# Impact & Recovery of Wetland Plant Communities after the Gulf Oil Spill in 2010 and Hurricane Isaac in 2012

Introduction: The coastal wetlands, estuaries and lagoon systems of the Gulf Coast are a hotspot of biodiversity, and provide critical services to fisheries, recreation, and coastal stability. The BP Deepwater Horizon oil spill, already the largest oil spill in history, has the potential to become the worst ecological disaster in the US. The full impact of the spill may not be evident for several decades as storms and hurricanes could potentially drive oil penetration further inland.
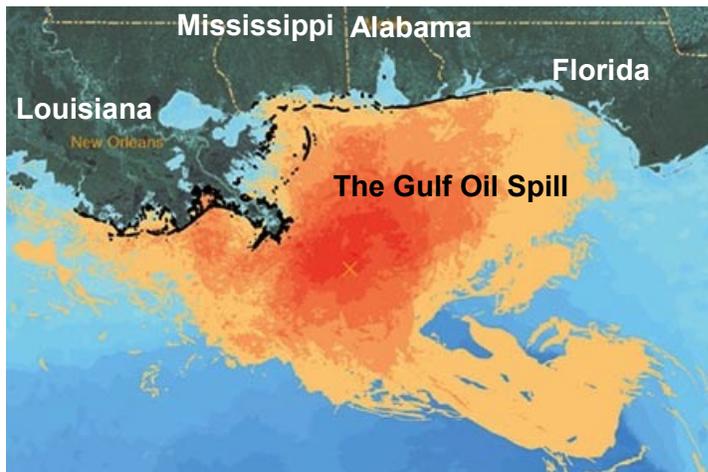
**Location and extent of the BP Deepwater Horizon Oil Spill**

Oil coating plants along the Gulf shoreline

Remote sensing is a valuable tool that has been used to map oil spills and their impacts on wetland vegetation. AVIRIS imagery flown over the marshes impacted by the oil spill in 2010, 2011 and 2012 provide us with a unique opportunity to study the impact and recovery of oil contamination on saltmarshes and other habitats of the Gulf. The passage of Hurricane Isaac in August of 2012 is a window of opportunity to determine if plant communities already stressed by oil contamination are more susceptible to erosion compared to healthy marshes.

The goals of this study are:

1. To map the extent of oil contamination in the Gulf,
2. To determine the impact of oil on the health of the plant community in the wetlands,
3. To document any recovery over the past two years, and
4. To determine if oil impacted wetlands were more susceptible to hurricane damage.
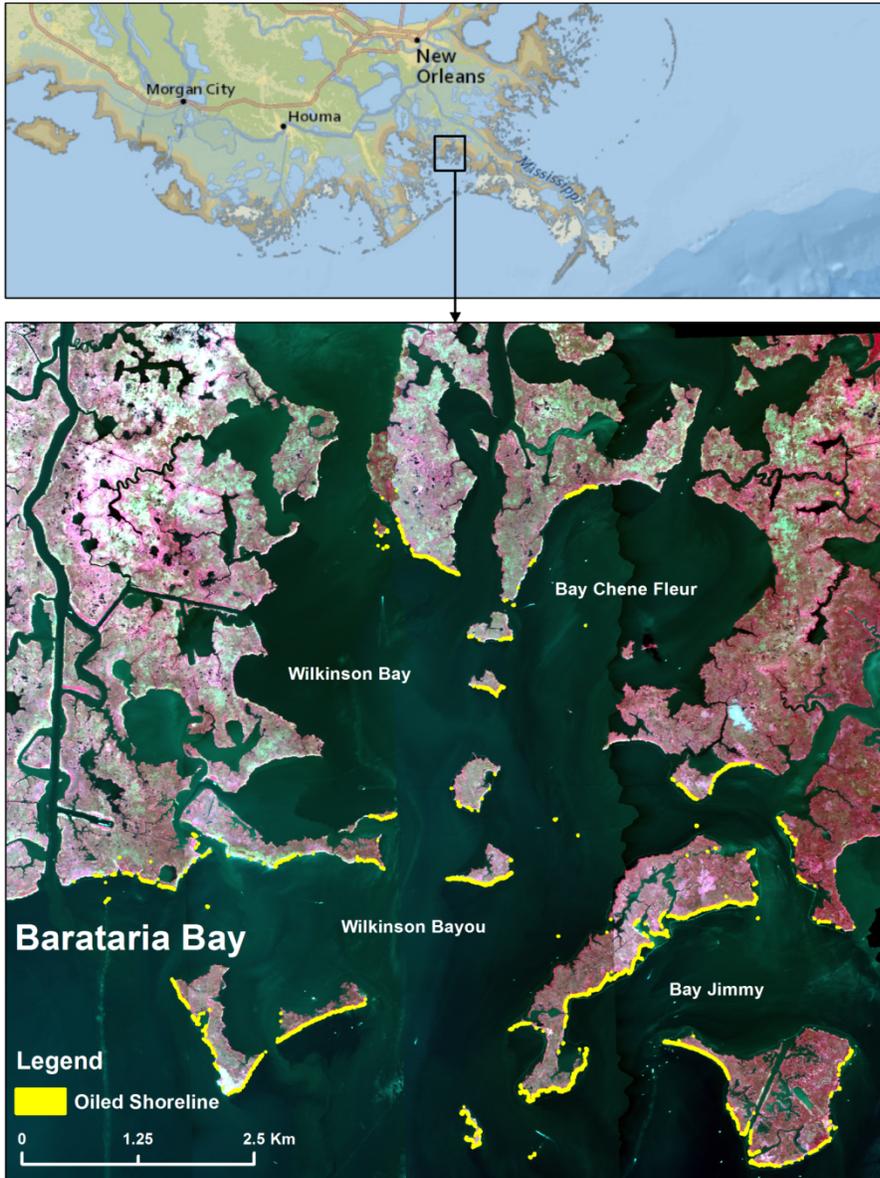
Bay depicted in color infrared bands (AVIRIS imagery) with oiled shoreline shown in yellow.

Data Analysis

AVIRIS imagery with spatial resolution from 3.3 to 7.8 m was preprocessed for 3 dates: September 2010, August 2011 and October 2012. The imagery was atmospherically corrected using ACORN mode 1.5, and coregistered to 2010 imagery to sub-pixel accuracy.

Various vegetation indices were calculated for each image and the images were classified into 6 classes, water, soil, dry vegetation, green vegetation and two oiled classes, oiled soil and oiled dry vegetation.

Oiled classes were differentiated based on two oil absorptions in the image spectra centered at 1730 and 2300 nm.

The image to the left shows the location of oiled pixels in the Barataria Bay region.

Methods & Results

The reference shoreline was generated based on the land class (all classes except water) of September 2010 imagery and used to calculate distance from shoreline for every pixel in all three years.

Index values were plotted with respect to "distance from shoreline" for both oiled shoreline and oilfree shorelines. Plants were more stressed along oiled shorelines for at least 14 m inland from the shore (following figure).
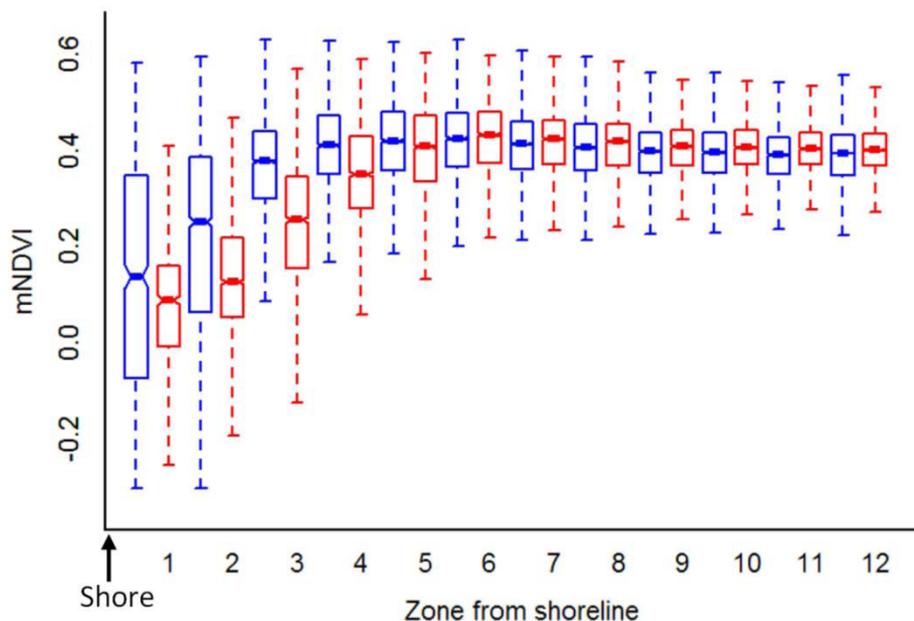

Box plots of mNDVI values for pixels vs. zone from shore ("1" being the first pixel from the shore and "12" being the twelfth) for oiled (red) and oil-free (blue) shoreline for the September 2010 dataset .

Comparison of pixels classified as green vegetation along oiled and oilfree shorelines also showed that oiled shorelines had lower green vegetation cover in the first 4-5 pixels next to the shore compared to oilfree shorelines (figure below). Maximum impact was observed in the second and third pixels from the shore.
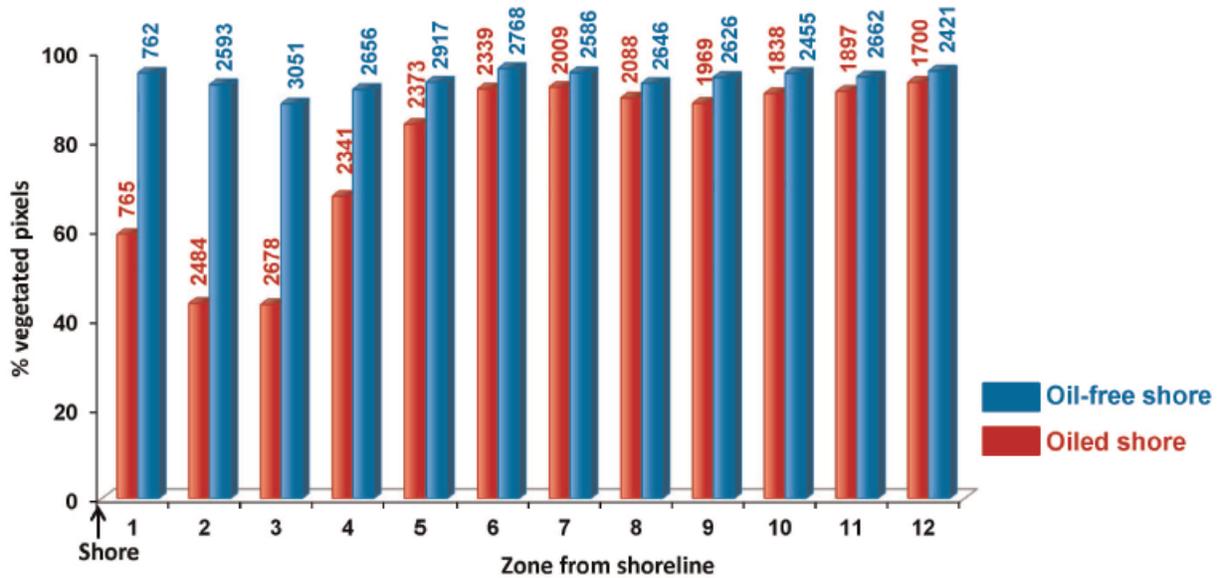
Percentage of photosynthetic vegetation pixels in oiled vs. oil-free shoreline zones in September 2010 ("1" being the first pixel from the shore and "12" being the twelfth). Total number of pixels for each zone for oiled and oil-free shoreline is shown above the bars.
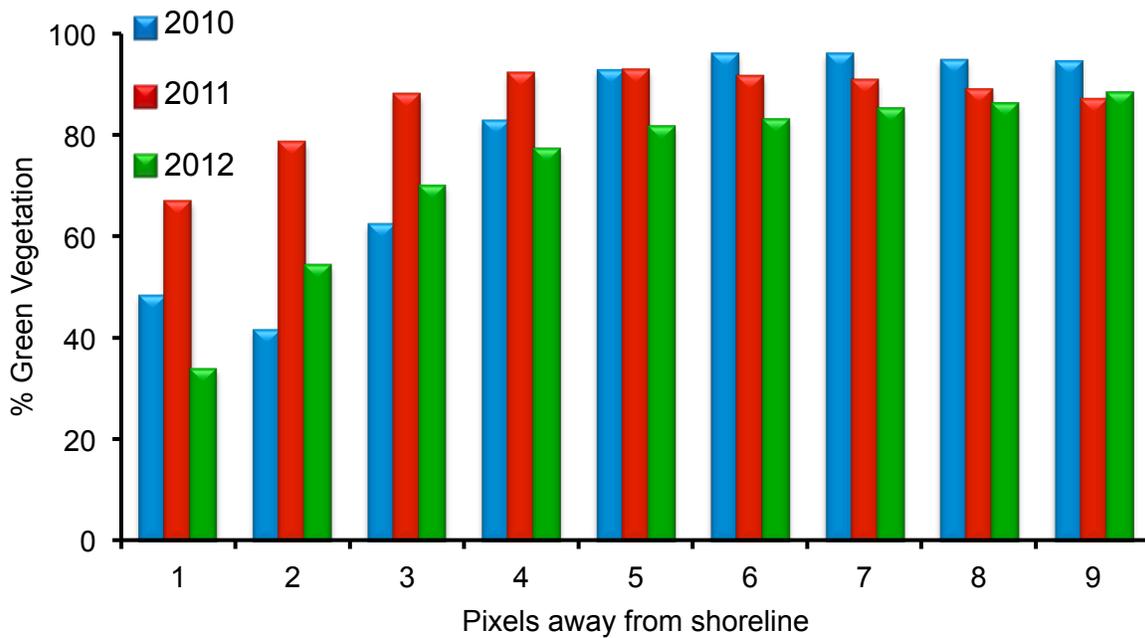
The percent green vegetation in each zone increases as we move inland from the shoreline in all three years. While 2011 data shows recovery of the marsh after the oil spill, the 2012 data shows the die-back of marsh vegetation after the hurricane with higher impact closer to the shoreline.

A multi-year comparison of the oiled shoreline shows that in 2011, all pixels recovered somewhat from the oil spill (figure above). However, in 2012, most of this recovery was lost as the hurricane denuded areas that were already stressed by the oil spill. Coastal marsh area was also lost as marsh banks were swept off into open water. A comparison of loss of green vegetation cover along oil-stressed and oil-free shoreline shorelines indicated that oil-stressed shorelines lost significantly more area to water than oil-free shorelines (Chi-square p-value < 0.0001).

Percent water pixels in the first 4 pixels (14 m) inland from the oiled vs. oil-free shores and in the first 2 pixels (7 m) inland from the two shores. More land was lost along oiled shores compared to oil-free shores.

	Oiled shoreline	Oil-free shoreline
First 4 pixels along shore	24.9	18.0
First 2 pixels along shore	34.7	27.1

Publications

Khanna, S., M. J. Santos, D. S. L. Ustin, A. Koltunov, R. F. Kokaly, and D. A. Roberts. (2013). Detection of Salt Marsh Vegetation Stress and Recovery after the Deepwater Horizon BP Oil Spill in Barataria Bay, Gulf of Mexico using AVIRIS Data. PLoS One, 8(11): e78989.

Kokaly, R. F., B. R. Couvillion, J. M. Holloway, D. A. Roberts, S. L. Ustin, S. H. Peterson, S. Khanna, and S. C. Piazza. (2013). Spectroscopic remote sensing of the distribution and persistence of oil from the Deepwater Horizon spill in Barataria Bay marshes. Remote Sensing of Environment, 129: 210-230.

Conference Presentations & Posters

Khanna, S., A. Koltunov, S.L. Ustin, E.L. Hestir, R. Kokaly, S. Peterson, and D. A. Roberts. (2011). Initial Assessments of Ecologic Response to Oil from the Deepwater Horizon Spill. AGU Fall Meeting, San Francisco, CA.

Khanna, S., P. J. Haverkamp, M. J. Santos, K. Shapiro, M. Lay, A. Koltunov, and S. L. Ustin. (2013). Impact of hurricane Isaac on recovery of saltmarshes affected by the BP oil spill in Barataria Bay in the Gulf of Mexico. AGU Fall Meeting, San Francisco, CA, USA.

Khanna, S., M. J. Santos, A. Koltunov, P. J. Haverkamp, M. C. Lay, R. Kokaly and S. L. Ustin (2013). Quantifying severity of plant stress induced by oil spill contamination in the Gulf of Mexico using hyperspectral remote sensing. Gulf of Mexico Oil Spill & Ecosystem Science Conference, New Orleans, LA, January 21-23.

Khanna, S., A. Koltunov, M. J. Santos, P. J. Haverkamp, M. C. Lay, S. L. Ustin (2013). Use of Hyperspectral Remote Sensing to Detect Plant Stress and Monitor Recovery from the Macondo Oil Spill in the Gulf of Mexico. ASPRS 2013 Annual Conference, Confluence by the Bay - A Gathering of Geospatial Insights, Baltimore, MA, March 24-28.

Ustin, S. L. and S. Khanna. (2011). Contributions of HyspIRI science to monitoring global coastal wetlands and near shore aquatic environments. NASA HyspIRI Science Workshop, Washington D.C., August 23-25.

Ustin, S. L., S. Khanna, A. Koltunov, D. A. Roberts, R. Kokaly. (2011). Monitoring coastal wetlands and near shore aquatic environments in response to the BP Horizon oil spill. NASA Carbon Cycle and Ecosystems Joint Science Workshop, Alexandria, VA, October 3-7.