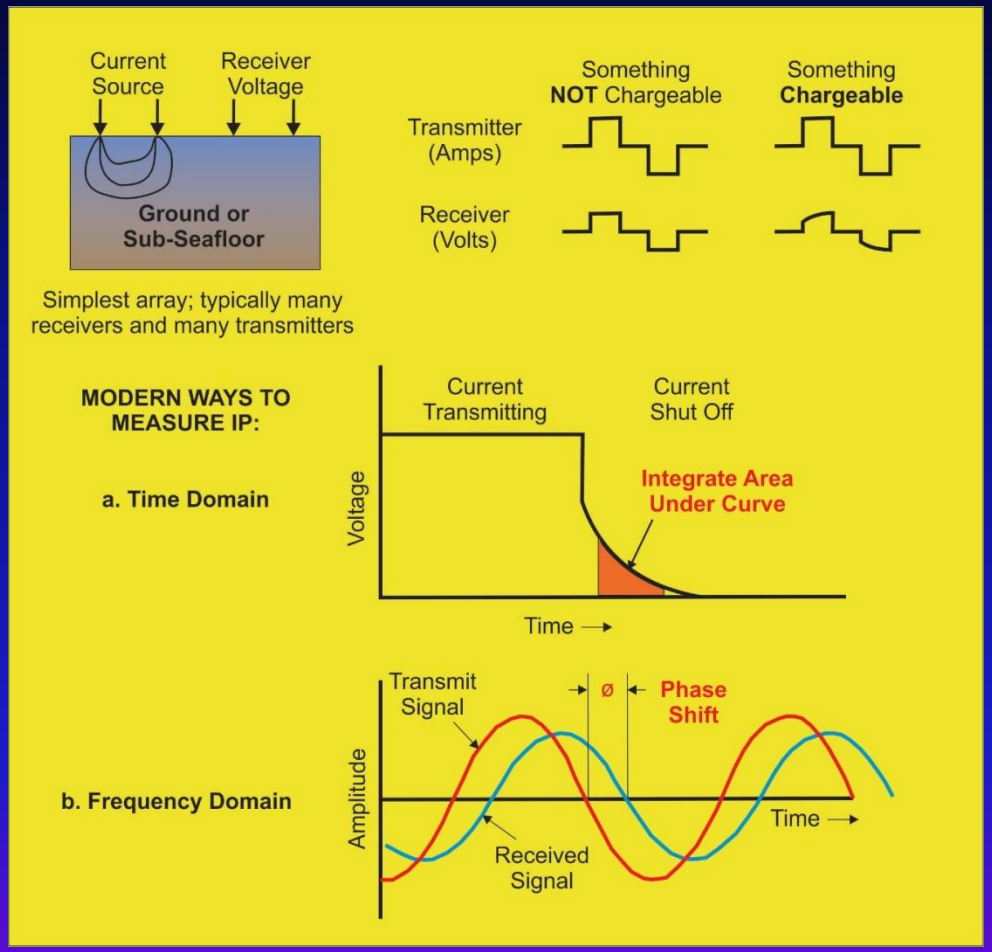
How Marine I.P. can detect oil in seawater starts with a topological equivalency…

- Hydrocarbons in seawater give the strongest response

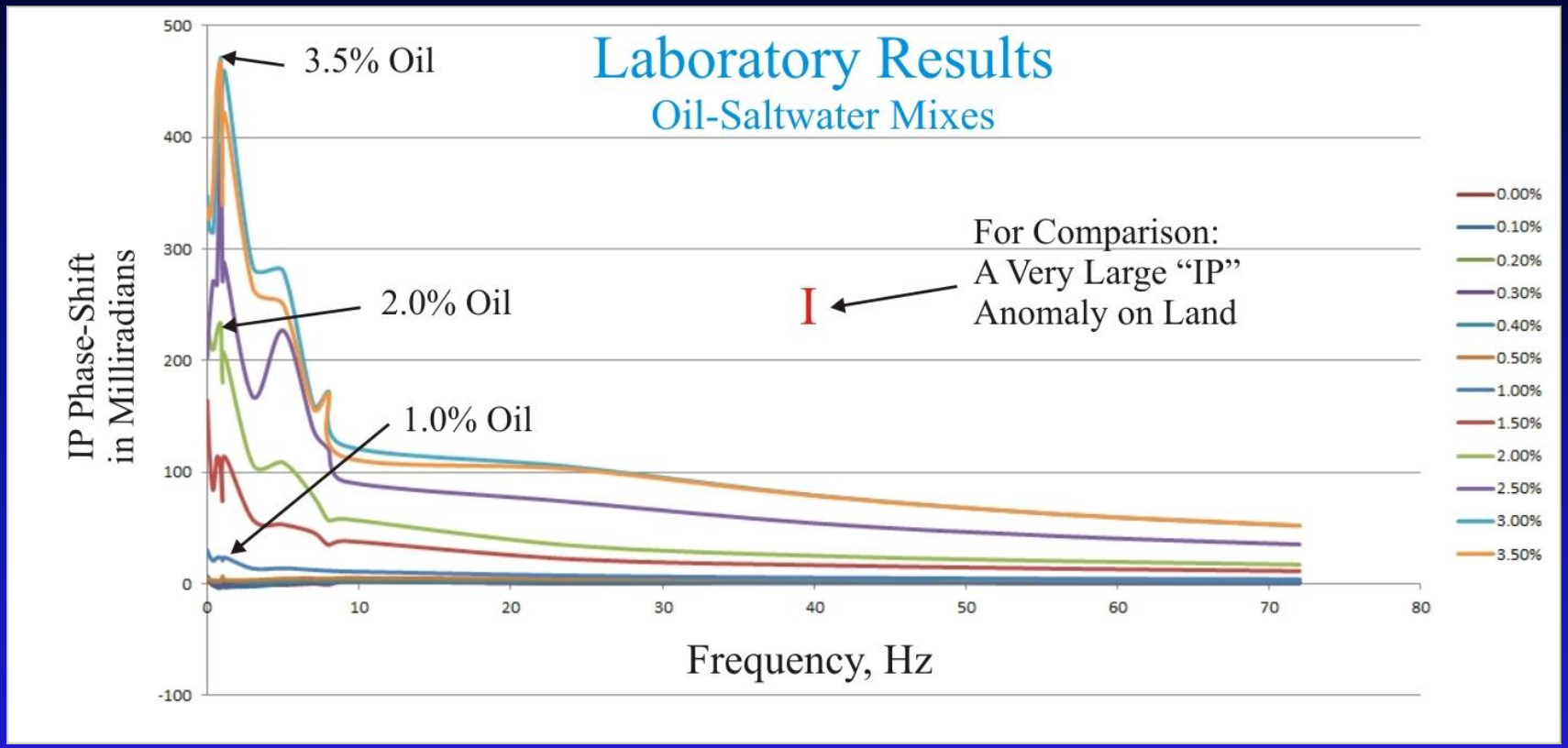


Induced Polarization: What does it *LOOK* like?



IP is a *SURFACE*-sensitive phenomenon

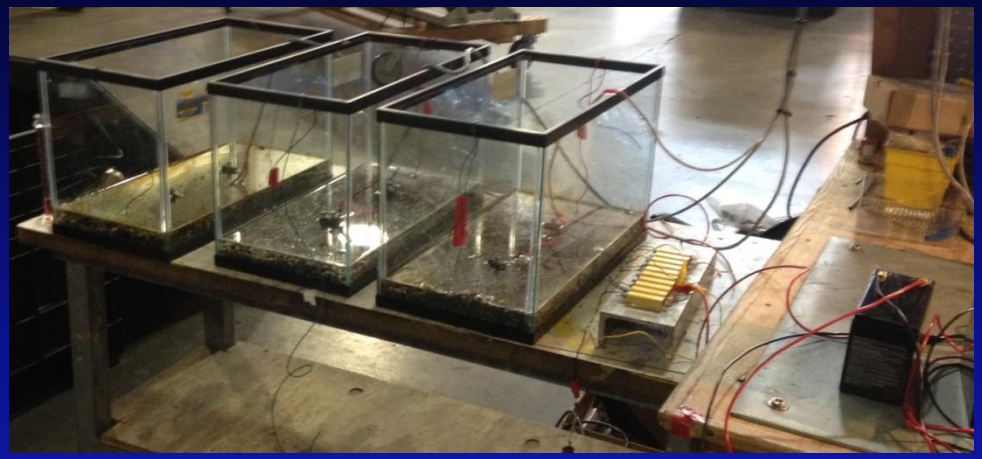
Hydrocarbons in seawater give the strongest response

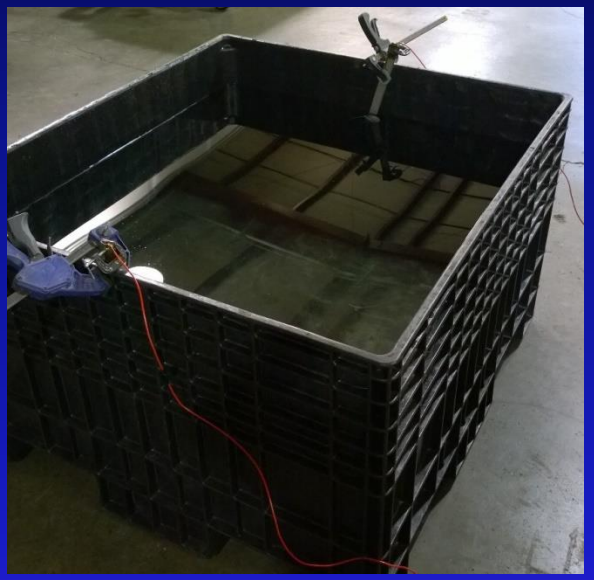


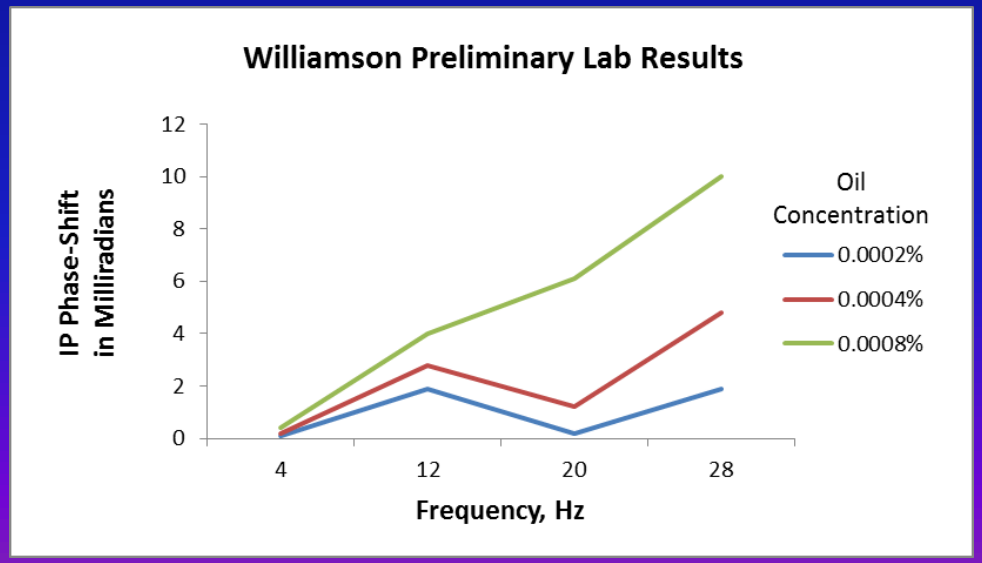
…these results beat ALL expectations.

We can theoretically detect 0.0001% oil in seawater.

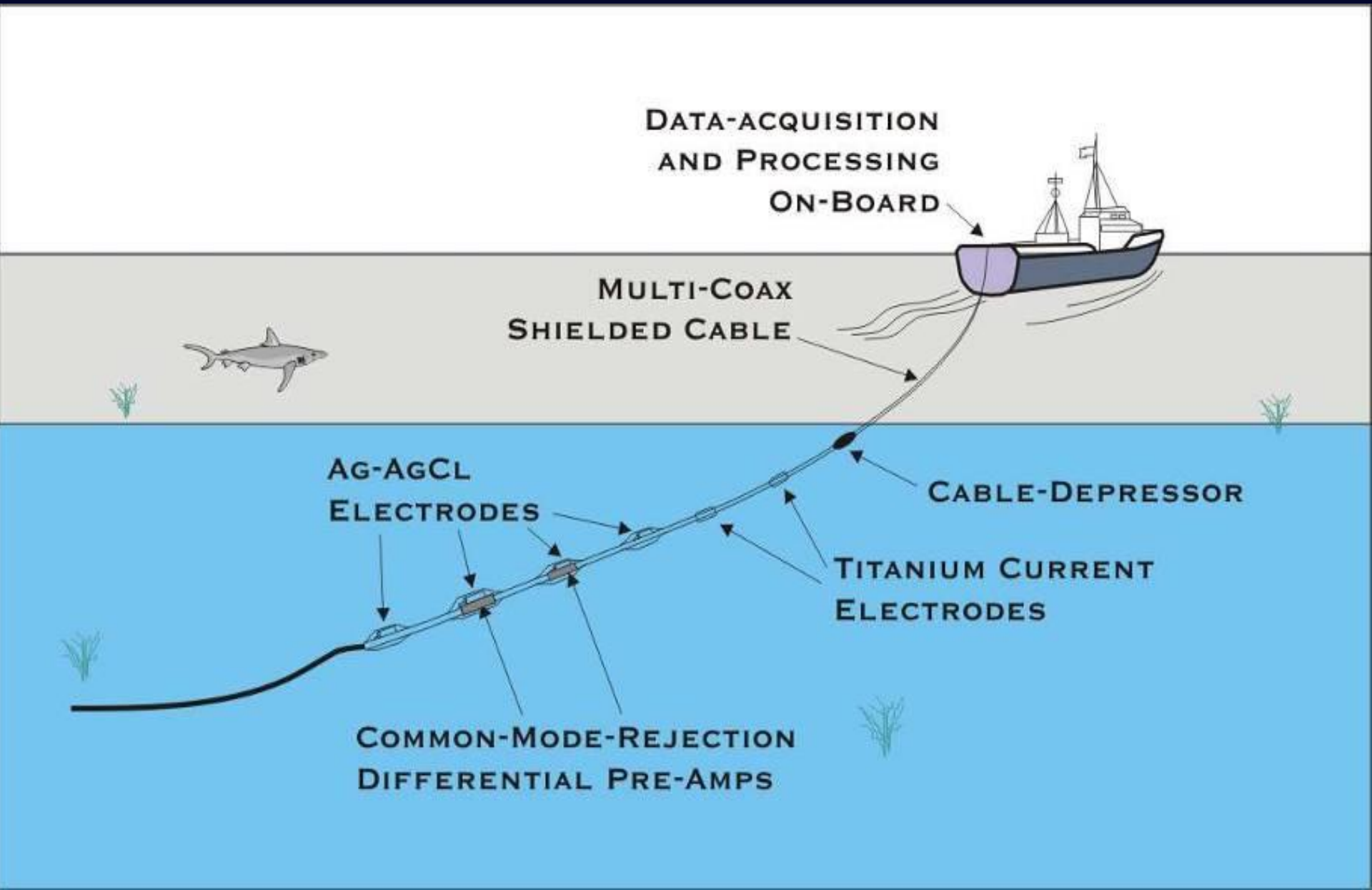
Williamson & Associates IP Lab





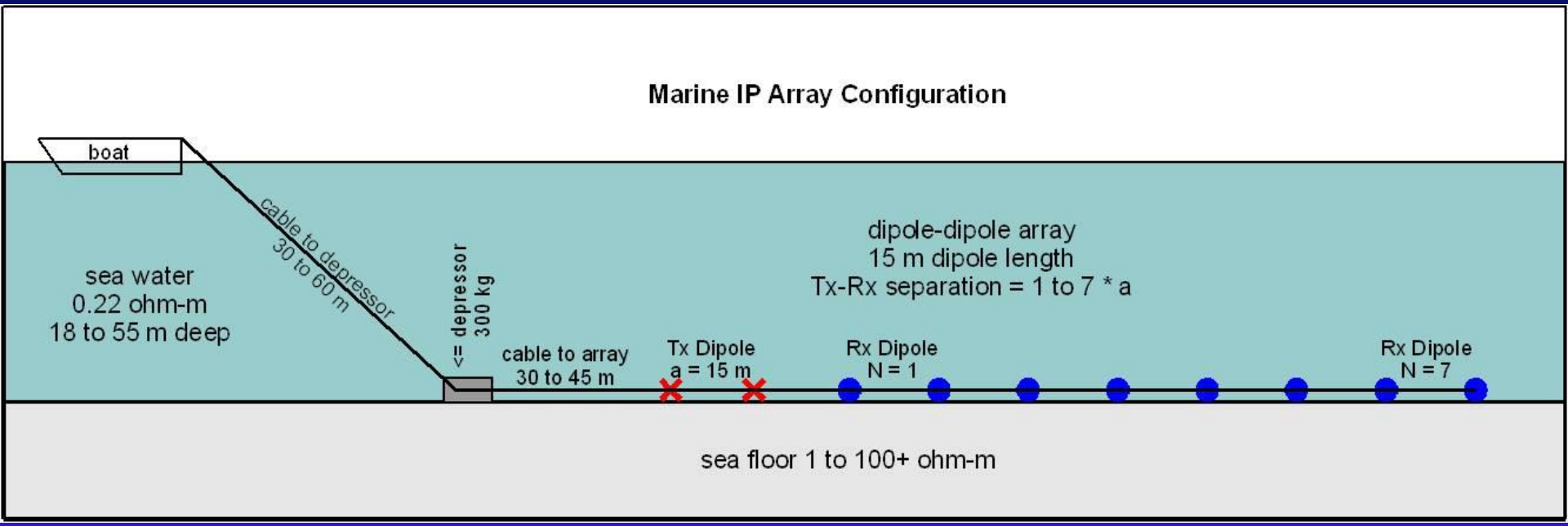


The Prototype Marine Induced Polarization Streamer System



How deep can we see?

Investigation range is primarily dependent on electrode spacing



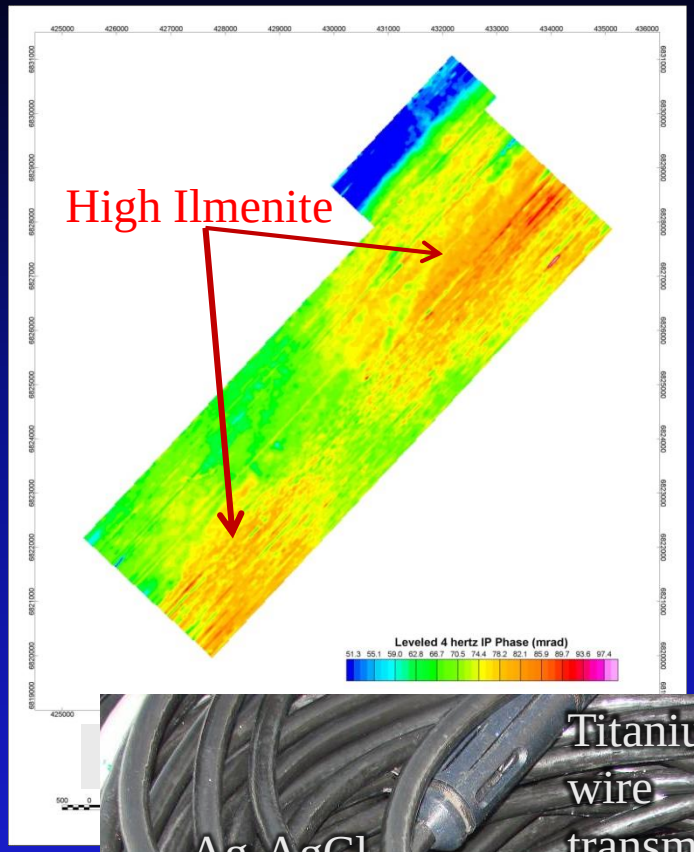
The South African Array achieved a depth-penetration of 20+ meters

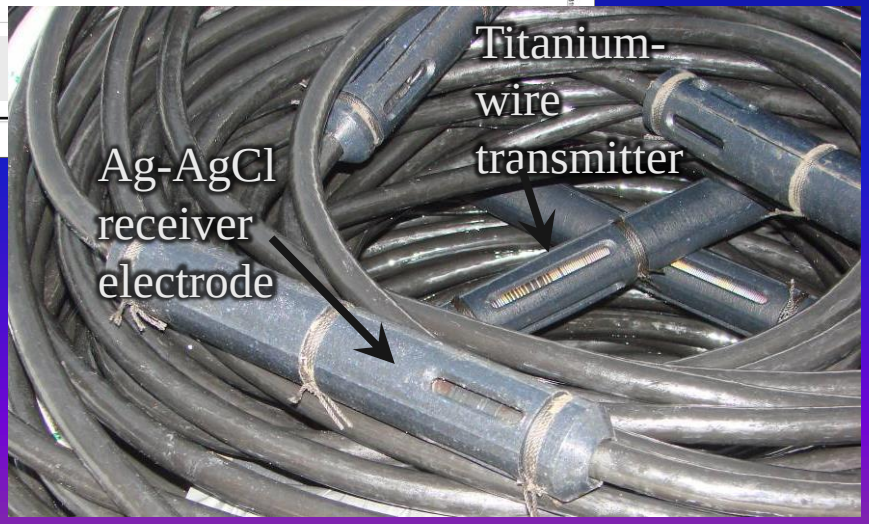
Marine Induced Polarization Technology

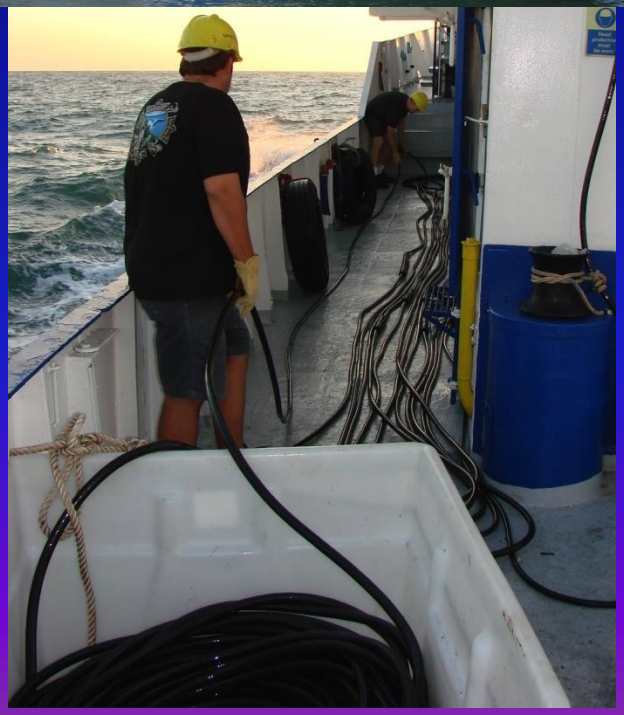
Sea-Trials and mineral exploration using IP:

- Offshore of the USA (Gulf and Atlantic coasts)
- Papua New Guinea
- South Africa

Case Study – South Africa







Case Study

Long Island Sound Organic Sludge

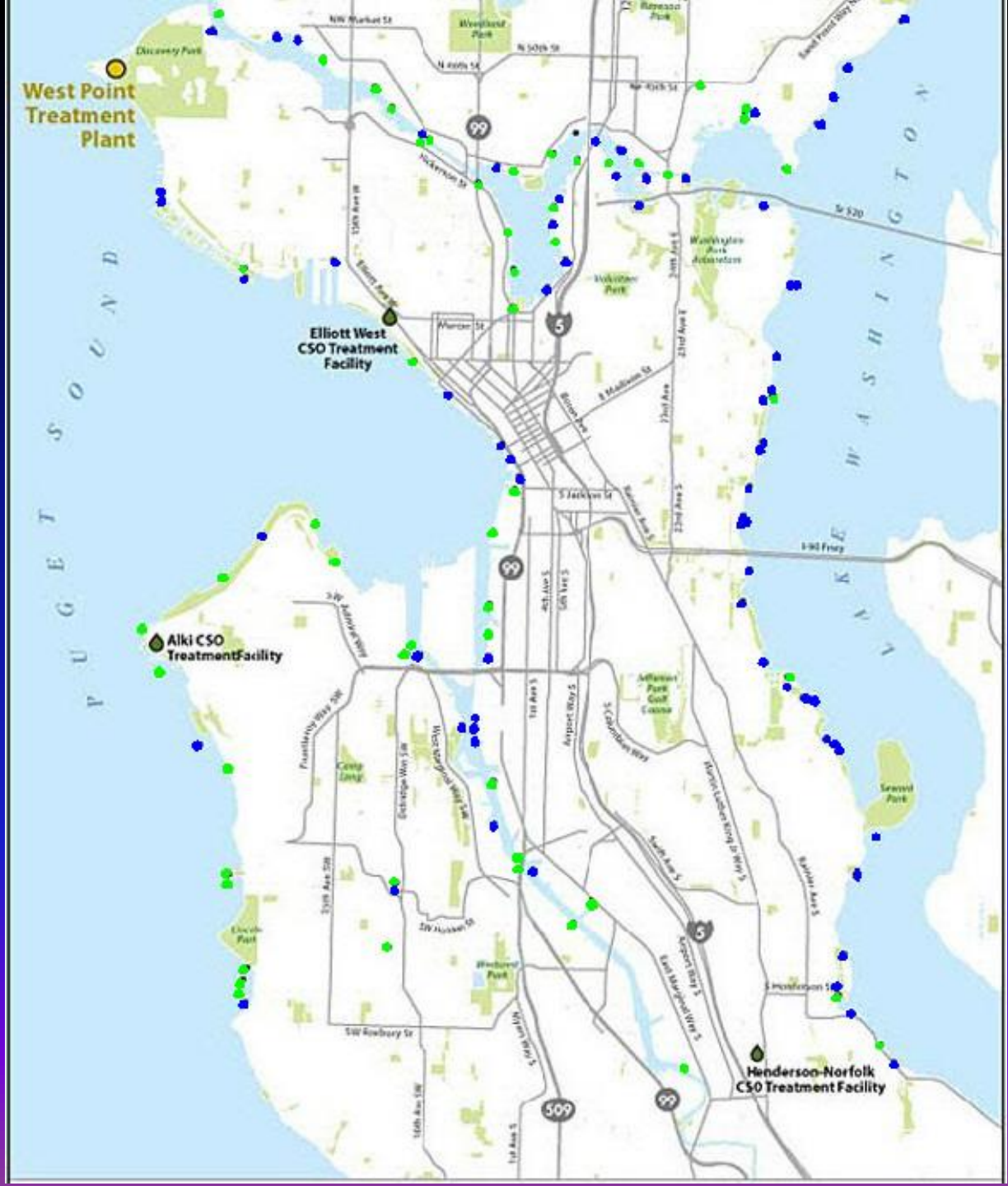
DANGEROUSLY TOXIC TO HUMANS AND WILDLIFE

- Up to 70,000 spores/cc of *Clostridium perfringens*
- ***Significant sulfide content*** (organic reducing environment)
- Moving slowly with tides and long-shore currents

Seattle CSO mapping

Marine IP technology will pick up:

- Sewage
- mill waste
- Pipelines
- metallic debris
- hydrocarbons



In Washington State:

- There are 5 refineries operating in Washington
  - “Crude by Rail” delivery where rails run along waterways such as parts of Puget Sound and the Columbia River
  - Tanker delivery
- Shell Oil platforms in Seattle
- Prolonged pollution from sewage outfalls and CSO events

In the Gulf of Mexico:

Aside from catastrophic well failures, potential for small leaks exists everywhere

- 7,400 drill platforms and well-heads from older platforms
- Estimates up to 1,000,000 MILES of pipeline
  - pipeline “spaghetti” was laid down in pre-GPS days and is poorly located
  - Buried and re-exposed by storm-surges

For more:

An invited feature article in Sea Technology magazine gives some basic background for Marine IP:

THE INDUSTRY'S RECOGNIZED AUTHORITY FOR DESIGN, ENGINEERING AND APPLICATION OF EQUIPMENT AND SERVICES IN THE GLOBAL OCEAN COMMUNITY

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Induced Polarization for Subseafloor, Deep-Ocean Mapping

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This paper in Ocean Science describes the hydrocarbon plume-tracking technology:

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Ocean Science

Seawater capacitance – a promising proxy for mapping and characterizing drifting hydrocarbon plumes in the deep ocean

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Abstract. Hydrocarbons released into the deep ocean are an inevitable consequence of natural seep, seafloor drilling, and leaking wellhead-to-collection-point pipelines. The Macondo 252 (Deepwater Horizon) well blowout of 2010 was even larger than the Ixtoc event in the Gulf of Campeche in 1979. History suggests it will not be the last accidental release, as deepwater drilling expands to meet an ever-growing demand. For those who must respond to this kind of disaster, the first line of action should be to know what is going on. This includes knowing where an oil plume is at any given time, where and how fast it is moving, and how it is evolving or degrading. We have experimented in the laboratory with induced polarization as a method to track hydrocarbons in the seawater column and find that finely dispersed oil in seawater gives rise to a large distributed capacitance. From previous sea trials, we infer this could potentially be used to both map and characterize oil plumes, down to a ratio of less than 0.001 oil-to-seawater, drifting and evolving in the deep ocean. A side benefit demonstrated in some earlier sea trials is that this same approach in modified form can also map certain heavy placer minerals, as well as communication cables, pipelines, and wrecks buried beneath the seafloor.

the world's oceans (Yapa and Chen, 2004). Where the complex hydrocarbons end up after such an event is important to scientists, policy planners, and litigants. After direct recovery, evaporation, skimming and burning, and "naturally dispersed" components are counted, the whereabouts of at least 38 % of the Macondo hydrocarbons remains unknown (Ramseur, 2010). Dissolved oxygen concentrations suggest that microbial consumption rates are very low in the cold abyssal sea, on the order of 1 micromolar oxygen per day (Camilli et al., 2010). As a result, a deep plume is thought to have advected away in the Gulf Loop Current at least several hundred kilometers from the Macondo well during 2010 (Kessler et al., 2011). A towed seawater capacitance-measuring geoelectrical array could be used to map and characterize such evolving plumes in the future.

Before mitigation can be planned or liability assessed, a hydrocarbon release must be mapped in 3-D, to see how it evolves and degrades in space and time. One way to do this is by cable-lowered rosette sampling (Breier, et al., 2010) deployed from a stationary ship. However, this is slow and expensive, requires downstream mass spectrometry or subsequent chemical analysis, and provides only a narrow vertical profile sample while a plume is moving past it. Another

Marine IP Technology: a broad application tool for deep ocean and seafloor oil mapping.

Williamson & Associates already have a shallow-water system operational.

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