Electrical Resistivity Imaging for Long-Term Monitoring of Contaminant Degradation

Poster 5-198

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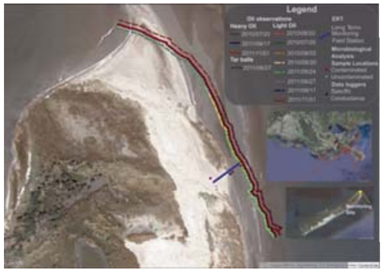
Overview

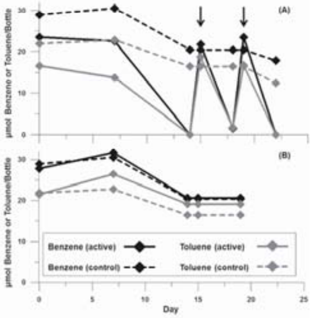
On April 20, 2010, oil and gas escaped from BP's Deepwater Horizon drill rig, located 130 miles to the SE of the southern tip of the Mississippi Delta, resulting in the release of approximately 4.4 million barrels of crude oil in the Gulf of Mexico and surrounding areas and 2.1 million gallons of dispersants as part of the clean-up process. The introduction of this contaminant into the environment impacted a large portion of the coastline, including beaches, marshes and wetlands. Although a huge ecological catastrophe, the Deepwater Horizon oil spill provided a unique opportunity to study an immature contamination, and monitor its evolution over time under natural attenuation using geophysical technologies.

Site Information

Grand Terre 1, LA:

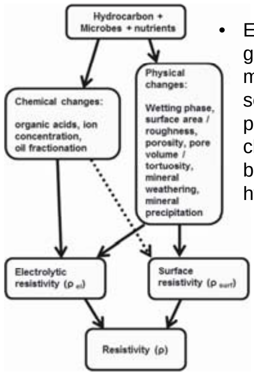
- This uninhabited barrier island (left) was impacted by the Deepwater Horizon oil spill. The lack of anthropogenic noise made it ideal to study the long term fate of the oil contamination.
- The oil contamination was located ~40-60 cm below the surface and is bounded by sand.



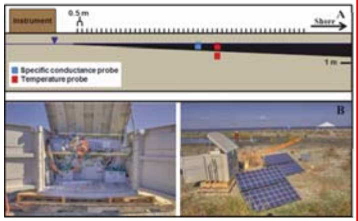


- Microcosm experiments using samples from the site (left).
  - The microcosm from the contaminated region (top) showed rapid hydrocarbon degradation.
  - The microcosm from the control region (bottom) did not show a response to the presence of hydrocarbons.

Methods

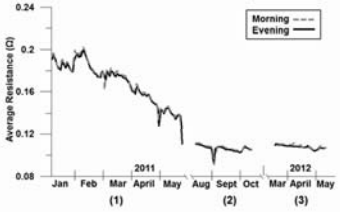


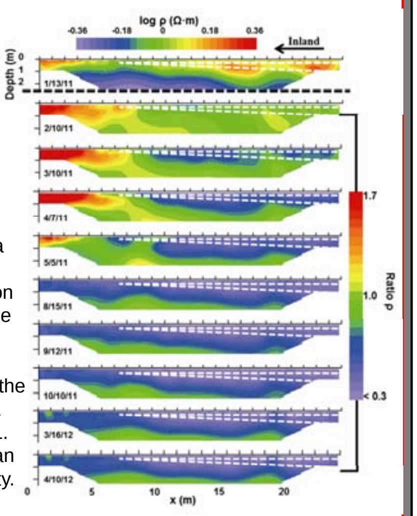
- Electrical geophysical methods are sensitive to physical/chemical changes caused by biodegredation of hydrocarbons (left).



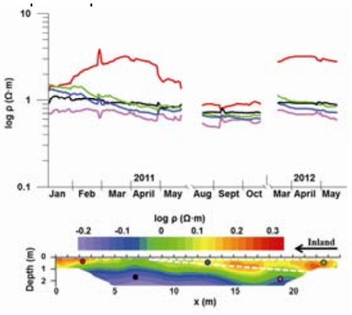
- Direct current resistivity measurements were collected using a 96 electrode Syscal Pro IRIS system (above).
  - 48 electrode surface line
  - Battery/solar powered
- Temperature and fluid conductivity were measured by onsite data loggers.

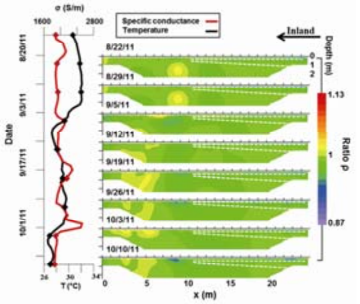
Results





- Resistance values from all of the datasets (above) showed decreases in bulk resistance of each dataset, followed by a period of relative stabilization.
- The top resistivity image (right) is a log resistivity distribution from day 1 of monitoring. There is a resistive anomaly in the upper meter that is consistent with the location of the oil contamination.
- Below the dashed line are ratio resistivity images showing the progression of resistivity through time. These images are a ratio of the dataset from that date to the dataset from day 1.
  - A value of 1 signifies a no change, >1 signifies an increase and <1 signifies a decrease in resistivity.
- Over time, the resistive anomaly from day 1 became less resistive while the surrounding area remained largely





- Analysis of single pixels from the data (above, left) showed that points within the region of contamination (blue, green) decreased in resistivity and then stabilized.
- Pixels from outside the zone of contamination (purple, black) remained relatively stable.
- The red line is near surface, far from shore. Changes do not appear to be linked to the contamination.
- Specific conductance (above, right) and temperature data show that the changes in resistivity appeared unrelated to changes in the two variables.

Conclusions

- The results from this experiment strongly suggest that the resistivity changes seen are the results of the biodegradation of the oil. This conclusion was further supported by the results of the microcosm experiment.
- These results demonstrate the utility of the resistivity method and long term autonomous data collection as a monitoring tool. This method proved beneficial because of its low maintenance requirements, its ability to work well in remote areas and its reputation as non-invasive and cost effective.

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