Analysis of predicted dune erosion along North Carolina barrier island shorelines

Jessie Straub
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Research Applied to Managing the Coast Symposium
North Carolina Dune Erosion

Florence accelerates Bogue Banks beach erosion

9/10/18 Reference Point

9/15/18 Reference Point

9/10/18 Reference Point

9/15/18 Reference Point
Dunes & Human Development

- Natural first line of defense from coastal winds, waves, and flooding
- Communities commonly expend resources to restore and stabilize dunes
- Increases in risky coastal development patterns
- Clear need for accurate forecasts of coastal dune erosion
Coastal Dune Erosion

• Dunes constantly change in shape, width, height

• Erosion types
  • Seasonal fluctuations
  • Storm-induced
  • Long-term

• Dune recovery controlled by SLR, changes in storm frequency, duration, vegetation growth
Components of Coastal Water Levels

- **Mean Sea level**
- **Tide**
- **Storm surge**
- **Wave runup**: elevation of water on beach face = setup + swash  
  - **Wave setup**: Time averaged elevated water level due to wave action  
  - **Wave swash**: Movement of water up the shore due to breaking waves
- **Total Water Level**: Tide + surge + wave runup
Dune Response: Storm Scaling Model

- **Swash**
  - Water level seaward of dune toe

- **Collision**
  - Water reaches base of dune: erosion of front of dune

- **Overwash**
  - Waves transport sand landward

- **Inundation**
  - Beach system completely submerged

Sallenger 2000
Dune Response: Collision Regime

- Total water level exceeds dune toe, but not dune crest
- Erosion of seaward dune face
- Beach can recover to pre-storm conditions in weeks to years

Sallenger 2000 and Stockdon et al. 2006
Current Models: USGS Storm Impact Assessment

- Probability of collision, overwash, and inundation from TWL and dune measurements
- Models parametrized with buoy data and SLOSH and SWAN models
- Not representing accurate wave runup and dune erosion

Research Question: How often do we need to updated beach topography data to have accurate predictions of dune erosion?
Predictions of Coastal Change During Storms

Model of approaching storm: ADCIRC+SWAN (waves, surge, water level)

Initial beach morphology: beach slope, dune toe and crest elevations
Study Sites

- **North Shackleford Banks:** Southwest facing low-energy shoreline
- **South Core Banks:** Southeast facing high-energy shoreline
- **Onslow Beach:** Southeast facing low-energy shoreline

![Study Area Map](image)
Comparing Beach Slope & Profile Changes Between Sites
Comparing Beach Slope & Profile Changes Between Sites

Core Banks September 2017 Beach Profile

Shackleford Banks September 2017 Beach Profile

Onslow Beach September 2012 Beach Profile
Dune Elevation & Beach Slope Differences Between Sites

- **Core Banks**
- **Shackleford Banks**
- **Onslow Beach**

- **Elevation (m, NAVD88)**
- **Slope**

- **Average Dune Crest**
- **Average Dune Toe**
- **Dune Crest All Data Points**
- **Dune Toe All Data Points**
- **Average Slope**
- **Slope All Data Points**
Core & Shackleford Banks Dune Erosion Example

Core Banks Hindcast September 23-27, 2017

Shackleford Banks Hindcast August 27-30, 2017
Collision Prediction Accuracy with Varying Beach Slopes

**Core Banks Collision Predictions with Varying Beach Slopes**

- **Most Recent Slope**: 100.0%
- **Average Slope**: 95.0%
- **Lowest Slope**: 85.0%
- **Highest Slope**: 70.0%

**Sensitivity**: 
\[ \frac{\text{# of days collision predicted}}{\text{# of days collision observed}} \]

**Predictive Power**: 
\[ \frac{\text{# of correct days collision predicted}}{\text{# of days collision predicted}} \]

**Graph**
- **Average Slope**
- **Slope All Data Points**

**Locations**
- Core Banks
- Shackleford Banks
- Onslow Beach
Collision Prediction Accuracy with Varying Beach Slopes

**Sensitivity:** # of days collision predicted

# of days collision observed

**Predictive Power:** # of correct days collision predicted

# of days collision predicted

Core Banks Collision Predictions with Varying Beach Slopes

- Most Recent Slope
- Average Slope
- Lowest Slope
- Highest Slope

Shackleford Banks Collision Predictions with Varying Beach Slopes

- Most Recent Slope
- Average Slope
- Lowest Slope
- Highest Slope

Onslow Beach Collision Predictions with Varying Beach Slopes

- Most Recent Slope
- Average Slope
- Lowest Slope
- Highest Slope

Onslow Beach Transects

- January 10 2012
- May 31 2013
- September 12 2012
- October 24 2012
- November 1 2012
- December 28 2012
- February 26 2013
- May 7 2013
- September 19 2013
- November 14 2013
- January 27 2014
- March 1 2014
- May 12 2014
- October 9 2014

Cross Shore Distance (ft)
Take Home Messages

- Up to date beach slope is important in wave runup and dune erosion prediction accuracy
- ADCIRC + SWAN can be used to accurately predict water levels along the coast
- **Reflective beaches**
  - Steeper more variable slopes
  - Wave runup occurs more frequently
  - Need updated topography data
- **Dissipative beaches**
  - More gradual and less variable slopes
  - Update topography data less often

Doran et al. 2015
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Questions