Induced Polarization Associates LLC

Marine Induced Polarization

An Electrical In-Water Hydrocarbon Detection Technology

Presentation
March 29, 2018

Kevin Hand
Induced Polarization Associates

USGS science for a changing world

Williamson & Associates

IntelliSense Marine

March 29, 2017 – “If you can’t <u>see</u> spilled oil, *how do you find it and clean it up?”*

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High Water and Sunken Oil on the Great Mississippi

March 29, 2017 - If you can’t see spilled oil, how do you find it and clean it up?

USCG conducting initial damage survey of barge from the UTV Amy Frances. Credit: U.S. Coast Guard

That’s the situation emergency responders faced in two oil spills on the Mississippi River that challenged their understanding of how to approach evaluating oil spill conditions.

The first incident was Sept. 3, 2015 when two tow barges collided on the Lower Mississippi River near Columbus, Kentucky. The second was Jan. 21, 2016 when a barge towed by the UTV *Amy Frances* struck the Natchez Bridge on the Lower Mississippi River. The Lower Mississippi is the most traveled and commercially important portion of the river’s system.

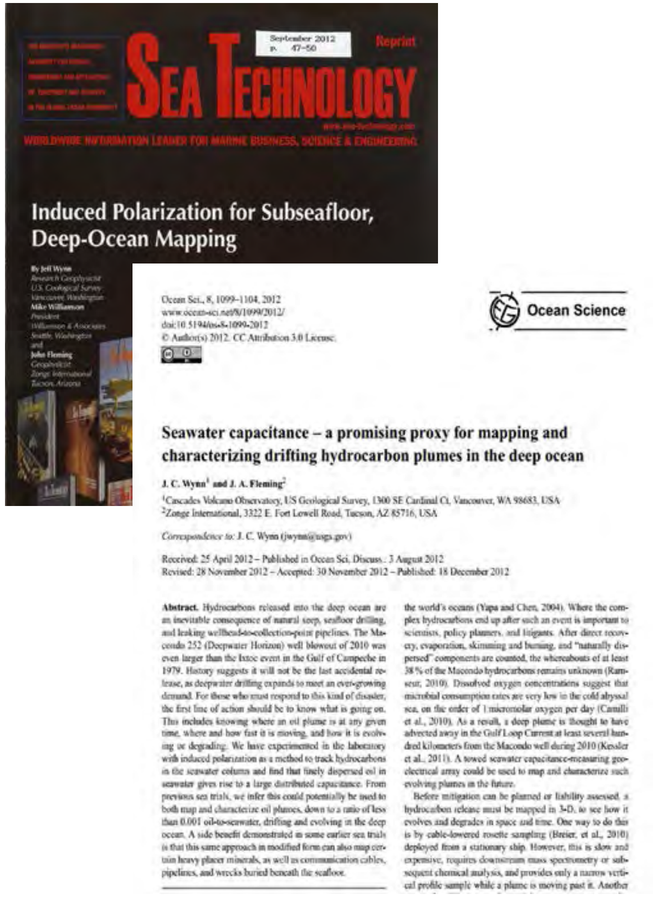
On Our Radar

Response Tools for Spills

Meet the New CAMEO Chemicals Mobile App

Preparing for Hurricane Season

Marine Induced Polarization



Excerpt: Ocean Science

<u>PEER-REVIEWED SCIENCE</u>

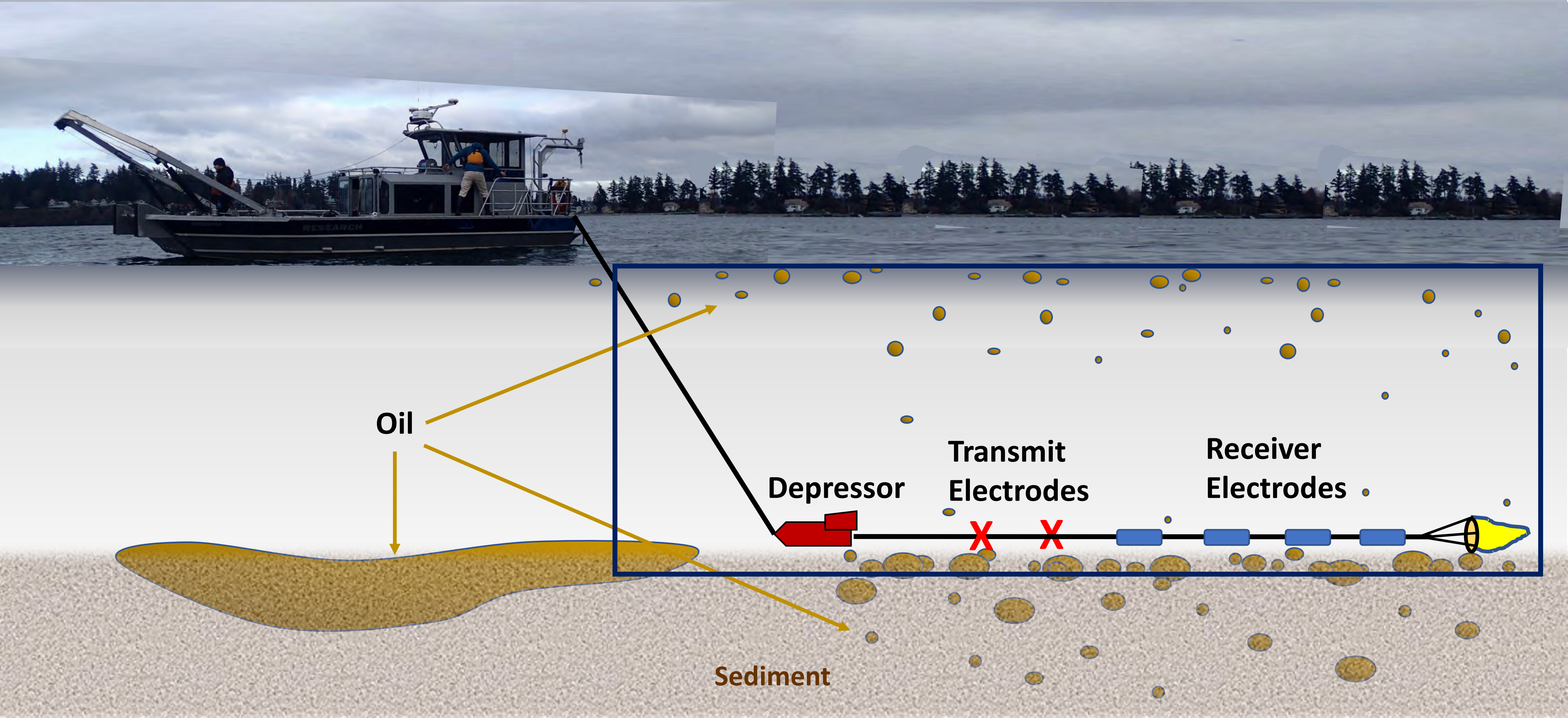
An Introduction:

- 2016: *Induced Polarization Associates LLC* was formed to explore the *commercial* applications of Marine Induced Polarization
- Proven technology relating to hydrocarbon detection
- Investigating the practicality of applications which benefit the oil spill community

A Brief History…

- Induced Polarization (IP) has been used on land for more than a half-century, its initial application aimed at mining for precious metals.
- Recently the focus has been on detection of hydrocarbons and associated derivatives in the water column, on sea and river beds, or sequestered in bottom sediments.
- Measurement of non-floating oil substances, both from industrial sources and collected weather-altered field samples, have been tested with similar positive results

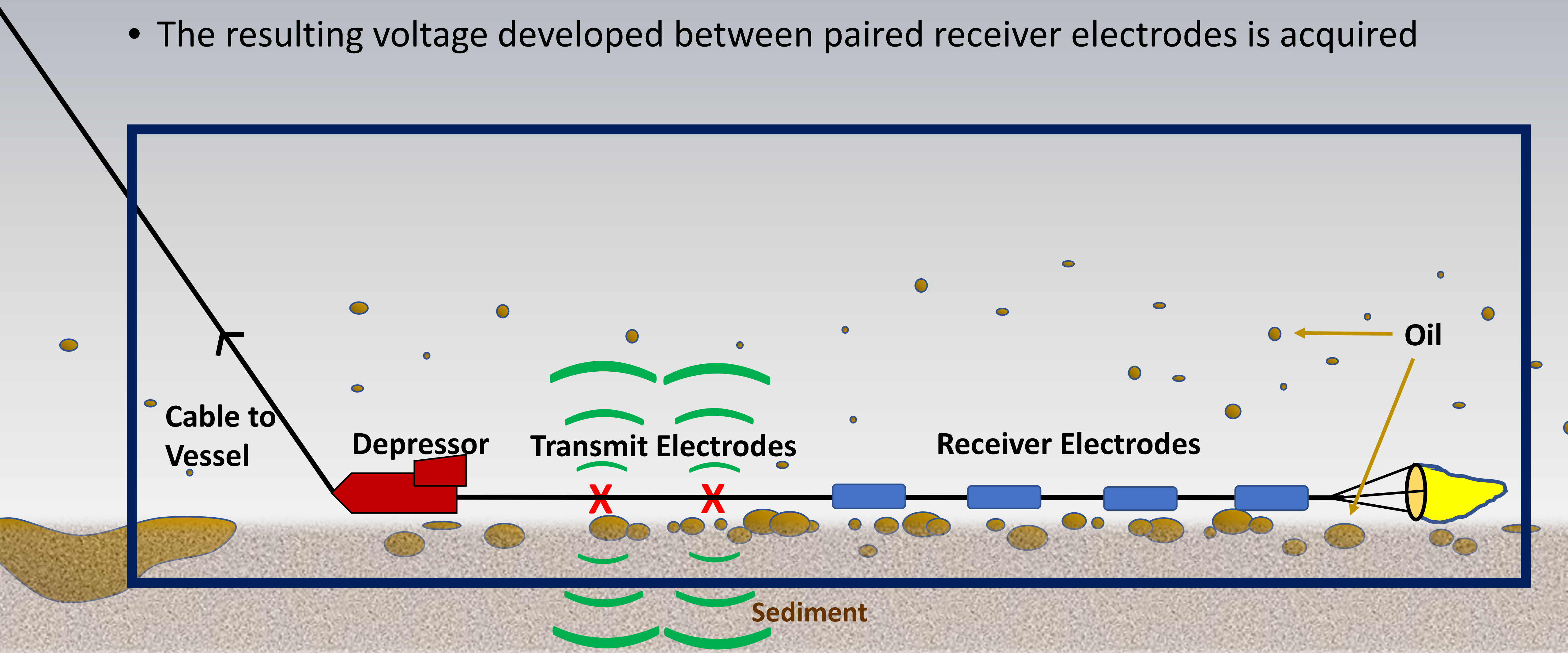
How it works



RESEARCH
Oil
Transmit
Electrodes
Receiver
Electrodes
Depressor
Sediment

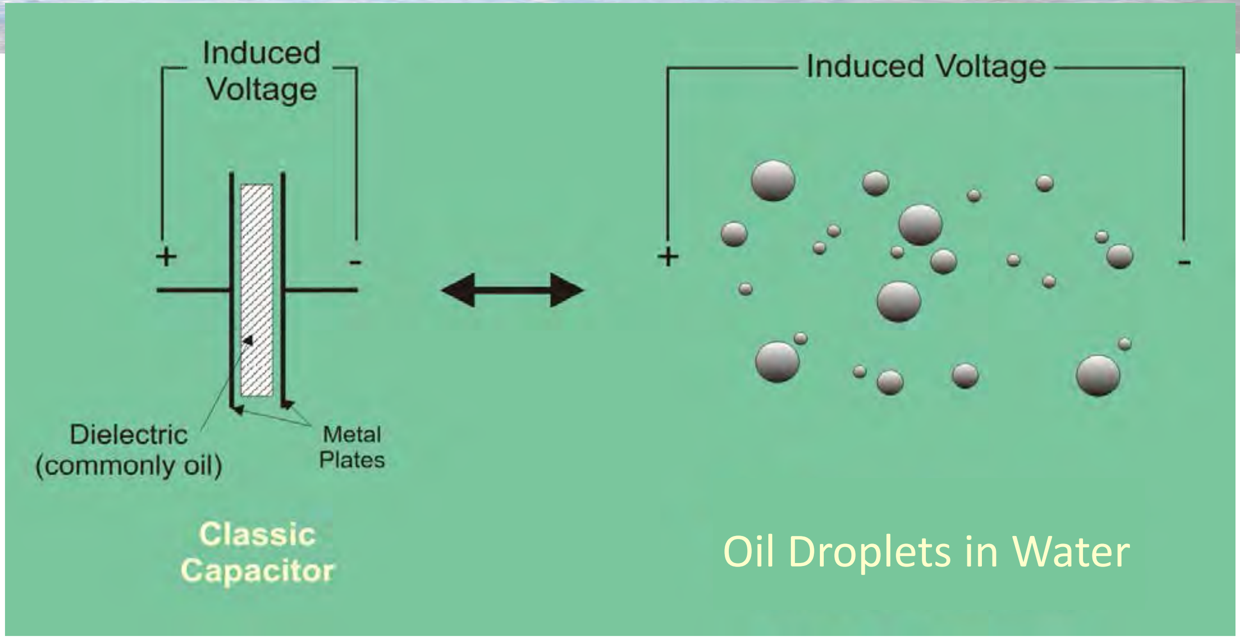
How it works

- A controlled electrical current is introduced into sea/river water
- The resulting voltage developed between paired receiver electrodes is acquired

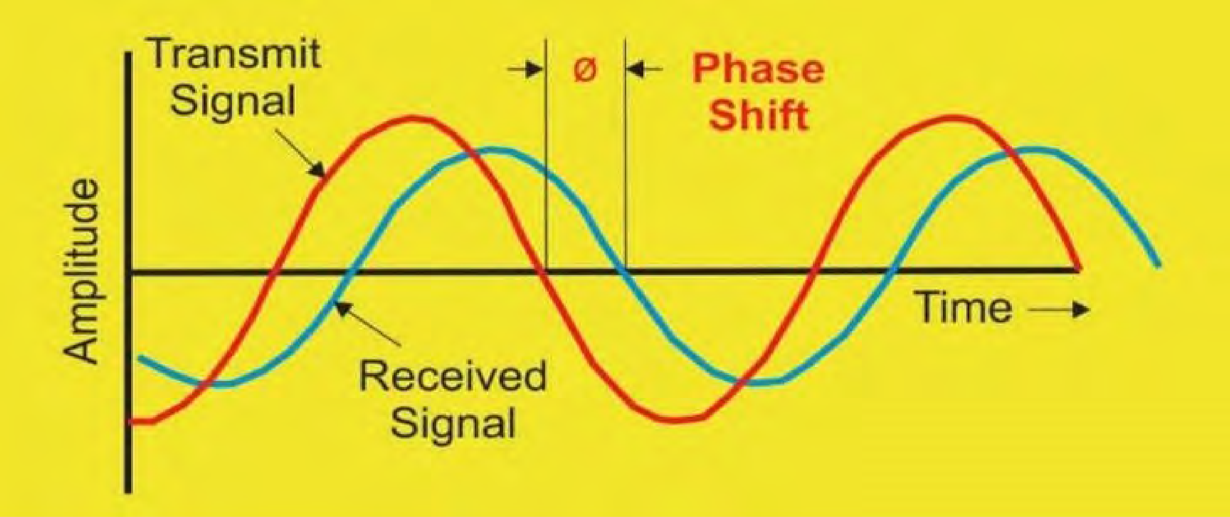


How it works

- Acts as a capacitor



- The phase shifts between the current and the voltage are used to identify anomalies, such as hydrocarbons.



How it works

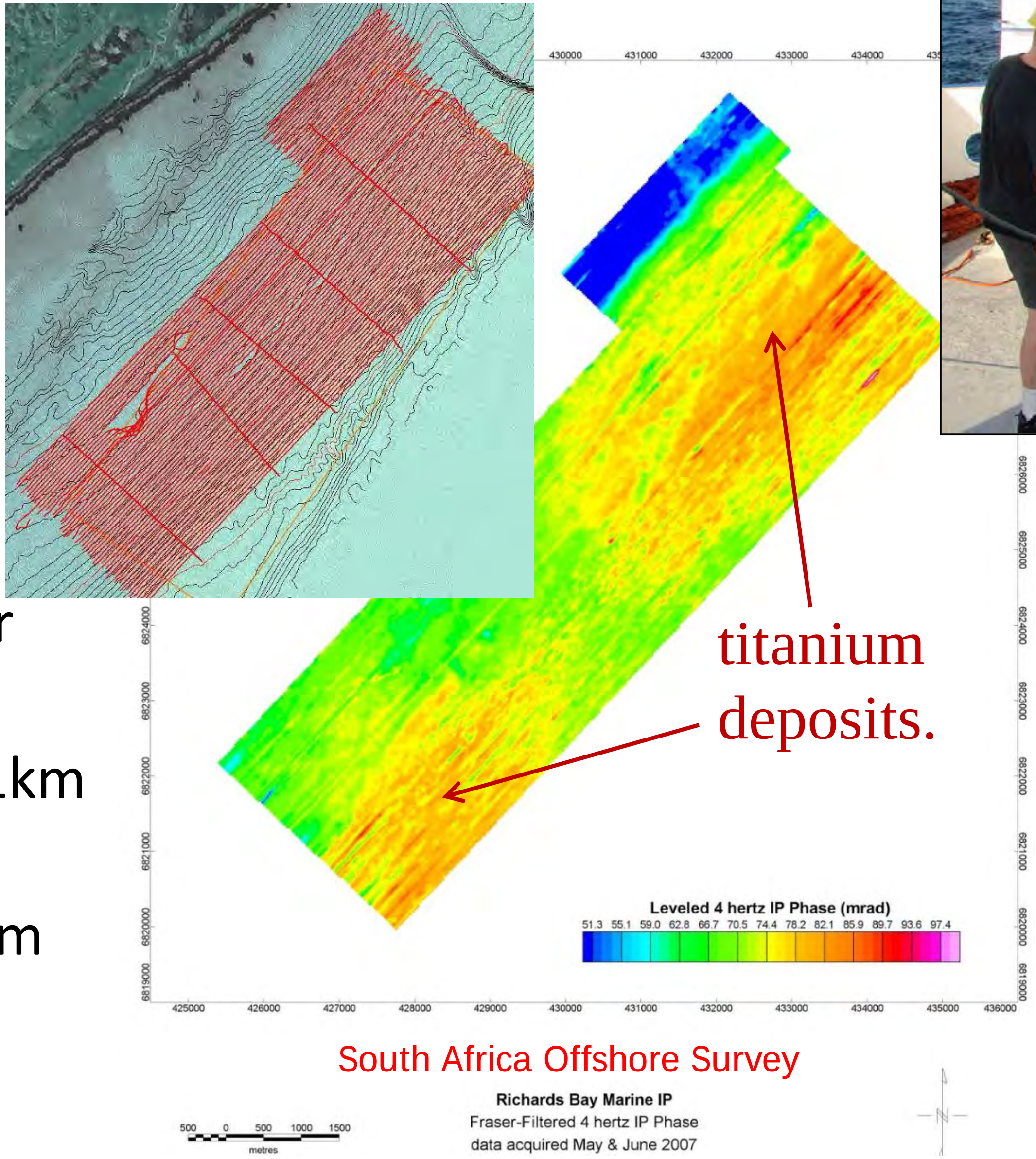
Specifications

- Salinity: Sea Water, Rivers, Lakes
- Minimum Temperature (°C): -2
- In laboratory, detection of oil down to 2 ppm
- Current cable configuration:
  - Total length: 160m
  - Weight: ~150 lbs.
- Cable's breaking strength: 6500 lbs.
- Water depth: 1m to Full Ocean Depth
- Penetration in sediment: Down to 20m
  - Transmitter/receiver geometries are adjustable
  - The distance between receiver electrode pairs determines depth of penetration.

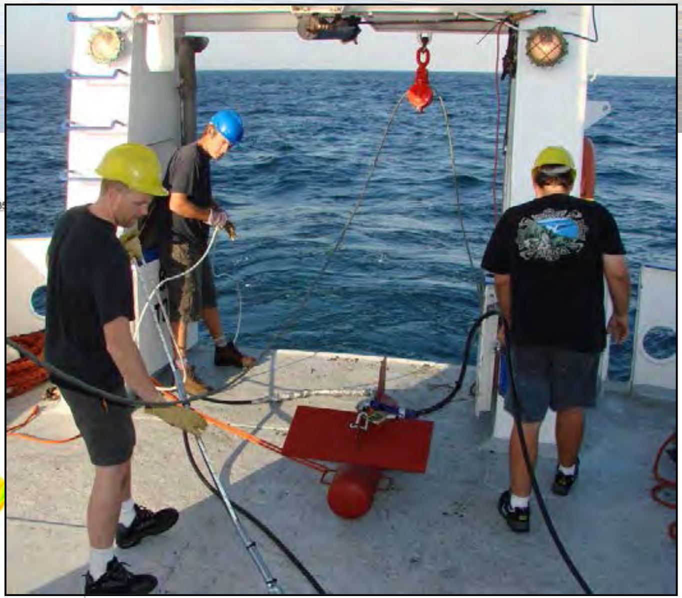
Seawater Field Measurements:

South Africa

- Commercial marine IP survey in South Africa
- Discovered 2 large & hidden placer titanium deposits
- Invisible to ROV or diver
- Survey area: 3.5km x 11km
- 25-day survey with 100m line spacing

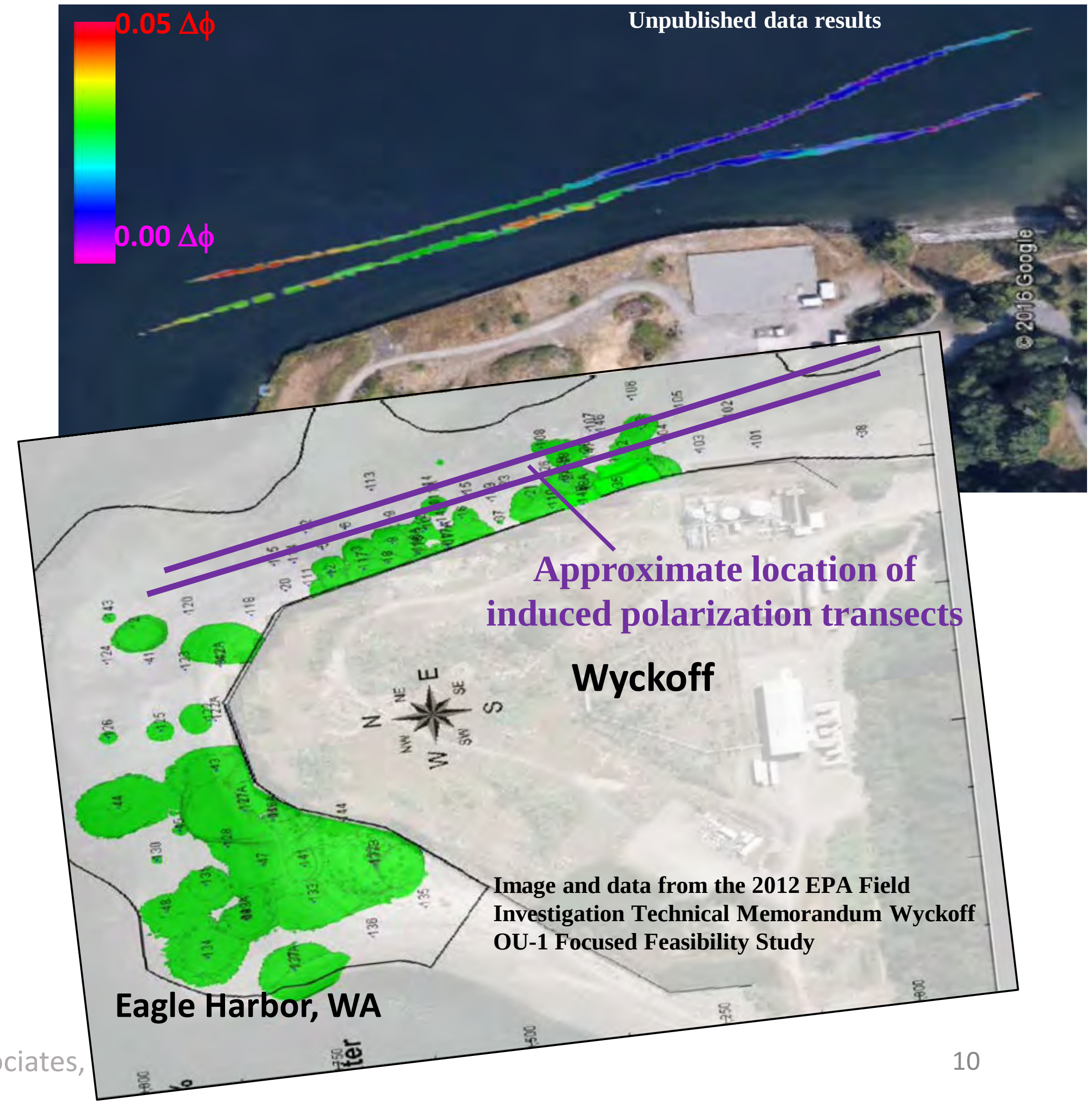


South Africa Offshore Survey



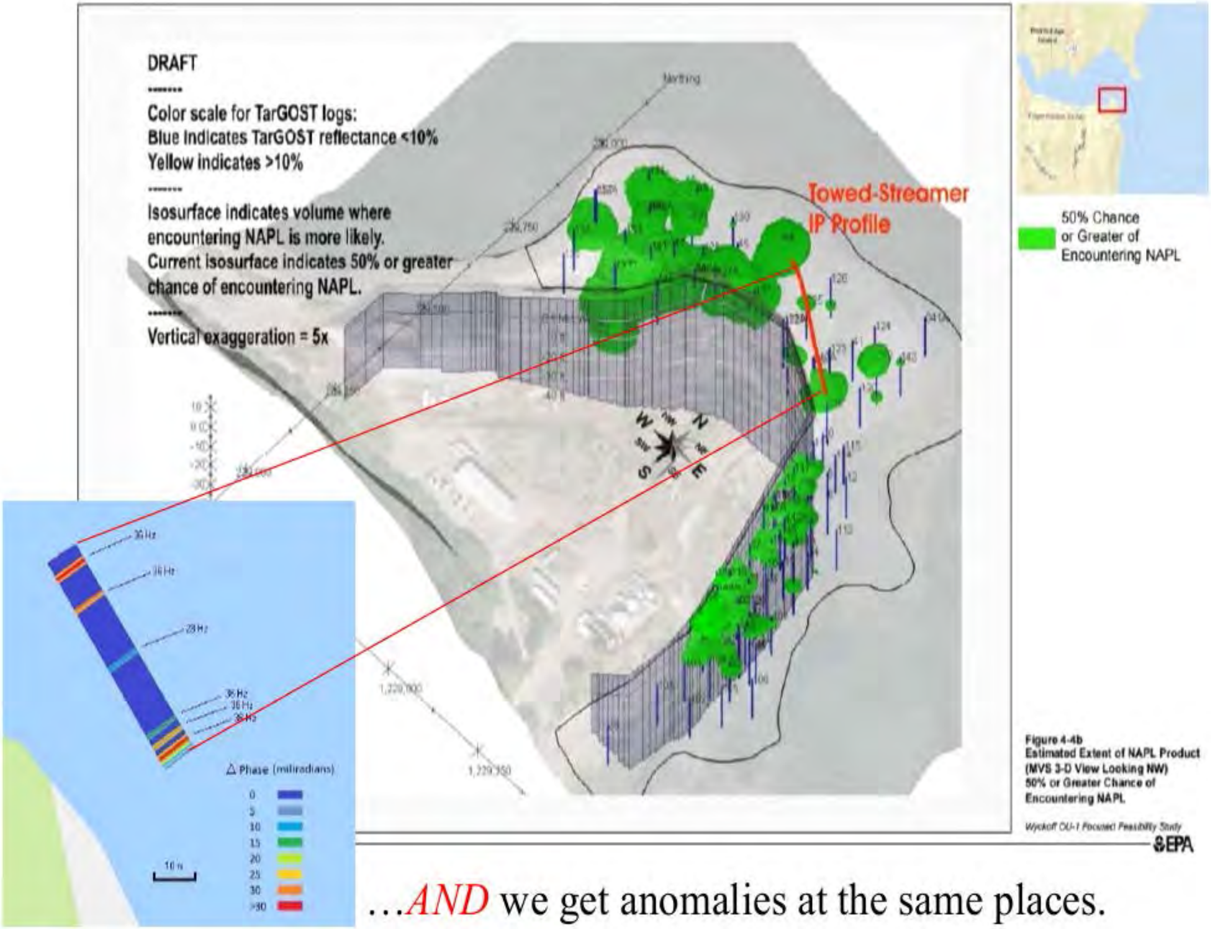
Seawater Field Measurements: Wycoff

- Field trials were conducted at the Wyckoff superfund site in Puget Sound, WA (2016)
- Former creosote manufacturing facility
- Pockets of creosote/tar, NAPL and PAH have either been capped and are randomly extruded to the seabed and/or transported to the intertidal zones



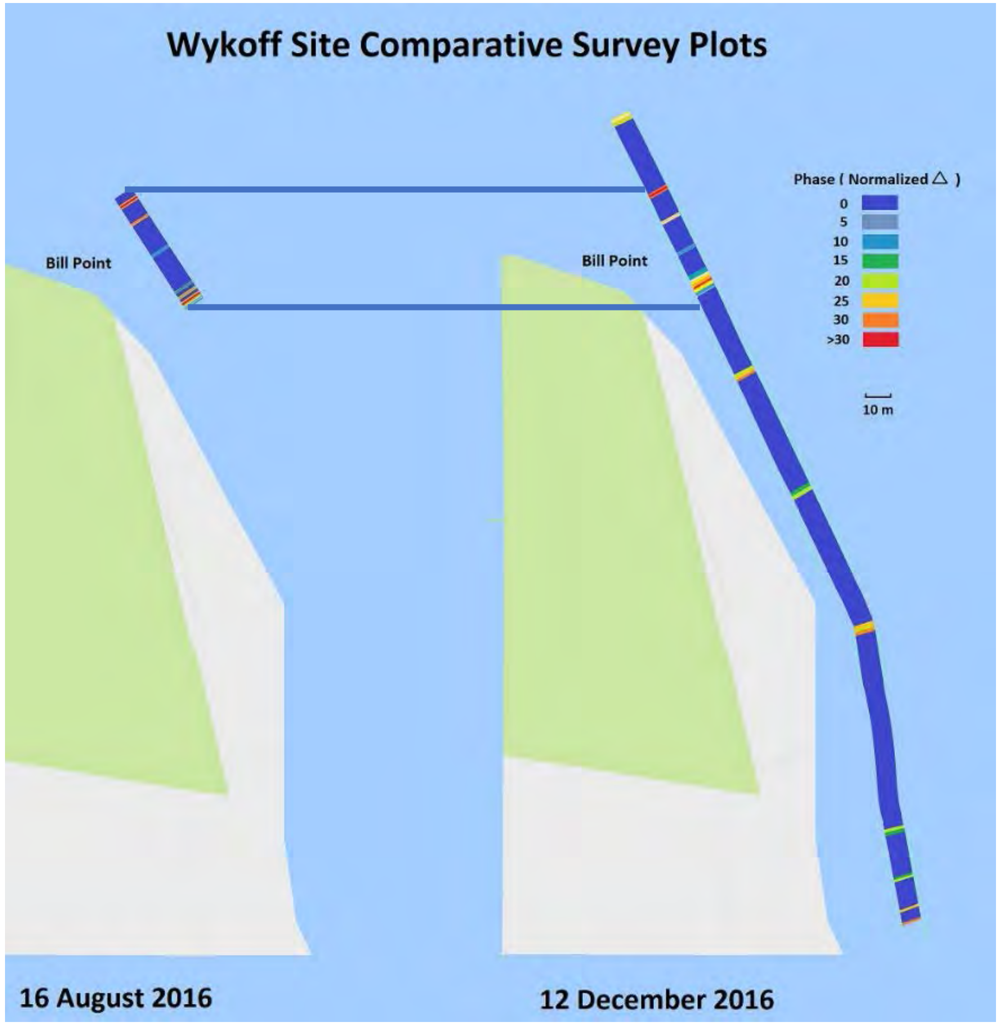
Seawater Field Measurements: Wycoff

Comparison Check: EPA TarGOST Survey Results



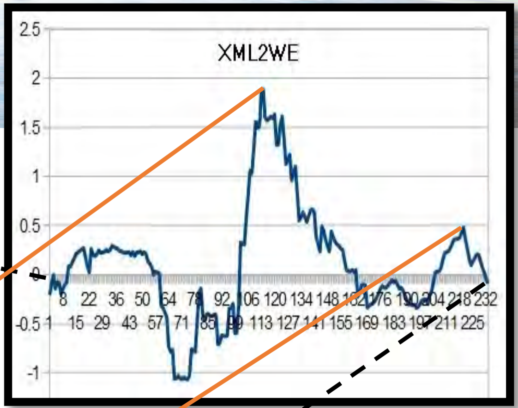
…*AND* we get anomalies at the same places.

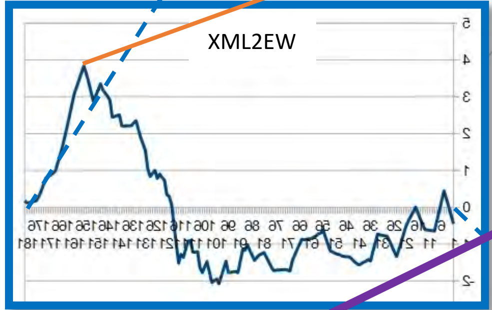
Replication Check:

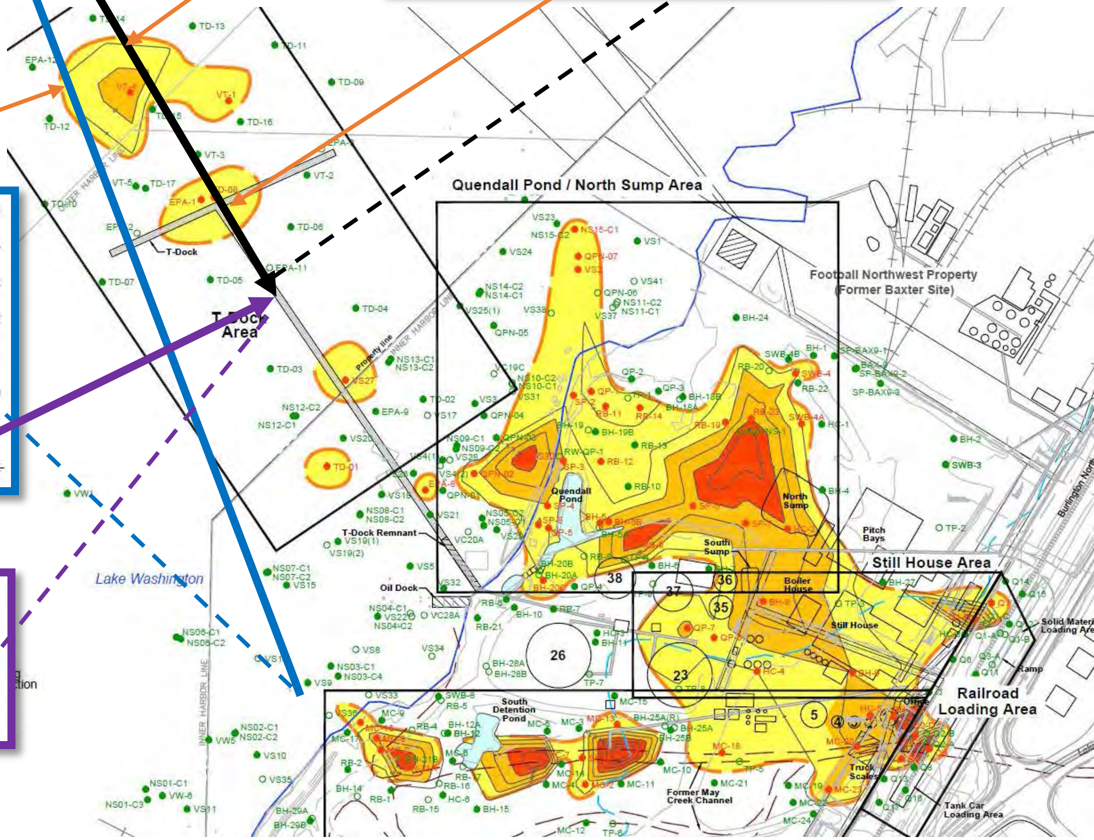


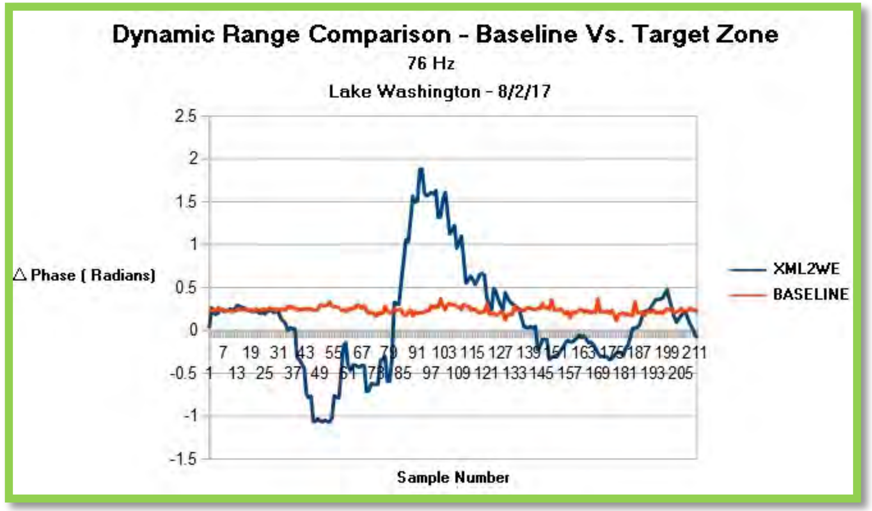
Freshwater Field Measurements: Lake Washington

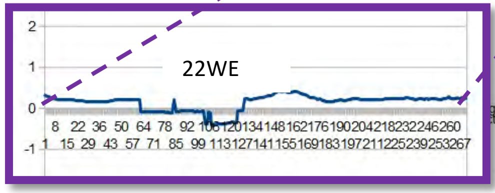
- Field trials were conducted at the Quendall Terminals superfund site in Lake Washington, WA (2017)
- Former creosote manufacturing facility









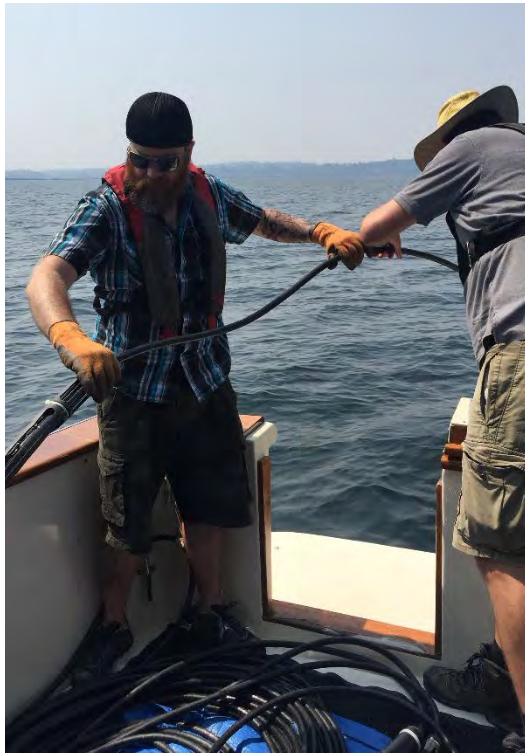


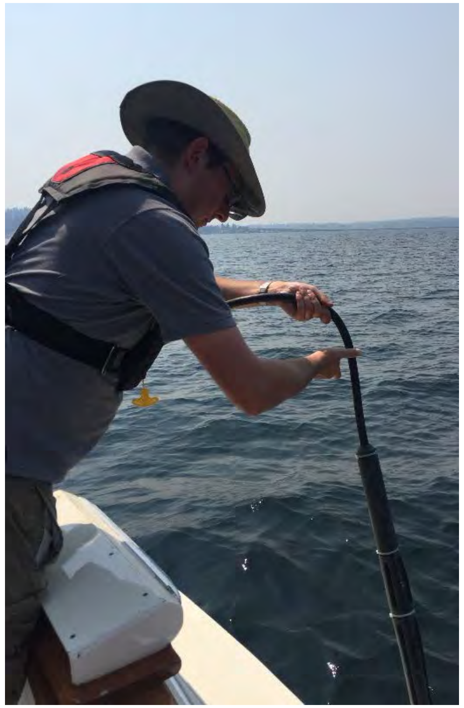
Field Operations

Deployment & Recovery

Vessel requirements

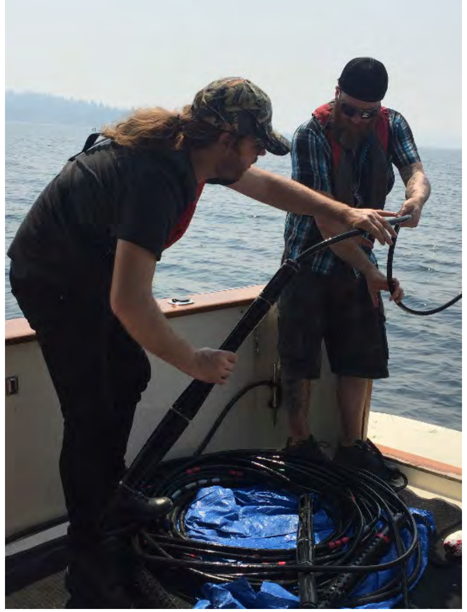
- Minimum 25 ft.
- Protected area for electronics
- 4 x 8 ft. deck space
- Ability to travel =< 3 kts





Hand Deployment

Cable being towed



Hand Recovery

Field Operations

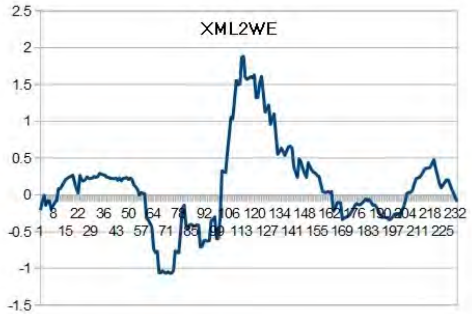
Data acquisition

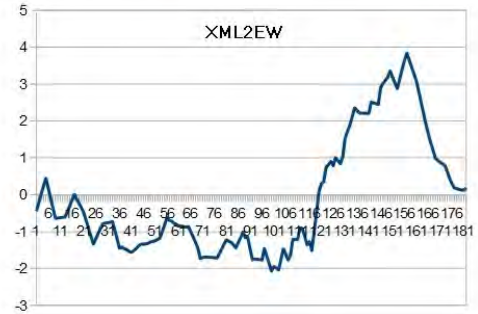
Field Operations

Data products

- Data files
    - *.txt
    - *.csv
    - *.xls
    - 3D Voxels
    - & Others
- Graphics files
    - Georeferenced maps
    - *.KMZ
    - Shapefiles
    - & Others

Example 10-min Product





Example for Reporting

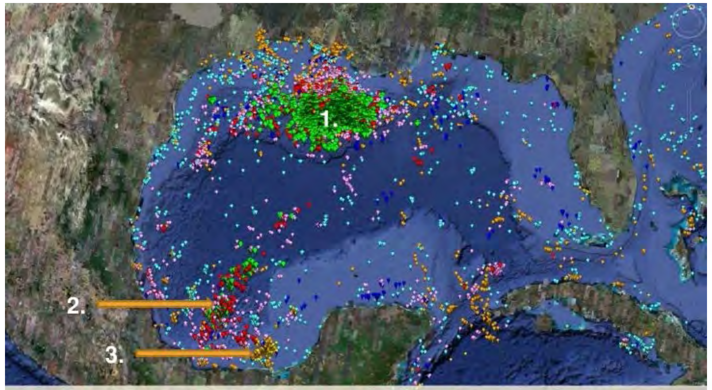
How can Marine IP be useful for Oil Spills?

- **Baseline Characterization**
- **Offshore Spill Response**
- **Nearshore, River, Fresh Water Incidents**
- **Legacy Spills**
- **Potential for Plastics**

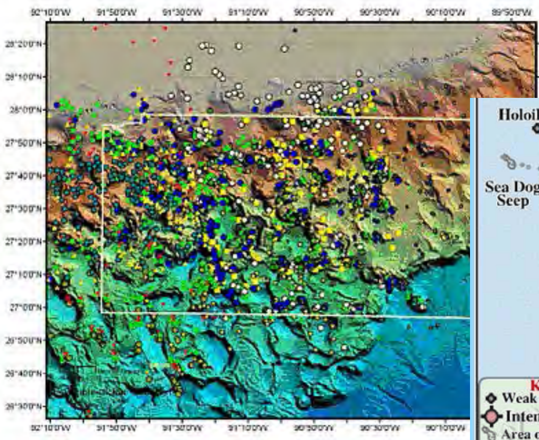
How can Marine IP be useful for Oil Spills?

Baseline Assessments – Categorizing Environmental Liability

- Mapping of existing oil seeps
    - Extent & Location of existing source releases
- Pre-existing contaminations
    - Prior E&P activity
    - Adjacent operators: source contamination potential



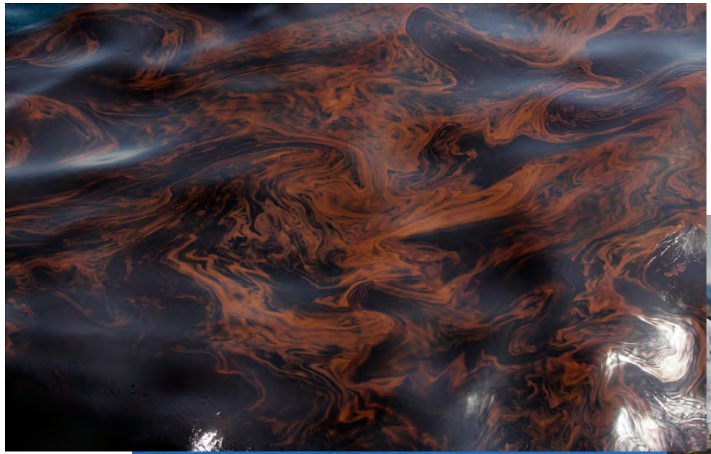
Green, red and pink are natural seepage-slicks mapped on satellite SAR. Dense repeating seepage coincide with many fields



How can Marine IP be useful for Oil Spills?

Spill Response

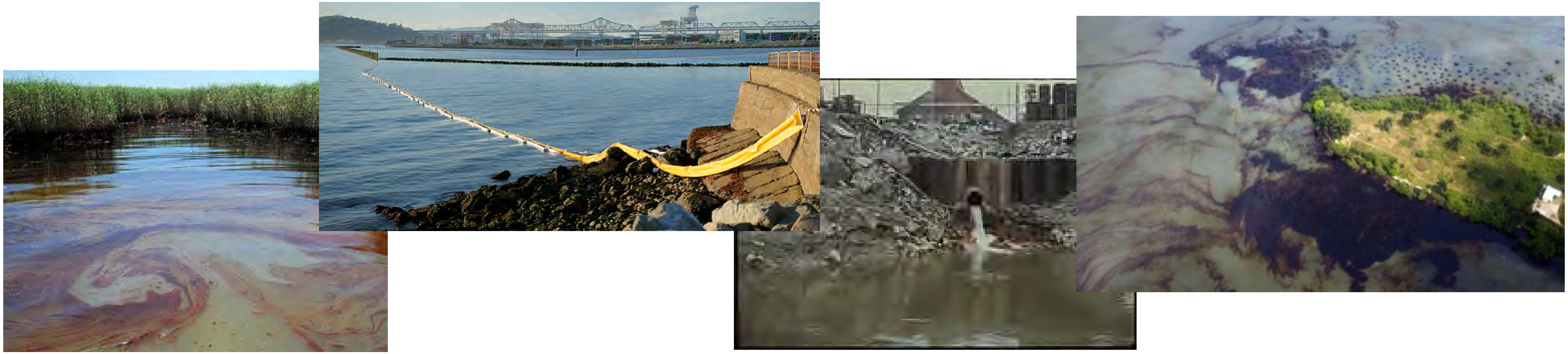
- ➢ Mapping of Oil in/on Sediment
- ➢ Potential: 3D Mapping of water column
  - Real-time data returns of extent
- ➢ Potential: Monitoring the movement of spill
  - Confirm validity of Trajectory Modeling
- ➢ Potential: Shoreline Incursion “ALARM”
  - Near-shore / Sensitive Area Warning System



How can Marine IP be useful for Oil Spills?

Nearshore, River, Freshwater Incident Response

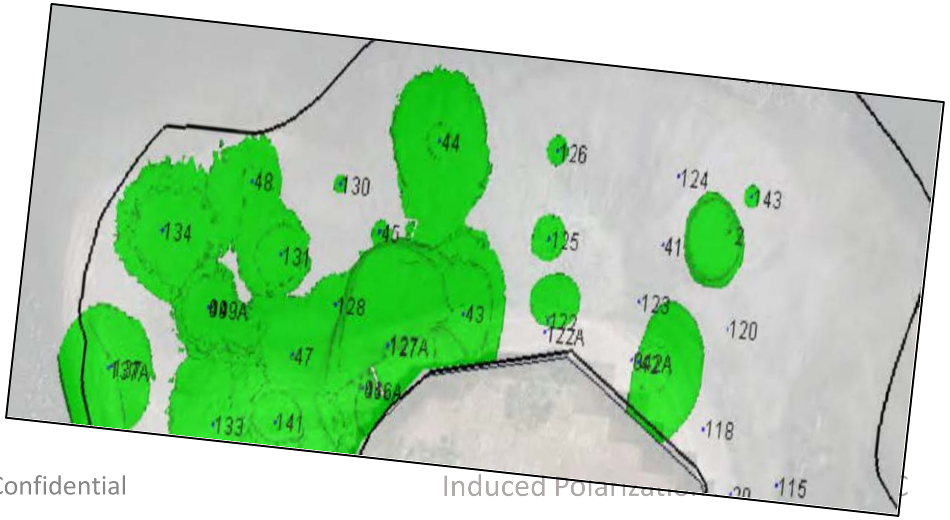
- IP is capable of strong signal returns in fresh & brackish water environments
  - Pipeline river crossings – leak detection
  - Static monitoring at inflows / outflows
  - Spill response/monitoring in shallow river deltas

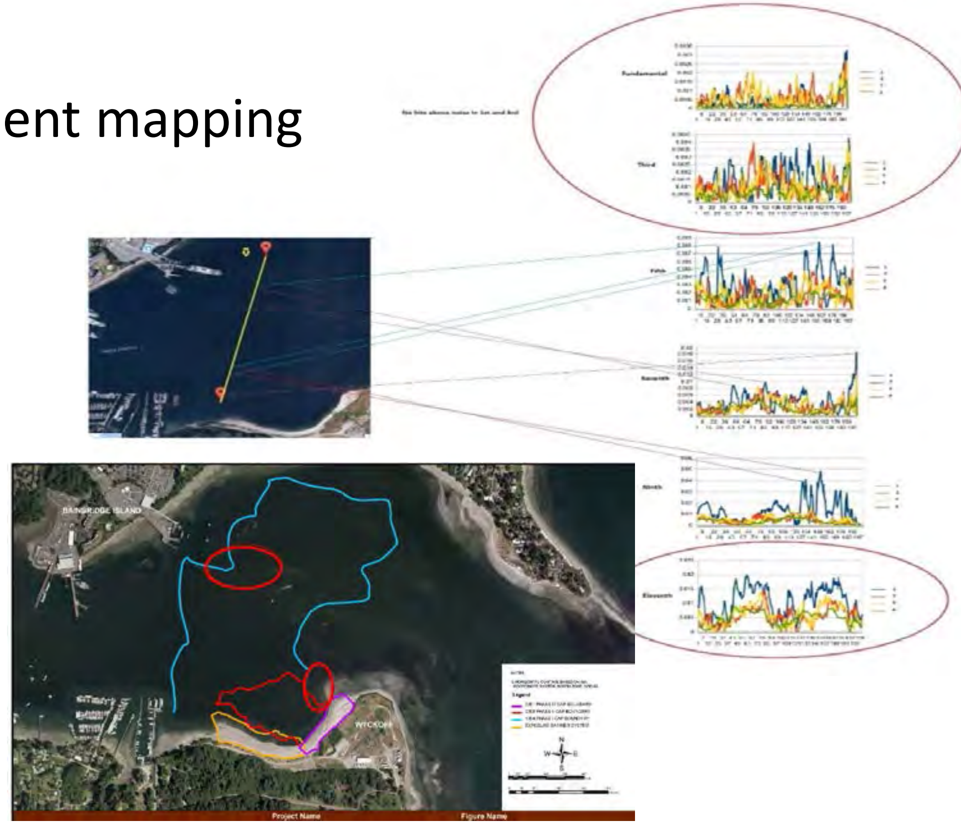


Marine IP Applications

Impact Assessments and Legacy Spills

- Identification of Location & Extent of Contaminated and Uncontaminated Areas
  - Single towed cable + detection into sediment = efficient mapping
  - Fills in otherwise interpolated areas between cores
  - Enables targeted & reduced sediment sampling





Example: Survey of Wycoff legacy contaminated site

Marine IP Applications

Plastics

- IPA has made *preliminary* lab measurements suggesting some plastics react to Induced Polarization techniques

- Potential Applications:
  - Microplastics detection & mapping
  - Marine debris at sea
  - Nearshore contaminations
    - Reef & other underwater critical habitats
    - Sensitive Areas: Estuaries, Refuges

- Further possibilities:
  - Lab testing is required for expanded sample sets

Plastic	Dielectric Strength		Dielectric Constant			Dissipation Factor		
Abbreviation (chemical name) Brand name	Volts/0.001"		@	@	@	@	@	@
	0.001"	0.005"	1KHz	1MHz	1GHz	1KHz	1MHz	1GHz
ECTFE (ethylene chlorotrifluoro ethylene copolymer)	5000 6000	-------	2.6	2.6	------	0.002	0.013	--------
ETFE (ethylene tetrafluoro-ethylene copolymer) Tefzel	5000	2500	2.6	2.6	2.4	0.0008	0.005	0.0005
FEP (fluorinated ethylene-propylene copolymer) Teflon FEP	6500	2000	2 2.5	2 2.05	2.05	<0.0002	0.0003	0.0015
PFA (perfluoroalkoxy) Teflon PFA	4000 5000	-------	2 2.1	2 2.1	2 2.1	0.0002	0.0002	0.00045
PCTFE (polychlorotrifluoro-ethylene)	3000 3900	2700 3300	2.5 2.7	2.3 2.4	2.3	0.022 0.024	0.009 0.017	0.004
PTFE (polytetrafluoroethylene) Teflon	2200 4400	1000 2000	2 2.1	2 2.1	2 2.1	<0.0001	<0.0001	<0.0001
PVF (polyvinylfluoride) Tedlar	3500	1700	8.5	7.4	------	1.6	--------	--------
PVDF (polyvinylidenefluoride) Kynar	--------	-------	8.4	------	------	0.019	--------	--------
(polycaprolactam) Nylon6	(0.002") 1300	-------	3.7	3	------	0.016	0.036	--------
PC (polycarbonate) Lexan	6300	2000	2.99	2.93	2.89	0.0015	0.01	0.012
PET (polyethyleneterephthalate) Mylar	7500	3400	3.2	3	2.8	0.005	0.016	0.003 0.008
LDPE (low density polyethylene)	5000	3000	2.2	2.2	2.2	0.0003	0.0003	0.0003
LLDPE (linear low density polyethylene)	5000	3000	2.2	2.2	2.2	0.0003	0.0003	0.0003
HDPE (high density polyethylene)	5000	3000	2.3	2.3	2.3	0.0005	0.0005	0.0005
UHMWPE (ultra high molecular weight polyethylene)	(0.010") 1300	-------	2.3	2.3	2.3	0.00023	--------	--------
PI (polyimide)	7000	3600	3.5	3.4	3.3	0.0025	0.01	0.004
PMMA (polymethylmethacrylate) Plexiglas	--------	-------	3.5 4	3 3.5	2.58	0.04	0.03	0.009
PP (polypropylene)	8000	2700	2.2	2.2	2.2	0.0003	0.0003	0.0003
PS (polystyrene) Styron	5000	-------	2.4 2.7	2.4 2.7	2.4 2.7	0.0005	0.0005	0.0005
PVC (polyvinylchloride)	--------	-------	3 3.3	2.7 3.1	2.8	0.009 0.017	0.006 0.017	0.019
PVDC (polyvinylidenechloride) Saran	--------	-------	3.9 4.5	3 4	2.7	0.052 0.063	0.05 0.08	0.016

Table A: Dielectric properties of various plastics

Comparative Analysis – Level of Effort

Marine IP v. Coring in potentially contaminated soils

Example Survey: Contaminant Delineation of Quendall Terminals Superfund Site

- Survey Efficiency: Able to identify extent of contaminated AND non-contaminated areas

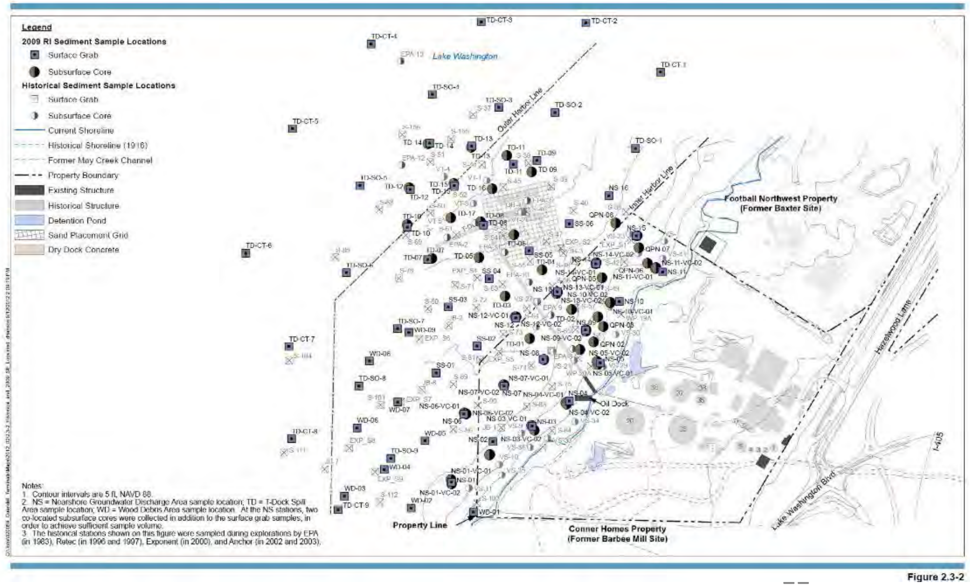
  = *Efficient, cost-effective, & fast understanding of delineation & extent*
- Rate of Collection: Provides verifiable results with reduced vessel costs, significant reduction of expensive chem analyses, chain-of-custody challenges, etc.

Survey Methodology:	**Marine IP**	**Coring**
Survey Days:		
Marine IP Survey	1	0
Sediment Sampling Days	2	18 *(estimated for 12 coring, 6 grabs)*
Total Vessel Survey Days	**3**	**18**
Data Collection:	**38**	**350**
# of Samples	(estimated: 8 cores, 15 VanVeen Grabs)	(actual: 67 Cores, 109 VanVeen Grabs)
Sediment Chemistry:	**$7,920**	**$84,000**

*Note: Costs are **ESTIMATES** only for exhibiting efficiencies of Marine IP system*

Survey Area: .1km^2 (.3km x .4km)

Assumptions: Cores/day = 6; Grabs/day = 20; Samples/Core = 4; Lab Chemistry: $240/sample



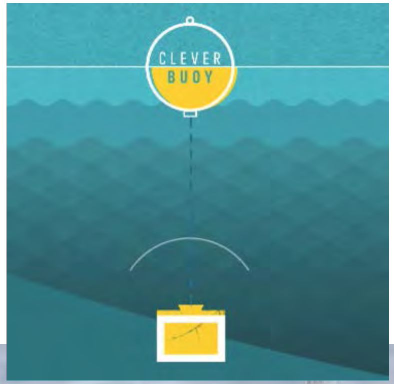
Potential Future Developments

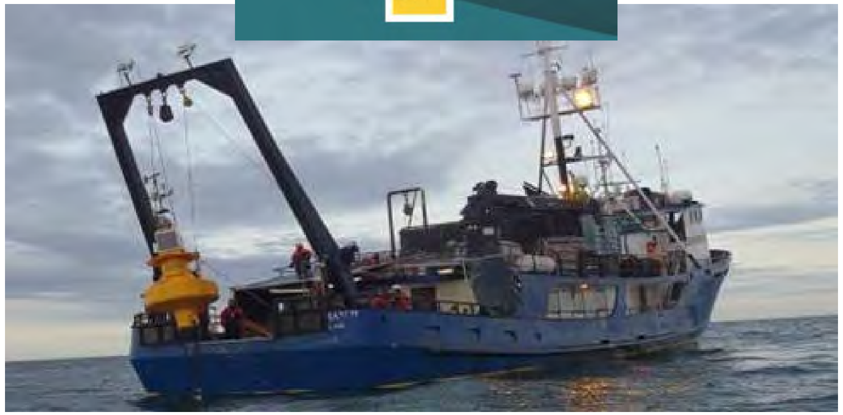
Fueling & Port Monitoring

- Shipping fueling ops
- ‘Smart Boom’: instant alert to leaks
- Improper ballast discharges

Static Mounts (e.g.: Buoys)

- Detection In specific targeted areas
- High-fidelity modeling when used in unison

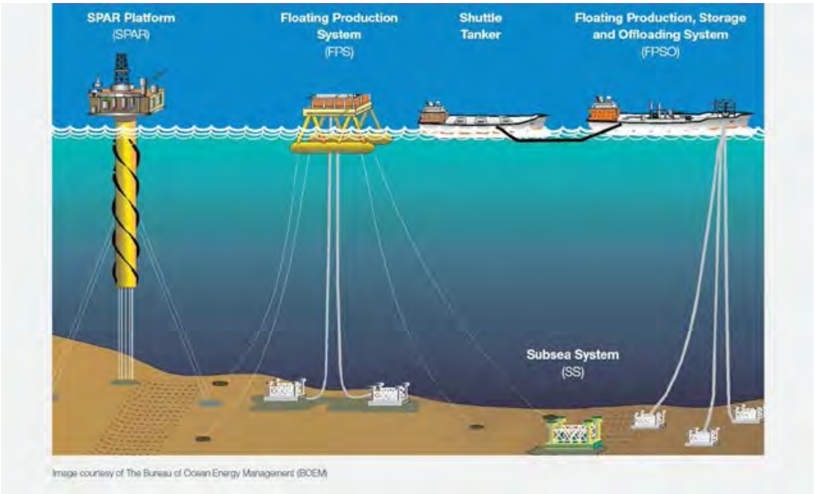




Rig Mounts

- Immediate Leak Detection
- Potential for other identifications:

  (e.g.: For regulatory compliance)
  - Sewer/effluent discharge
  - Operating fluids
  - Other contaminants (polarizable)



Advantages

- Compliant with USCG/OSRO guideline with respect to non-floating oil
- Unique in its ability to detect hydrocarbons in the water column, river/seabed and embedded in sediments
- Highly robust and ruggedized
- Easily transportable: small instrument foot print can be mobilized on a vessel of opportunity as small as 25-ft
- Small environmental footprint: In bottom reference mode bottom disturbance no greater than medium sized flat fish.
- On-the-fly interpretable real time displays
  - Fast output a layered geo-plot for onsite
  - Potentially detect and locate leaky outfalls and pipelines

Limitations

- Not optimal for sea surface detections
- Current signature library is still limited, though expanding
- Effect of biofouling on static arrays unknown (primarily a receiver dipole design issue)

Conclusions

- Marine IP is an efficient tool for detection & mapping of non-floating hydrocarbons
- Field-verified technology
- During an incident or for legacy spills, marine IP:
  - provides a more complete georeferenced data set
  - enables more targeted sediment sampling, reducing costs
- Potential to detect & map oil in water column during incidents
- Potential for oil spill monitoring and early-warning alerts:
  - Ports and Docks
  - Pipeline leaks
  - Intakes, sensitive areas

Thank you!

For more information:

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