Sediment Management Options for Galveston Island, Texas, USA

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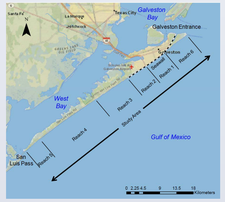
ABSTRACT

Galveston Island is a major tourist and commercial center on the Gulf of Mexico at the mouth of Galveston Bay, Texas, USA. The shoreline along the Galveston Seawall regularly requires beach nourishment while the beach west of the Seawall has severely eroded. In order to protect the island and ensure it is available for generations to come, a 50-year sediment management plan was developed. A sediment budget using the Sediment Budget Analysis System was calculated and numerous alternatives were simulated with GenCade, a shoreline change and sand transport model. Finally, several alternatives ranging from no action to a comprehensive beach fill and backpassing system were evaluated as part of the sand management plan.

INTRODUCTION AND BACKGROUND

1. Study Area ~ 47 km long;
Reach 1 is highest priority;
Reach 6 is lowest priority



2. Sediment Budget Analysis System (SBAS)

SBAS provides a framework for formulating, documenting, and calculating sediment budgets

SBAS sediment budget equation (Rosati and Kraus 2001, rev 2003)

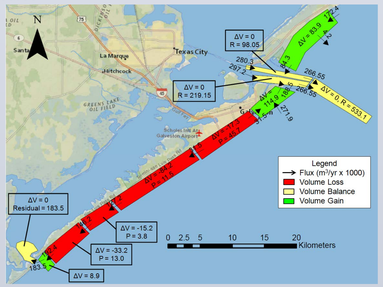
$\Sigma Q_{source} - \Sigma Q_{sink} - \Delta V + P - R = Residual$

ΣQ_{source} , ΣQ_{sink} = sources and sinks to the cell; ΔV = volume change rate within a cell; P = volume rate placed; R = volume rate removed; *Residual* = degree to which a cell is balanced

3. GenCade is a one-line shoreline change, sand transport, and inlet sand-sharing model (Frey et al. 2012) which combines the project-scale, engineering-design level calculations of GENESIS (Hanson and Kraus 1989) with the regional-scale, planning-level calculations of Cascade (Larson et al. 2003).

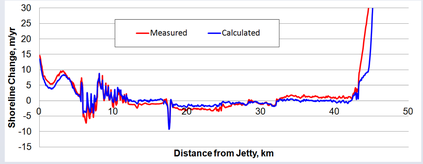
RESULTS: SEDIMENT BUDGET

- Updated from Morang (2006)
- Budget consists of 11 cells and pre-Hurricane Ike conditions
- 271,900 m^3/yr moving onshore needed to balance cell near jetty; sand may be coming from offshore disposal area (USACE 1993) or other source



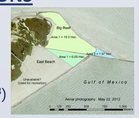
RESULTS: GENCADE CALIBRATION

- Two grids used to improve results near west end of Seawall and increase efficiency
- Initial shoreline = 1995; calibrated to 2000 shoreline
- Cell spacing between 15 and 60 m
- Galveston Seawall, groins, and beach fills included in simulation
- Waves (Wave Information Study (WIS) Station 73070 and WIS 73067)
- Source term of 271,900 m^3/yr added near South jetty (from sediment budget)
- Longshore sand transport calibration coefficients: K1 = 0.4, K2 = 0.2



SAND MANAGEMENT OPTIONS

Sand borrow sources:
- East Beach (300,000 m^3)
- Big Reef (1,100,000 m^3)
- Heald Bank (55 km offshore = 585,000,000 m^3)
- Sabine Bank (110 km offshore = 1,200,000,000 m^3)

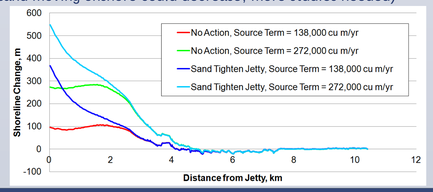


Options to recycle sand:
- East Beach deposition basin (up to 136,000 m^3/yr)
- Reduce transmission through South jetty*
- Reduce wind-blown sand (~ 45,000-60,000 m^3/yr)
- Sand Backpassing*

* Modeled with GenCade

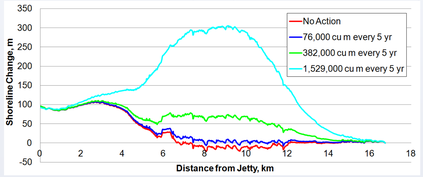
RESULTS: GENCADE ALTERNATIVES

1. Seawall (Reaches 6, 1, and 2)
- No action and sand tightening jetty with onshore Source term of 272,000 m^3/yr and Source term of 138,000 m^3/yr (future rate of sand moving onshore could decrease; more studies needed)

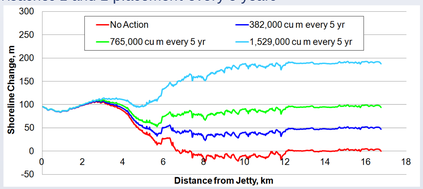


RESULTS: GENCADE ALTERNATIVES

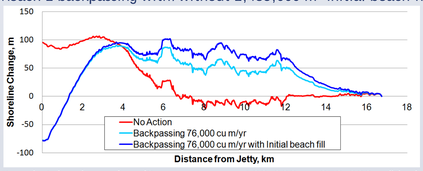
- Beach Fills
  - Reach 1 placement every 5 years (Source term = 138,000 m^3/yr)



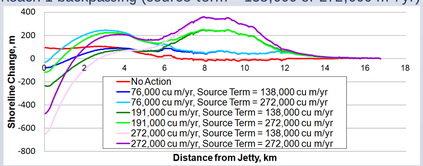
  - Reaches 1 and 2 placement every 5 years



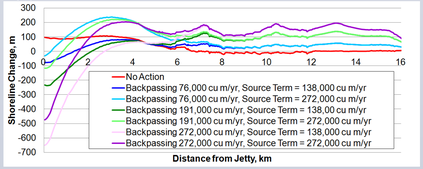
- Backpassing
  - Reach 1 backpassing with/without 1,485,000 m^3 initial beach fill



  - Reach 1 backpassing (Source term = 138,000 or 272,000 m^3/yr)

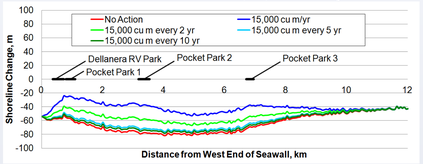


  - Reach 1 and 2 backpassing (Source term = 138,000 or 272,000 m^3/yr)

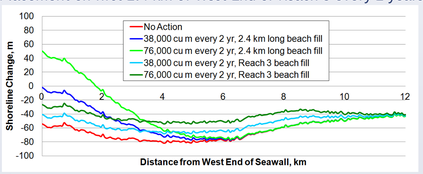


RESULTS: GENCADE ALTERNATIVES

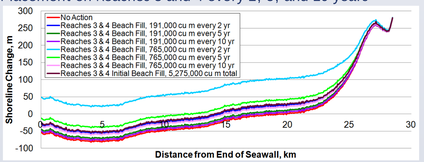
2. West End (Reaches 3, 4, and 5)
- Beach Fills
  - Placement on Galveston Park Board properties only



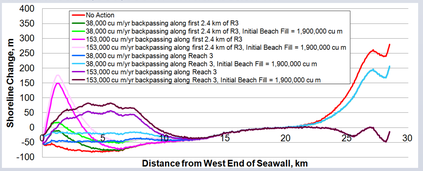
  - Placement on first 2.4 km of West End or Reach 3 every 2 years



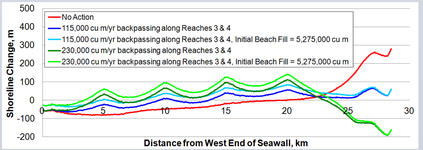
  - Placement on Reaches 3 and 4 every 2, 5, and 10 years



- Backpassing
  - Backpassing along first 2.4 km of West End or Reach 3; with/without 1,900,000 m^3 initial beach fill



  - Backpassing along Reaches 3 and 4; with/without 5,275,000 m^3 initial beach fill



SEDIMENT MANAGEMENT PLAN

Plan (Most to least comprehensive)	Reaches	New Material (Offshore or other sources)	Management and recycling of existing sand sources and dredge material	Perfor-mance moni-toring	Notes
Comprehensive beach fill & backpassing	1, 2, 3, 4, 5	X	X	X	Beach revitalization plan
Limited area beach fill & backpassing	1, 2, 3	X	X	X	Most critical areas only
Systematic recycle	1, 2		X		Reuse existing sediment in system without external new sediment
Present action plan	1, 2				Reacts to storms or emergencies
No action					Baseline

SUMMARY AND CONCLUSIONS

The main purpose of this study was to develop a 50-year sand management plan for Galveston Island. Based on the sediment budget and GenCade simulations, initial beach fills and backpassing plants on both ends of the island are the best strategies to widen the beaches of Galveston Island, improve tourism, and better protect the island from storms. If there are funding restrictions or limited sand sources, more localized beach fills could be constructed to keep the future beaches similar to the existing ones. Before a plan is finalized, it is recommended that the rate of material moving onshore at East Beach be studied in further detail, a beach profiling program be initiated, and the magnitude and direction of wind-blown transport be quantified.

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