Inlet Engineering Toolbox

Focus: develop desktop PC and web-based tools to aid in studies of the consequences of engineering actions at coastal inlets

- Statements of Need addressed
  - GenCade
    - 2017-N-71: Modeling Effects of Sea Level Change at Tidal Inlets
  - Modeling and Monitoring of Coastal Foredunes
    - 2015-N-11: Resilience Guidance
    - 2014-N-10: Update of engineering guidance for the development and maintenance of coastal dune systems
    - 2017-N-72: Improved Simulation of Dune Morphological Response at Short & Long Time-scales
  - Vessel Wake Effects
    - 2017-N-09: Shoreline sediment resuspension and wave energy dissipation due to vessel wake
Overview of FY18 Products

**TRs**

**TNs**
- Hartman, M. and R. Styles, Vessel wake prediction tool. (In management review)
- Kim, S., R. Styles, Y. Ding, R. Permenter, and A. Frey, Cross-shore transport in GenCade
- Munger, S. and A. Frey, Computer-based calibration and uncertainty analysis of GenCade: Description and proof of concept (In management review)

**Workshop/Webinar/Conference**
- Conery, I. High-resolution lidar scanning of developed and natural beach-dune systems on the Outer Banks, NC Ocean Sciences
- Brodie, K., Terrestrial Lidar Observations of Coastal Morphodynamics in Duck, NC, Ocean Sciences
- Brodie, K., Observations of Dune Morphological Evolution in Duck, NC, Over Monthly and Decadal Time-Scales ASBPA
- Palmsten, M., High temporal Resolution Observations and Modeling of Dune Erosion in the Collision Regime ASBPA
- Conery, I., “High-Resolution LiDAR Observations of Developed and Natural Beach-Dune Systems on the Outer Banks, NC” ASBPA

Overview of FY18 Products (cont.)
- Permenter (2017) GenCade: Current Status and Future Work/ Presented at Coastal Working Group Meeting, November 15, 2017
- Styles, R Vessel wake prediction tool. CERF, Rhode Island
GenCade
V&V of GenCade for FRF Shoreline: Data Analyses

(a) Study site at FRF, Duck, NC
(b) Comparison of Shorelines on 6/28/05
(c) RMSEs for 25 times surveys
(d) Probability Distribution of Shoreline Changes
(e) Mean Shoreline Positions vs Observation
(f) Maximum erosion at Return Year

Risk of Sea Level Rise
GenCade
Model Comparisons: GenCade, Pelnard-Considere, and LITPACK

(a) Single Groin
(b) Beach Fill
(c) Single Groin with Beach Fill
(d) Two Groins

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Vessel Wake
Vessel wake prediction tool
• Matlab program for rapid assessment of potential vessel effects
• Wake height from 7 wake models (barges, container ships, small vessels)
• Computes wake parameters (height, period, bottom stress, critical stress, celerity, energy, energy flux)

Features
• Input vessel information (speed, beam, draft, length)
• Constant/equilibrium bathymetry profile or read in bathymetry file

Vessel Stochastics
• Computes total wake energy as a function of # of vessels
• Computes tidal energy
• Computes river energy

TN - user guide
TR - bank erosion

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**Vessel Wake**

FY18 Products (Wake Extraction Algorithm)
- New extreme analysis algorithm
- ID vessel information (AVIS)
- ID vessel position from AISAP
- Vessel wake ID software implemented (Charleston Post 45)

Tech Transfer
TR (Vessel Effects in Wetlands)
New collaborations: SAG/Texas A&M, US Naval Academy
BBLM – CIRP website

Vessel Wake Detection Efficacy

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<th>Period</th>
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<th>Medium</th>
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**Inlet Engineering Toolbox**

**Coastal Foredunes**

- Modeling and Monitoring of Coastal Foredunes:
  - Goal: Improved understanding and predictive capabilities of dune dynamics in natural and managed systems at time-scales important for project lifetimes and event-relevant management decisions

  - SoNs addressed in FY18:
    - 2017-N-72 Improved Simulation of Dune Morphological Response at Short & Long Time-scales
  - PDT: Kate Brodie, Meg Palmsten (NRL), Matthew Geheran, Ian Conery (Pathways Intern)

  → New FY19 PDT Member: Nick Cohn
Coastal Foredunes FY18 Products

- Completed prototype web-tool for the Dune Erosion Planning Tool
- Completed testing and evaluation of web-tool for Hurricane Joaquin dataset at the FRF; JP in-prep→FY19 Deliverable.
- Completed initial setup of Aeolis (dune growth tool) at developed dune site
- 2 Presentations at Ocean Sciences 2018 Meeting:
  (1) High-resolution lidar scanning of developed and natural beach-dune systems on the Outer Banks, NC – Ian Conery (50% CIRP; 50% F&C)
  (2) Terrestrial Lidar Observations of Coastal Morphodynamics in Duck, NC – Katherine Brodie (33% CIRP; 33% F&C; 33% CFDC)
- 3 Presentations at ASBPA 2017 Meeting:
  “Observations of Dune Morphological Evolution in Duck, NC, Over Monthly and Decadal Time-Scales” — Katherine Brodie (40% CIRP; 40% F&C; 20% CFDC)
  “High temporal Resolution Observations and Modeling of Dune Erosion in the Collision Regime” — Margaret Palmsten (80% CIRP; 20% CFDC)
  “High-Resolution LiDAR Observations of Developed and Natural Beach-Dune Systems on the Outer Banks, NC” — Ian Conery (50% CIRP; 50% F&C)

Dune Erosion Planning Tool
(Palmsten & Holman 2011)

Hindcast Mode
- Wave data from NDBC and CDIP historical buoy data.
- Water level data from NOAA water level stations (sparse coverage).

Forecast Mode – designed off the USGS Coastal Change Hazards Portal
- Wave data from WaveWatch III.
- Water level from NOAA ESTOFS.
→ Could tie in with CHS in the future once data is available for whole U.S. East Coasts

Assumption: all wave impacts lead to dune erosion.
Testing Dune Growth Models

Tested 2 approaches to simulate dune growth at a developed dune site:
• Simplified Bagnold Predictions (Keijser 2014)
• 1D Aeolis (Hoonhout and de Vries, 2016; Cohn, 2018)

Model Comparison

Overview of FY19 R&D and SoNs

• GenCade Model Improvements (V&V; Inlet Reservoir Model; Tech Transfer)
  ► 2017-N-71: Modeling effects of sea level change at tidal inlets
  ► 2017-N-67: Guidance for numerical modeling of inlet ebb shoal and navigation mining studies

• Coastal Foredunes (Erosion & Probabilistic Tool; Test dune accretion tool (east/west coast); Tech Transfer, CWG);
  ► 2017-N-72 Improved simulation of dune morphological response at short & long Time-scales

• Vessel Wake Prediction Tool (Energy Threshold; Validation; Tech Transfer)
  ► 2017-N-1: testing and evaluating USACE coastal numerical models
  ► 2017-N-9: Shoreline wave energy dissipation due to vessel wake
FY19 R&D
V&V for DE Coasts

- Challenges
  - Regional Scale Shoreline Change
  - Beach Nourishments
  - Inlet Bypassing
- Approaches
  - Identify significant processes
  - Add/modify GenCade for each process
  - Verification
    - Algorithm Test
    - Sensitivity Test
  - Validation – using survey data
- Additional Support from RSM
- TR for V&V for DE Coast
- JP for V&V of GenCade (combining FRF and DE Coast applications)
- Short Course (Coastal Sediments)

FY19 R&D
Inlet Reservoir Module Test

- GenCade IRM algorithms will be assessed and tested.
- Guidelines for coefficient tuning will be provided based on analyzing two-dimensional models (e.g. CMS).
- TN for Inlet Reservoir Module (a) Delaware Coast around Indian River Inlet (b) IRM model in GenCade
FY19 R&D
Vessel Wake Energy Analysis

- Compute wave energy and power from wave height measurements
- Relate power to energy dissipated at shore
- Develop energy threshold requirements for wake energy comparison
- Test algorithms for maximum stress and run-up (Pujara et al. 2015; Si-yu et al. 2017)
- JP – wake extraction methods

\[ E_I = \frac{1}{8} \rho g H_I^2 \]
\[ P_I = \frac{1}{8} \rho g H_I^2 C_g \]
\[ E_D = \sum_{i=1}^{n} P T_i \]

Coastal Foredunes FY19 R&D

- Test Aeolis at a west coast prograding beach adjacent to a navigation structure
- Improve incorporation of vegetation and structure feedbacks within Aeolis modeling framework
- Use Aeolis to evaluate sediment fluxes into the dune and adjacent inlet between 2014 to 2018 and to explore implications of management actions (e.g. dune grass planting, sand fencing, etc.) at reducing input to the inlet

Active collaboration with OSU (Dr. Peter Ruggiero) and NWP (Rod Moritz, Kate Groth, Jarod Norton) on this project
Reimbursable Studies

- NAP – 20+ years validation data for GenCade, external review (Jeff Gilbert, Rob Hampson)
- SAM – datasets for validation
- SAG – Field support, measurements, and sediment analysis (Texas A&M); outside review for GenCade (P. Hamilton)
- SAC – Harbor deepening project, validation data, test vessel extraction algorithm (H. Carpenter)
- NWP – Dune transport model west coast dune system

Collaborations

- Academic:
  - Drs. JP Walsh & Reide Corbett, East Carolina University, Coastal Studies Institute
  - Dr. Kristen Splinter, University of New South Wales
  - Dr. Peter Ruggiero, OSU
  - Drs. Britt Raubenheimer & Steve Elgar, WHOI
  - Dr. Jens Figlus, Will Fuller, Texas A&M
  - Dr. Anna Wargula, US Naval Academy
- Federal:
  - USGS, NOAA, NRL through Nearshore Collaboration Effort
- Other R&D Programs
  - RSM, DOER, F&C, FRF
- Non-governmental:
  - ASBPA
Conclusion

- FY18 major advances
  - V&V for FRF coast (cross-shore transport as a critical process)
  - Monte-Carlos Method for Probability Shoreline Modeling and Uncertainty Assessment of Shoreline Change
  - Model comparisons (Verified against Pelnard-Considere analytical solutions; GenCade comparable to LITPACK)
  - Tool/App to simulate dune erosion planning
  - Initial setup of dune growth tool
  - Implementation (operational) vessel wake extraction

- FY19 key products/advances
  - V&V for DE Coast (focus on beach nourishment and inlet bypassing)
  - JP - V&V of GenCade (combining FRF and DE coast V&V)
  - Transition dune erosion tool to operations
  - Evaluate 1- and 2-D aeolian transport tool (dune growth)
  - Wake height extraction validation with 2-D model (JP)