USING LIDAR- DERIVED DIGITAL ELEVATION MODELS TO PROJECT FUTURE BARRIER- ISLAND CHANGE CAUSED BY RELATIVE SEA- LEVEL RISE

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Texas Coast
Relative Sea-Level Change
Galveston Island, Texas

Pier 21 - Galveston

\[ y = 0.652x - 1145.6 \]
\[ R^2 = 0.9436 \]

Average water level (cm)

Global ocean-level rise
\[ 4.36 + 2.16 = 6.52 \text{ mm/yr} \]

Local land subsidence

Year

Barrier Island Cross Section

Today

Bay

Wetland
Future Wetland
Upland
Island Core
Wetland
Protective Ridge
Upland
Future Beach/Dune
Beach/Dune

Gulf

After 60 Years of Sea-Level Rise and Erosion

Wetland
Upland
Island Core
Upland
Beach/Dune
Galveston Island
POST-STORM BEACH MORPHOLOGY IN DEVELOPED & UNDEVELOPED AREAS

Morton, Paine, & Gibeaut, (1994)
Beach/Dune Profile Translation

-125 -100 -75 -50 -25 0 25 50 75 100 125
Distance from Monument (m)

-1 0 1 2 3 4
Height Above NAVD88 (m)

2002 profile
2062 estimated profile

vertical exaggeration = 10:1

High Geohazard Potential/
Future Critical Environment

Imminent Geohazard Potential/
Present Critical Environment

2002 profile
2062 estimated profile
University of Texas Airborne Topographic Lidar System

(Optech model ALTM1225)
Foredune Mapping
Lidar Topographic Image
Foredune Mapping

landward dune line

shoreline
Barrier Island Cross Section

Today

Bay

Wetland | Upland | Island Core | Upland | Protective Ridge | Upland | Beach/Dune

Future Wetland

Gulf

Future Beach/Dune

After 60 Years of Sea-Level Rise and Erosion

Wetland | Upland | Island Core | Upland | Beach/Dune
Barrier Island Environments
Topographic Profile

BEG12 – Follets Island
Christmas Bay
January 31, 2002

Distance from Monument (m)

Height (m)

vertical exaggeration = 20:1

Gulf of Mexico
Total Estuarine Marsh Area
Galveston Island, Texas

From White et al., 2004
Causes of Wetland Loss

• Development/Land Use
• Global Sea-Level Rise
• Land Subsidence
• Topographic/Morphology Effects
• Sediment Deficit
• Marsh Edge Erosion by Waves and Currents
Development

1956
Development

1979
Relative Sea-Level Change

Pier 21 - Galveston

Average water level (cm)

Global ocean-level rise
4.36 + 2.16 = 6.52 mm/yr
Local land subsidence

y = 0.652x - 1145.6
R² = 0.9436

Year

Changes Due to Relative Sea-Level Rise
Shoreline Change

Average Annual Shoreline Rate of Change
1930 to 1995

Rate of Change (ft/yr)
- negative = retreat; positive = advance
- -44.9 - -33.4
- -33.4 - -23.4
- -23.4 - -17.5
- -17.5 - -13.7
- -13.7 - -11.3
- -11.3 - -9.7
- -9.7 - -8.5
- -8.5 - -7.5
- -7.5 - -6.7
- -6.7 - -5.9
- -5.9 - -5.2
- -5.2 - -4.5
- -4.5 - -3.9
- -3.9 - -3.4
- -3.4 - -2.8
- -2.8 - -2.3
- -2.3 - -1.8
- -1.8 - -1.4
- -1.4 - -0.9
- -0.9 - -0.5
- -0.5 - -0.1
- -0.1 - 0.4
- 0.4 - 1.2
- 1.2 - 2.1
- 2.1 - 3.2
- 3.2 - 4.7
- 4.7 - 6.6
- 6.6 - 8.9
- 8.9 - 12.9
- 12.9 - 18.9

From Gibeaut et al., 2003
Color IR Mosaic

Gulf of Mexico
Habitat Classification Map From Color IR Photography

Data from White et al., 2002
University of Texas Airborne Topographic Lidar System (Optech model ALTM1225)
DEM, 30 X 30 m
From National Elevation Data
1 – Meter Lidar Digital Elevation Model
Average Heights and Standard Deviations of Barrier Island Habitats
Ground and Lidar Profiles

MAI01 Matagorda Island
June 4, 2002

Lidar Last Return
Ground-based Profile
Vegetation Height

Elevation (m)

subtidal pond
low marsh
upland
high sandy flat
monument
subtidal pond
low marsh
subtidal pond

San Antonio Bay

Distance from Monument (m)

vertical exaggeration 50:1
View Bayward along Transect
Waveform versus Discrete Return
Model Flow

DEM (original)

Classify habitat types according to elevation

Future date reached?

Yes

No

Apply local subsidence adjustment

Apply vertical accretion adjustment

Apply global sea level adjustment

Retreat shoreline

Adjusted DEM

Shoreline change grid

Habitat grid

1-year loop

Output habitat grid

Compute statistics of habitat status

Maps

Statistics

Graphs
Projected Marsh Change

![Diagram showing the projected change in marsh area over years for both low and high marsh areas. The graph indicates a decrease in low marsh area and an increase in high marsh area with time.](image)
New Development
(post geohazard mapping)
## Geohazards Map Units

**Open Water**
- Bay, ocean, natural or excavated ponds and swales that are always inundated.

**Low Geohazard Potential**
- Island Core Upland: Centrally located upland areas generally more than 5 feet above sea level and not expected to become critical environments in 60 years’ time (2062).

**Moderate Geohazard Potential**
- Upland: Upland areas generally less than 5 feet above sea level that are not expected to become critical environments during the next 60 years (2062) (see above) but may be affected by storm surge caused by typical tropical storms or category-one hurricanes.

**High Geohazard Potential**
- Future Critical Environments: Areas expected to become critical environments (see above) in 60 years’ time (2062) if historical rates of relative sea-level rise and shoreline change continue and if development or restoration projects do not affect natural processes.

**Imminent Geohazard Potential**
- Present Critical Environments: Salt and freshwater wetlands, including beaches, tidal flats, and marshes. Along Gulf of Mexico shoreline, including beaches and fore dunes.
Post Hurricane Carla, 1961
Area of enhanced potential for washover

Natural protective ridge

Storm washover paths
Barrier Island Cross Section

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Future Wetland

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Upland
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After 60 Years of Sea-Level Rise and Erosion

Bay

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Upland
Island Core
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Protective Ridge
Beach/Dune

After 60 Years

Wetland
Upland
Island Core
Upland
Beach/Dune