Analysis of marsh loss and erosion within Northern Barataria Bay, Louisiana:
the effects of the *Deepwater Horizon* oil spill

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Background

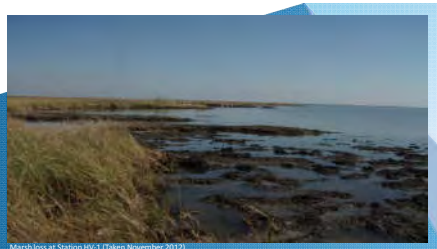
- The release of an estimated 3.19 million barrels of oil from the *Deepwater Horizon* (*DWH*) event exposed the nation's largest and most productive wetland-estuarine environment to an unprecedented potential for environmental damage.
- Coastal Louisiana sustained widespread damage to its ecological structure and function, potentially affecting wetland resilience and sustainability.
- The impact of wetland oiling on shoreline erosion has direct consequences to the sustainability of these important coastal systems (Silliman *et al.* 2012, McClenachan *et al.* 2013, Zengel *et al.* 2015, Rangoonwala *et al.* 2016, Turner *et al.* 2016).

Goals

- The goal of our project was to examine the effects of oiling on shoreline stability, specifically shoreline erosion.
- What are station-specific background erosional rates in Barataria Bay, and have marsh erosion rates increased in response to shoreline oiling?
- Does shoreline response to oiling differ with different degrees of oiling and different shoreline locations?

Methods

- Aerials used included 1998, 2004, 2005, 2010, 2011, 2012, and 2013. No results were presented with Spring imagery.
- Sampling sites span northern Barataria Bay, LA, from Wilkinson Bay to Bay Jimmy and represent areas of marsh shoreline classified as reference (no observed oil), moderately oiled (some oiling observed), and heavily oiled (significant oiling observed) as determined from SCAT surveys, personal observations, and soil TPH analyses.
- Available aerials of the region were obtained pre-and-post-spill to examine a time series of erosion rates.
- The distance from sampling site to marsh edge (+/- 0.45 m) was measured using ArcGIS at a 1:1500 scale; additional measurements were taken from two sites located to either side (approximately 10m) of the sampling site and an average distance to marsh edge was calculated.
- Average distance to marsh edge was compared across aerials to give an estimate of marsh loss during the time period; all time periods were normalized to an annual basis.



Marsh loss at Station HV-1 (Taken November 2012)

References

McClenachan, G., R.E. Turner and A.W. Tweel. 2013. Effects of oil on the rate and trajectory of Louisiana marsh shoreline erosion. Environ. Res. Lett. 8 (2013) 8pp.

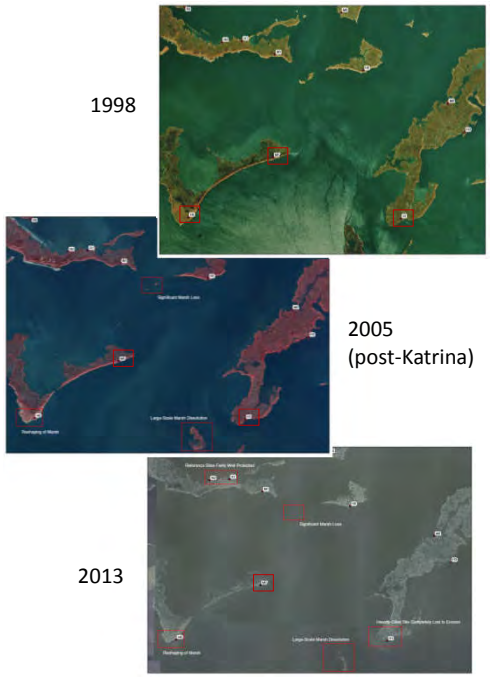
Rangoonwala, A., C.E. Jones, and E. Ramsey III. 2016. Wetland shoreline recession in the Mississippi River Delta from petroleum oiling and cyclonic storms. Geophys. Res. Lett., 43, doi:10.1002/2016GL070624.

Silliman, B.R., J. van de Koppel, M.W. McCoy, J. Diller, G.N. Kasozi, K. Earl, P.N. Adams, and A. R. Zimmerman. 2012. Degradation and resilience in Louisiana salt marshes after the BP-Deepwater Horizon oil spill. PNAS, vol. 109, no.28, 11234-11239.

Turner, R.E., G. McClenachan, A.W. Tweel. 2016. Islands in the oil: Quantifying salt marsh shoreline erosion after Deepwater Horizon oiling. Mar. Poll. Bull., http://dx.doi.org/10.1016/j.marpolbul.2016.04.045

Zengel, S., B.M. Bernik, N. Rutherford and Z. Nixon, J. Michel. 2015. Heavily Oiled Salt Marsh following the Deepwater Horizon Oil Spill, Ecological Comparisons of Shoreline Cleanup Treatments and Recovery. PLoS ONE 10(7): e0132324. doi:10.1371/journal.pone. 66p.

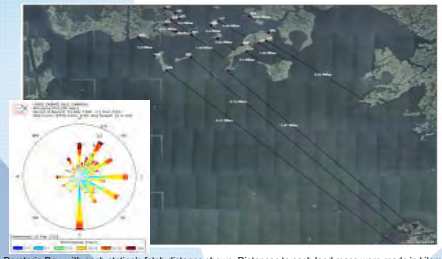
Erosion Images



The above images show how a subsample of our sampling sites were affected over time. 1998 was the earliest aerial examined, 2005 was chosen to show effects from Katrina, and 2013 represents post-Deepwater Horizon effects. Heavily-oiled sites were affected the most due to their positioning in relation to the open bay as well as oiling effects.

Wind Rose/Fetch Analysis

- Fetch (wind wave exposure) is a useful tool in analyzing potential erosion. The greater the fetch, the less protection for the marsh from wave action.
- A wind rose for the area was used to determine the prevailing wind direction (from the SE, other directions were investigated); the landmass nearest to each station was measured to the SE, giving a fetch distance.
- Fetch was measured for each station to give an idea of potential wave action and erosion.



Barataria Bay, with each station's fetch distance shown. Distances to each land mass were made in kilometers.

Acknowledgements

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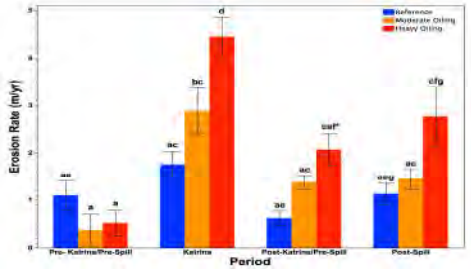
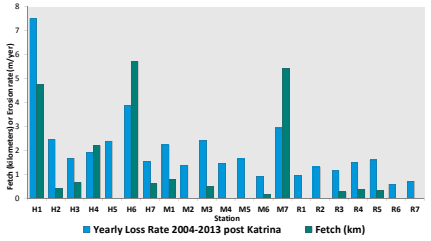
Erosion Results



- The effect of oiling category on erosion rate was dependent on time period (significant oiling category x time period interaction, $p<0.0001$).
- Katrina significantly shifted the erosion baseline at the heavily oiled stations relative to the 1998-2004 pre-Katrina period. A similar shift in erosion baseline at moderately oiled stations was not statistically significant.
- At heavily oiled stations, post-spill erosion rates, although somewhat higher than pre-spill (2005-2010), were within the overall variation for these two time periods and not significantly different. Moderately oiled shorelines also saw no oil spill effect.
- This post-spill shift towards increased erosion may be due to barrier island loss to the seaward side of the marsh (see aerial photo sequence at left and Rangoonwala *et al.* 2016).
- Average shoreline erosion prior to the *DWH* oil spill was primarily influenced by storms, in particular Hurricane Katrina. We found no statistically significant oil-spill accelerated erosion for this part of northern Barataria Bay.



H = heavily oiled, M = moderately oiled, R = reference

- The three longest fetches (H1, H6, and M7) correspond to the three highest rates of marsh erosion, regardless of oiling level and were once protected by a marsh island (aerial photos and Rangoonwala *et al.*, 2016).
- A longer fetch amplifies the effects of erosion due to increased wave generation and propagation.
- A longer fetch also may indicate that the marsh is more likely to be heavily oiled. Hence, the effects of oiling on shoreline erosion are confounded by the effects of wave-generated erosion.
- Only a comparison of post-spill and pre-spill erosion rates, as done here, can begin to separate oiling effect from background erosion.
- Our analysis did not detect accelerated erosion due to the DWH spill, when post-Katrina erosion rates serve as background.

Next steps

- Continue sampling and investigating the long-term recovery of the DWH oil spill impacted coastal salt marshes to determine if the oil spill affects the sustainability and stability of the marsh ecosystem (physical sampling at each station has been initiated).
- Implement a remediation study by sampling transplanted native dominant plant species in combination with stimulating agents to determine the effectiveness of initiating and promoting wetland resilience.