RISING ABOVE: IMPACTS OF COASTAL POLICIES WITH RESPECT TO SEA LEVEL RISE IN GALVESTON BAY, TEXAS

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Background

Galveston Bay has one of the highest vulnerabilities to large storms and SLR in the country as well as large population pressures (Arkema et al, 2013). 25% of Texas' population lives in its eighteen coastal counties, and 75% of that 25% lives around Galveston Bay (Merrell et al., 2011). The currently predominant shoreline protection paradigm emphasizes shoreline hardening as the primary mode to combat SLR. In recent years, however, there has been recognition of the benefits that natural shorelines offer. This has resulted in a push towards utilizing living shorelines, a green infrastructure approach. There are many benefits of protecting the connectivity of land and sea in such a way.

The Galveston Seawall was installed in the early 1900s to provide protection against storm surges. Storm surges will get larger as a result of SLR.

A better understanding of the potential effects that result from these protective measures will increase the knowledge of coastal communities in the Galveston Bay area. This project attempts to determine the efficacy of different shoreline stabilization techniques for subsites throughout Galveston Bay undergoing SLR. It is part of a larger study on living with sea level rise along the Texas coast.

Objectives

This work uses the Sea Level Affecting Marshes Model (SLAMM) to quantify the effects of different shoreline stabilization techniques in regards to SLR on subsites within Galveston Bay. Results can be used to estimate the costs and benefits of various techniques for other communities around Galveston Bay.

The Brownwood subdivision, located in Baytown, TX, was converted to the Eddie V. Gray Wetlands Education Center due to subsidence-caused inundation.

Relevance

- Subsidence + SLR = increased vulnerability to storms such as Hurricane Ike, Hurricane of 1900
- SLR and coastal squeeze cause a net loss of ecosystem services which are estimated to be over $5 billion per year in Galveston Bay (SSPEED, 2014).
- 0.69 m of SLR in Galveston Bay is predicted to cause the loss of $88 million/year in fresh marsh ecosystem services and $14/year in salt marsh ecosystem services (Yoskowitz et. al, 2012).
- Estimates predict that up to one-third of Galveston Island could be eroded or underwater within thirty years (Rice, 2013).

Methods & Model

The Sea Level Affecting Marshes Model (SLAMM) uses a rule-based decision tree to project SLR-induced changes to coastal environments. It is used in this project to estimate the effect of different shoreline stabilization techniques on the distribution of coastal habitats around Galveston Bay under various SLR scenarios by 2100.

Subsites:

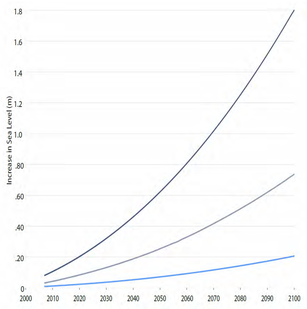
For each subsite:

Model Inputs (constant) + SLR Scenarios (3) + Shoreline Stabilization Techniques (4) → Outputs (12 per subsite)

Model Inputs:

- Digital Elevation Model
- National Wetlands Inventory (land classification)
- Subsidence grid (cm/yr)
- VDATUM (NAVD88 to mean tide level datum)
- Slope (degrees)
- Percent impervious (development)

SLR Scenarios:



1.8 m by 2100- Jevrejeva et al. 2014

0.74 m by 2100- IPCC's AR5 RCP 8.5

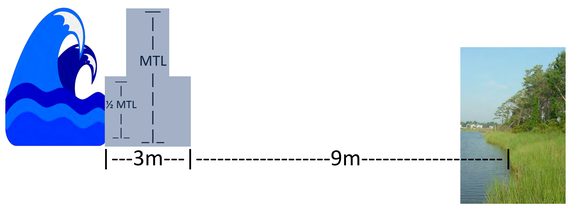
0.2 m by 2100- extrapolation from satellite altimetry

Shoreline Stabilization Techniques:

Achieved by manipulating dike input file.

- "Armoring Removed"- employs no shoreline protection
- Current Armoring Scenario- uses the current situation (2007) regarding development and armoring
- All Armored- describes the armoring of the entire coastline
- Green infrastructure- living shorelines as coastal protection

Living Shoreline:



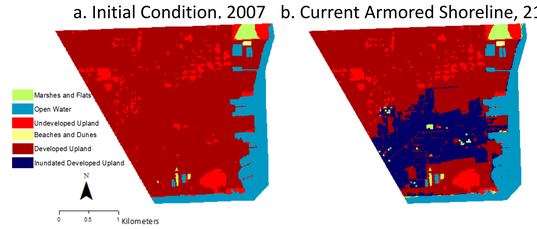
Limitations:

- No hydrodynamics
- Spatially simple erosional component

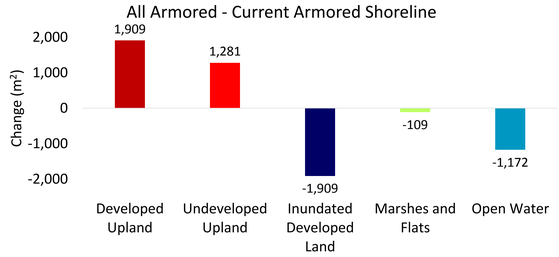
Results

Texas City *(0.74 m of SLR by 2100)*

a. Initial Condition. 2007 b. Current Armored Shoreline, 2100



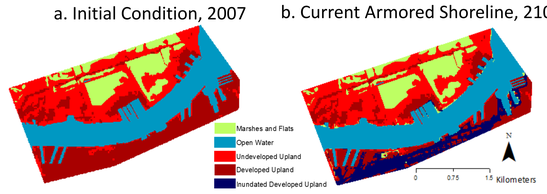
All Armored - Current Armored Shoreline



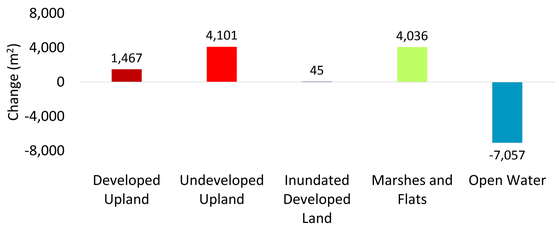
- All Armored protects more uplands.

Galveston

a. Initial Condition, 2007 b. Current Armored Shoreline, 2100



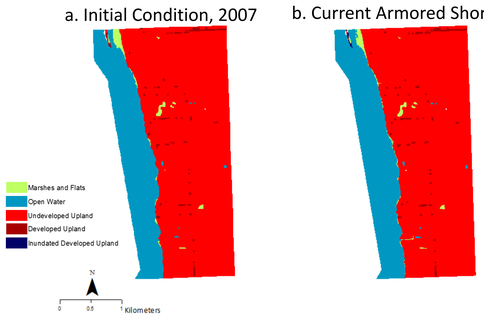
All Armored - Current Armored Shoreline



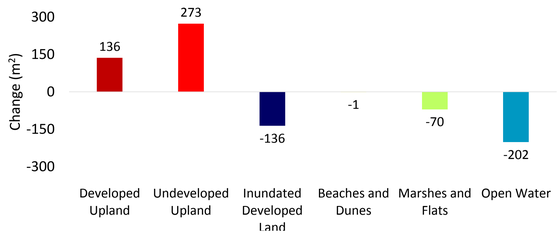
- All Armored protects more uplands and prevents shoreline erosion.

Anahuac

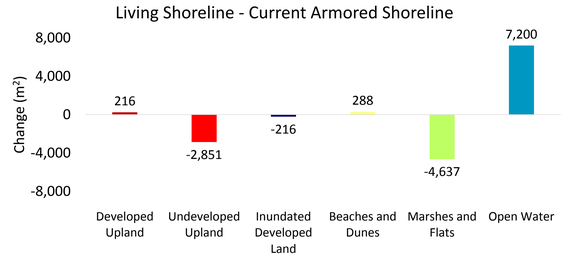
a. Initial Condition, 2007 b. Current Armored Shoreline, 2100



All Armored - Current Armored Shoreline



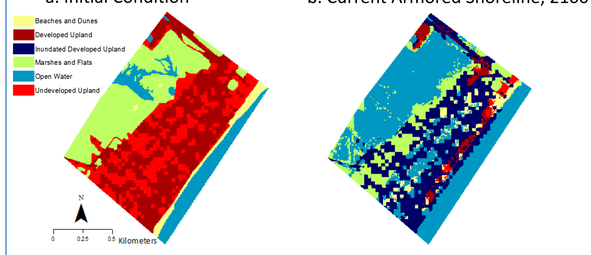
Living Shoreline - Current Armored Shoreline



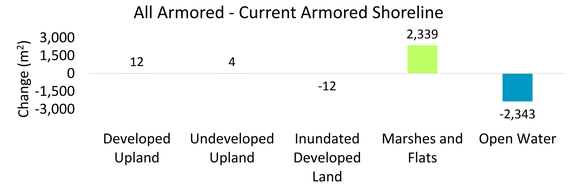
- Living Shorelines protect more Developed Uplands than All Armored.
- Open Water erodes the shoreline in Living Shorelines, resulting in less Marshes and Flats.

Surfside Beach

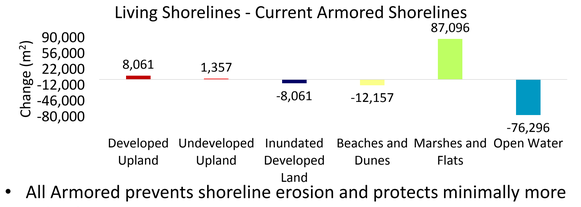
a. Initial Condition b. Current Armored Shoreline, 2100



All Armored - Current Armored Shoreline



Living Shorelines - Current Armored Shorelines



- All Armored prevents shoreline erosion and protects minimally more uplands.
- Living Shorelines preserves more uplands and Marshes and Flats; it is the best strategy for dealing with SLR of the options presented here.

Discussion

- The best decision varies depending upon the site's physical properties and community values.
- Places with pre-existing valuable infrastructure such as Texas City may prioritize protection; armoring may be best for these situations.
- Galveston may best protect against SLR by armoring some locations but leaving others natural or installing a living shoreline.
- Rural areas such as Anahuac may prioritize the environment, and thus living shorelines may be best particularly since Living Shorelines protect more Developed Uplands than All Armored.
- Surfside Beach would best protect itself with living shorelines, but it is still at risk of severe erosion. An organized retreat may be necessary.
- This project will help develop a thorough understanding of what responses can be expected from each policy option which helps enable the government to determine the best course of action for a given location.

Conclusions

- There are a multitude of ways to combat SLR, and the ideal solution depends upon the individual location and the needs of its stakeholders.
- SLR will impact the world's coasts, but today's actions will directly affect how severe those impacts are. The largest benefits of early action may not be seen for several generations (Nicholls and Lowe, 2004).
- Proactive action has the greatest benefit when it is executed sooner; society can either invest in protective and adaptive measures immediately, or it can wait until natural disasters, particularly hurricanes and floods which are exacerbated by SLR, require a much greater payout in the future.

Acknowledgements

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