USCRP Funded Research Projects (2016-2020)

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2020 USCRP Funded Projects

Dr. Cindy Palinkas (University of Maryland): Assessing shoreline erosion and sediment deposition as contrasting influences on the sustainability of natural marshes and living shorelines: Plant communities in created marshes are usually similar to those in natural marshes after a few growing seasons, but other characteristics may take decades to approach equivalency. This study examines whether tools and metrics developed for natural marshes are applicable to living shorelines from installation onward, or if refinements are necessary as the created marsh ages. Insights from this project are critical for assessing potential vulnerability of living shorelines to environmental changes over time to prioritize them for action.

Dr. Joseph Long and Dr. Andrea Hawkes (University of North Carolina Wilmington): Beach Berms: The Missing Link to Predicting Decadal-Scale Barrier Island Evolution will develop and test a model for the coupled beach-dune system at Masonboro Island, NC to predict barrier island evolution over annual to decadal timescales. By monitoring island topography, aeolian sediment transport, offshore wave characteristics, storm-induced water levels, and meteorological conditions, we will assess the ability of the model to represent these processes. Project outcomes aim to benefit the NC National Estuarine Research Reserve that manages the island and other coastal stakeholders and agencies that rely on predictions of island evolution to make management decisions.

Dr. Kevin Befus and Dr. Michelle Hummel (University of Arkansas): Hydrologic dynamics influence the physical and chemical environment of coastal wetlands by controlling water levels and transporting materials. Trajectories of groundwater, surface water, and land elevations in managed settings with sea-level rise tests how feedbacks between surface and subsurface hydrology can alter hydro-ecologic zones, wetland carbon cycling, and soil elevation trajectories. This project will provide stakeholders with an improved understanding of how diked coastal systems can be managed or rehabilitated to protect coastal environments while maintaining beneficial habitats.

Dr. Mara M Orescanin and Dr. Liliana Velasquez-Montoya (Naval Postgraduate School - U.S. Naval Academy): Long term morphodynamic stability at a bar-built estuary with implications for breach management combines in-situ observations and morphodynamic modeling to look at processes during beach breaching and closure. This study leverages several years of morphological observations at the

Carmel River State Beach and will use numerical models to determine long-term trends in breach characteristics and morphological evolution. Project outcomes will benefit and inform management breaching and closure practices at bar-built estuaries along the entire California coast by providing a data-driven model that can be used to assess breach conditions for future events.

Dr. Thomas Wahl and Dr. Katy Serafin (University of Central Florida): When forces collide: Developing a scalable framework for compound flood risk assessment investigates the spatial variation and extent of transition zones, where joint river and ocean processes combine to exacerbate flooding along coastal river systems. Using multivariate statistical models, hydrodynamic numerical models, and machine learning algorithms, this project develops an efficient and scalable hybrid modeling framework for quantifying graduated compound flood risk. The hybrid framework will be employed at locations around the U.S. to advance the understanding of along-river compounding effects for different local characteristics, supporting ongoing efforts to increase resiliency in coastal communities susceptible to compound flooding.

Dr. Rachel Gittman (East Carolina University): Natural and nature-based features, such as oyster breakwaters, are being proposed as viable alternatives to gray approaches for reducing shoreline erosion and attenuating boat-wakes along narrow, heavily trafficked waterways. Evaluating the Coastal Protection and Ecological Co-Benefits of Novel Marsh-Oyster Restoration Approaches evaluates the performance of oyster breakwaters in attenuating boat-wake induced wave energy, protecting, and restoring marsh shorelines, and restoring oyster habitat.

Dr. Tiffany Roberts Briggs (Florida Atlantic University): Natural and Anthropogenic Influences on National Beach Nourishment Activities and the Impact on Regional Sediment Budgets assesses historical trends in beach nourishment events over the last century at national and regional scales, evaluates possible natural and anthropogenic drivers of nourishment events, and explores the impacts on sediment budgets over time. Project outcomes aim to benefit coastal stakeholders, agencies, and managers by providing information to help better plan for future sediment resource needs and a methodological template to implement similar analyses at various scales of interest.

Dr. Steve Elgar and Dr. Britt Raubenheimer (Woods Hole Oceanographic Institution): Processes that Cause Long-term Nearshore Morphological Evolution is a collaborative effort with USGS partners to use a wide range of existing field observations to evaluate and improve numerical models, which can be used to examine the long-term evolution of nearshore regions, including beaches, inlets, and coastal bays and sounds. The models can also simulate future scenarios, such as more intense and long-lived storms and sea-level rise. The observations encompass extreme events (hurricanes and strong nor'easters), more moderate, but longer-acting stormy periods, and calmer conditions, allowing investigations into storm-induced changes to the shoreline, and the slower post-storm recovery important to long-term resiliency and sustainability.

Dr. Amanda Spivak (University of Georgia): Structures restricting tidal flow to coastal marshes are common and often have negative consequences for ecosystem functioning and the delivery of valuable services. Hydrological management of a tidally restricted coastal wetland: Characterizing biogeochemical responses over multiple time scales is a collaborative effort with USGS scientists to quantify the long-term impacts of tidal restriction on soil carbon accretion rates and evaluate the impact of restoration on ecosystem functioning related to the installation of box culverts. A key deliverable will be dissemination of data products and results to end users and restoration practitioners at government and non-governmental agencies to support their decision-making processes.

Dr. Greg Wilson (Oregon State University): Innovations in acoustic remote sensing of sediment transport for improving short-to-long-term models is studying how waves transport sand on open coastlines, and how this process varies from the shoreline to offshore of the wave break point. Studying wave-driven transport requires detailed observations very near to the seabed, without causing disturbances to the near-bed flow. For this reason, the project is developing acoustic sonar methods to remotely probe near-bed sediment load and flow velocity. This and related instrumentation will be installed on an amphibious vehicle (see figure), allowing measurements to be collected in a variety of water depths and wave conditions. The resulting data will be used to validate sediment transport theories used in numerical models.

Dr. Giulio Mariotti (Louisiana State University): Bridging the gap between process-based marsh evolution models and data-driven metrics of marsh health partners with USGS to improve models for marsh evolution and their comparison with real sites. A new model and geospatial analysis better interpret geomorphological metrics commonly used to characterize marsh sites, and quantify the contribution of different mechanisms – ponding, drowning, channel widening, and edge erosion – to the total marsh loss. The model is used to hindcast marsh evolution at selected sites, applying the improved metrics to calibrate and validate the model. A key deliverable is the fully documented, open source, numerically efficient marsh evolution model, which can be used to hindcast and forecast marsh changes, as well as to simulate marsh restoration techniques.

Dr. Jim Chen (Northeastern University): The goal of coupling CSHORE and Aeolis/Duna to Model Co-Evolution of Nearshore-Beach-Dune Systems is to develop the predictive capability of modeling nearshore-beach-dune co-evolution at various temporal scales ranging from years to decades to quantify the protective function of coastal dunes. The process-based numerical models, setup with accurate input data, will provide robust methods for predicting storm impacts and subsequent dune recovery while allowing detailed investigations into the governing marine and aeolian processes which are otherwise difficult or expensive to observe. The development and validation of the coupled CSHORE-Duna and CSHORE-Aeolis will improve our predictive capability of modeling nearshore-beach-dune system co-evolution.

Dr. Brett Webb (University of South Alabama): The project is focused on applying systems engineering principles for the purpose of identifying resilient strategies for communities impacted by coastal hazards. The application of systems engineering principles provides an opportunity and a framework by which to consider the complex social, natural, and technical relationships and how they may enhance or diminish a community's overall resilience to extreme events and long-term sea level rise.

Dr. Peter Traykovski (Woods Hole Oceanographic Institution): The goal of the project Mapping Nearshore Bathymetric Change with Surf-Zone Capable Unmannded Surface Vessels is to conduct bathymetric surveys of the near-shore region including the surf-zone before and after storms to map bathymetric change during high energy events while continuing development of unmanned surface vessels (USVs) to efficiently perform these surveys. Bathymetric survey data at the storm time scale is essential for developing and testing models of the morphodynamic response of the nearshore region and barrier islands to hydrodynamic forcing.

Dr. Andrew Ashton (Woods Hole Oceanographic Institution): Using an existing long-term, large-scale morphodynamic modeling approach that addresses how interactions between overwash and shoreface dynamics affect barrier dynamics and potential for functional breakdown, this project aims to improve our understanding on the controls on barrier survival over the coming decades and beyond. Through continued model development, the model framework will track sediment volume changes in both the cross-shore and alongshore dimension.

2019 USCRP Funded Projects

Dr. Jim Thomson (University of Washington): Coherent drifter arrays during DUNEX is focused on studying nearshore wave breaking and wave-driven circulation during the DUNEX experiment using a coherent array of drifting microSWIFT buoys. The project is helping the Army Corps develop new rapid-response sampling tools for the coastal community, including mapping patterns of waves, currents, and inundation.

Dr. Rick Luettich and Dr. Taylor Asher (University of North Carolina-Chapel Hill): Climatological and Hydrodynamic Model Uncertainties quantifies uncertainties in storm surge models and flood hazard studies by leveraging large datasets of modeled and measured water levels. The work will help the Nuclear Regulatory Commission, the Army Corps, FEMA and other stakeholders include improved understanding of model error structure and more accurate flood hazard estimates.

Dr. Daphne Munroe (Rutgers University): Oyster farms located in shallow coastal habitats provide a plethora of ecosystem functions, including physically interacting with waves and currents to potentially stabilize sediment and protect vulnerable shorelines. Back bay shellfish farms as a model for studying coastal ecosystem feedback systems investigates how oyster farms may act to reduce habitat loss and shoreline loss, ultimately helping the Army Corps and other stakeholders develop shoreline management practices, adaptation planning, and in permitting considerations for future aquaculture operations.

Dr. Tiffany Briggs (Florida Atlantic University): Investigating Impacts of Morphology and Sediment Variability on the Beach and Nearshore Ecosystem evaluates environmental characteristics associated with construction of a shore protection project and influences on the spatial and temporal distribution of black-tip sharks in the nearshore and sea turtle nests on the beach. Benefits include prediction of Outer Continental Shelf sediment dynamics because of natural and dredging processes to develop best practices for sand placement to mitigate impacts on the coastal and marine ecosystem.

Paige Hovenga (PhD Student) (Oregon State University): Quantifying uncertainty of beach/dune evolution models: application to managed and natural post-storm foredune recovery couples numerical modeling and a field campaign effort to quantify the applicability and uncertainty of beach-dune evolution models and better understand the relationships between ecological/environmental conditions and dune evolution. These findings will help the Army Corps and other stakeholders improve the application of developing beach-dune models, which may be used to better predict coastal hazard vulnerability, improve coastal engineering design, and inform decisions for resilience planning.

Mariko Polk (PhD Student) (University of North Carolina – Wilmington): Living shorelines are a nature-based shoreline management approach that protect coastal habitats and reduce erosion.

Multidisciplinary quantification of biogeomorphological impacts of living shorelines studies how living shorelines affect their biological and physical surroundings, their benefits as habitat, and performance as forms of restoration and in building coastal resiliency. This study will provide stakeholders with important information that can influence future project designs and provides information on how living shorelines influence the environment and the coastal communities that invest in them.

Dr. Britt Raubenheimer (Woods Hole Oceanographic Institution): Mechanisms for Dune Failure During Wave Impacts (DUNEX) centers on observations of surf and swash waves and flows, and beach and dune in/exfiltration and moisture content to examine hydrodynamic and morphological processes during wave-dune collision. This information will be shared with colleagues studying swash, groundwater, dune, and geotechnical processes. Benefits to the Army Corps and other stakeholders include improved parameterizations for dune evolution during and following storms, leading to improved models and management decisions.

Dr. Jennifer Irish (Virginia Tech): Impact of Coastal Restoration on Barrier-Island Evolution and Future Flooding addresses the fate of barrier islands and the role they play in altering hurricane surge in coastal communities. Using many computer simulations, both the range of future barrier-island change and the influence of these changes on future hurricane flooding are characterized. Outcomes will equip FEMA, the National Park Service, USGS and other stakeholders with critical knowledge needed to evaluate restoration alternatives (e.g., beach fill and marsh creation in the context of minimizing future hurricane flooding).

Dr. Stephanie Smallegan (University of South Alabama): This project develops a community-informed adaptation pathway for Dauphin Island, Alabama that includes an evaluation of strategies for preventing barrier island breaching during hurricanes. By involving stakeholders in the project adaptation pathway development, stakeholders will better understand and trust its viability and applicability to their own communities, optimizing the benefits for the Army Corps to consider the adaptation pathway in community planning.

Dr. Diane Henschel (Indiana University): Identifying and Communicating Coastal Impacts of Storm-Related Events and Other Predicted Climate-Related Stressors to Communities in the U.S. Great Lakes Watershed develops guidance for diverse-sized communities (rural, suburban, urban) to increase their resilience to current and future storm and climate stressors. Through spatial analyses, a survey, and community-based focus groups, this project improves understanding of risk and vulnerability to storms and climate stressors across the Great Lakes region and develops methods to communicate and mitigate risk. The Army Corps and other stakeholders will benefit through improved understanding of: 1) community risk and vulnerability, 2) strengths and resilience characteristics, and 3) feasible strategies to mitigate risk.

Dr. Greg Wilson (Oregon State University): Data-Driven Uncertainty Reduction During Nearshore Events aims to improve models that predict nearshore processes during storms by reducing uncertainty associated with rapidly evolving sand bars and other seabed features. The project is developing methods to automatically correct models based on data, such as video from beach cameras that indicate how the seabed is changing over time. Benefits to the Army Corps and other stakeholders include improved forecasting capabilities and new techniques for surveying the nearshore environment with remote sensing.

Dr. Britt Raubenheimer (Woods Hole Oceanographic Institution): Using buried pressure sensors and inland groundwater measurements, Coastal Groundwater, Water Quality, and Sediment Transport during Storms characterizes storm-driven changes in the groundwater flow patterns that affect flooding and pollution transport. Benefits to stakeholders include building collaborations with academic and federal DUNEX participants (Army Corps, USGS) interested in swash, coastal groundwater, and beach evolution; continuing partnerships with local town managers; and developing tools to aid in management of flooding and pollution hazards.

Dr. Sarah Giddings (Scripps Institution of Oceanography): Predicting Coastal Water Quality develops advanced modeling tools to predict the timing and extent of poor coastal water quality events by linking hydrodynamic modeling to pollutant transport models. This project also investigates the potential for this project to extend to policy-related economic tools. Partnerships with NOAA, Wildcoast, and Surfrider assist in public outreach and engagement with stakeholders, to improve coastal management decisions.

Dr. Paul Paris and Dr. Reide Corbett (East Carolina University): Long-term Impacts of Nourishment Projects on Beach Characteristics and Essential Habitat investigates long-term (>= 5 yrs.) ecological impacts resulting from re-nourishment on sandy, barrier island beaches. Findings will help the U.S. Fish & Wildlife Service and other stakeholders improve understanding of the natural-system response to re-nourishment and inform engineers in the design of future projects that more equitably restore both economic and indigenous ecosystem viability to the reconstructed beach.

Megan Vahsen (PhD Student) (University of Notre Dame): Quantifying and reducing uncertainty of marsh accretion through data-model integration of above ground plant productivity fuses data and models to create forecasts of coastal marsh accretion. Using advanced statistical data assimilation techniques, predictions are made that consider the relative uncertainties of the data and model components.

Dr. Casey Dietrich (North Carolina State University): Sustainability of Barrier Island Protection Policies under Changing Climates addresses methods to adapt beach and dune nourishment to improve resilience. A stochastic climate emulator is coupled with a library of high-fidelity simulations to identify triggers (beach width, dune height) for renourishment. Benefits to stakeholders include a planning tool that adapts to future climate scenarios.

Dr. Bret Webb (University of South Alabama): Barrier Island Hydrodynamics and Morphodynamics DURING an Extreme Event addresses the goal of continuously measuring hydrodynamic and morphodynamic processes on low-lying barrier islands during extreme events. This project aims to describe the time-dependency of these processes and their interactions by developing and building low-cost sensors that provide the ability to increase spatial resolution of storm processes measurements while minimizing the high-risk nature of extreme event deployments. The results will improve the Army Corps' and other stakeholders' understanding of barrier island resilience to extreme events.

Dr. Celso Ferreira and Graduate Student Tyler Miesse (George Mason University): Natural and Nature-Based Coastal Defenses: Closing the Gap on the Potential Protection from Marshes in the US East Coast investigates and quantifies the interaction of storm surges and waves with coastal vegetation by measuring hydrodynamic conditions (waves, currents and water levels) and vegetation characteristics, and conducting topographic/bathymetric surveys at two natural areas in the Outer Banks, NC during extreme events as part of DUNEX. This project provides field-based evidence and information to support U.S. Fish & Wildlife Service and coastal communities to safely and cost-effectively rely on natural and nature-based features (NNBF) for local-level resilience against flooding.

Dr. Don Resio (University of North Florida): Predicting Near-Bottom Currents for Erosion and Deposition Sequences addresses developing a new paradigm for estimating near-bottom currents. This project is analyzing a large set of previously unanalyzed, near-bottom current data from three locations near Duck, NC. The project is developing and utilizing two models to quantify the role of winds, waves and turbulent fluxes in the water column to test theoretical concepts of near-bottom currents against the large set of observations. Such information is expected to be valuable to the Army Corps in understanding short-term and long-term beach erosion/deposition under future sea-level change conditions.

Dr. Hannah Cooper (East Carolina University): Estuarine bluff shorelines: Inter-relation between erosion processes and development vulnerability integrates scientific information on the risks of bluff erosion with local land use plans and development controls critical to reducing property loss and vulnerability. By incorporating Unmanned Aerial Vehicle (UAV) and RTK-GNSS surveys with hydrological and meteorological sensors we will correlate bluff erosion rates with prevailing environmental conditions in the Neuse River section of the Pamlico estuary. These results along with the expertise of local officials and stakeholders will be used to encourage rural estuarine shoreline communities to consider the best actions for recovery and adaption to bluff erosion.

Dr. Nobuhisa Kobayashi (University of Delaware): Coastal structure design and rehabilitation incorporating stochastic risk and uncertainty performs laboratory experiments to investigate the structure settlement of rock mound structures on sand barriers and the rehabilitation of damaged or aged rubble mound structures. The work will help the Army Corps develop a systematic methodology for evaluating the remaining capacity and structure settlement of a coastal structure for present and future design conditions and for upgrading the deficient capacity if warranted economically.

Dr. Timu Gallien (University of California – Los Angeles): A compound flooding assessment and quantitative modeling methodology for optimizing coastal community resilience examines the pressures of urbanization and climate change that can dramatically increase coastal flood risk. The objective of this research is to develop a hydrodynamic modeling methodology that quantifies both marine (high water levels, waves) and hydrologic (precipitation, pluvial, fluvial) flooding and considers how compound flood risk evolves with infrastructure and intervention. The cities of Long Beach, Seal Beach, Huntington Beach, Imperial Beach, industry and state agencies have been engaged to identify future flood vulnerabilities and guide management decisions.

Dr. Navid Jafari (Louisiana State University): Evaluation the Distribution and Geotechnical Properties of Outer Continental Shelf (OCS) Sand Resources and Coupled Environmental Responses to Dredging is conducting field work offshore the coast of Louisiana to collect vibracores from a submerged dredge pit near Raccoon Island. As part of the fieldwork, strict COVID-19 precautions were followed and enforced prior to departure. A total of 10 vibracores were collected within and outside of the dredge pit. Gamma ray density profiles of the vibracores indicate that there are primarily under-consolidated clays overlying normally consolidated clays inside the pit with potentially gas-charged layers present in the sediment. Sands appear to dominate the cores taken outside the pit. Field work and geotechnical testing are ongoing.

2018 USCRP Funded Projects

Dr. Jack Puleo (University of Delaware): Intra-storm Erosion Processes on an Engineered Dune System develops new sensing capabilities for measuring intra-storm processes on natural and engineered beach systems. These instruments will be used to measure surf zone processes such as near bed currents and rapidly changing water and seabed levels. Benefits include process understanding and quantification for engineering design and numerical model validation and training next generation researchers.

Dr. Tori Tomiczek Johnson (U.S. Naval Academy): Shoreline Wave Attenuation by Mangroves and Marshes (SWAMM) develops quantitative relationships of wave attenuation through vegetation using physical model experiments and field measurements of boat wakes and wind wave transformation near mangrove shorelines as well as training of midshipmen research students. Benefits to stakeholders and the Army Corps include a better understanding of the potential and limitations of natural and nature-based features as shoreline protection.

Dr. Talea Mayo (University of Central Florida): Data assimilation for the improved forecasting of hurricane storm surges investigates the potential of computational methods to improve real-time prediction of hurricane storm surges using data. Benefits to stakeholders include a potential increased capacity of emergency management and responders to provide effective, timely community information during coastal hazards, particularly as the climate changes and the risk of storm surge increases.

Dr. Matto Mildenberger (University of California at Santa Barbara): Communicating sea-level rise risks to US publics in high-risk FEMA flood zones evaluates how coastal residents in California, New Jersey, Virginia and Florida understand sea-level rise risks in their local communities. Using geographically disaggregated surveys, this project provides members of the public with customized information about sea-level rise risks across their census track, highlighting the position of their own residence. The project survey then evaluates interest in individual and community-level resilience behaviors in response to these individual and systemic risk messages. This research will help inform how FEMA and private stakeholders can best communicate the risks of sea-level rise to impacted residents.

Rachel Housego (PhD Student) (Woods Hole Oceanographic Institution): Total Groundwater Levels and Flooding During Major Storms uses ongoing groundwater measurements and citizen-science data submitted through the iFlood app to evaluate and improve models of flooding from ocean storms and rainfall on the N.C. Outer Banks. The researchers aim to increase community awareness of coastal flooding hazards and inform local town managers about the processes contributing to flooding in their community to guide future management strategies and strengthen engagement between communities, town managers and scientists.

Dr. Robert J. Weaver (Florida Institute of Technology): Development and coupling of a parametric wave model with ADCIRC: An Ensemble Approach creates and tests a fetch based parametric wave solver for coastal estuaries coupled into an ensemble nested circulation and wave modeling system for estuaries and bays, eliminating the need for a computationally expensive 3rd generation wave model. The resulting system performs high-resolution wave and circulation predictions for coastal estuaries using a fraction of the computational resources typically required. The improvements in modeling efficiency benefits stakeholders, NOAA, and the Army Corps by enabling real-time ensemble and/or scenario-based modeling approaches to risk management.

Dr. Casey Dietrich (North Carolina State University): Coupling of Inlet-Scale and Region-Scale Flooding Predictions addresses the need for dynamic feedback between storm processes and barrier island response. This project considered the erosion and breaching of Hatteras Island during Hurricane Isabel (2003), to examine how flow through 'Isabel Inlet' affected the sound side of the island. This is a necessary step toward dynamic forecasts for decision support for FEMA, NOAA, and the Army Corps.

2016 USCRP Funded Projects

Dr. Peter Ruggiero (Oregon State University): Quantifying uncertainty of beach/dune evolution models: application to managed and natural post-storm foredune recovery develops a front-end interface to the Windsurf model called CReST (the Coastal Recovery from Storms Tool) to add the ability to incorporate beach nourishment and dune construction, beach and dune grading, dune grass planting scenarios, dune grass removal, and the presence of hard engineering structures into the model framework. This added capability allows for better accounting for the complex dynamics of managed coastlines and a flexible framework to investigate the complex interactions between beaches and dunes for a variety of exploratory and applied applications.

Dr. Laura Moore & Dr. Evan Goldstein (University of North Carolina – Chapel Hill): A Calibration Workflow for Coastal Dune Models using Structure-from-Motion Photogrammetry and a Genetic Algorithm develops an approach for calibrating models of coastal foredune growth using structure-from-motion photogrammetry and a machine learning technique (genetic algorithms). This project is a step towards better predicting dune growth during inter-storm time periods.

Dr. Bianca Charbonneau (University of Pennsylvania): Wind Tunnel Analyses of Vegetation Species: Differences in Sand Capture Efficiency for Natural & Nature-Based Dune Accretion & Management explores the biogeomorphic relationships between plant morphology and density with foredune genesis. Stakeholder benefits from this project include interdisciplinary and applied research for coastal management, modelling parameterization, as well as the opportunity for local and national community involvement with a custom wind tunnel.

Dr. Doug Sherman (University of Alabama): The goal of Estimating Potential Dune Vulnerability to Storm Sequences: A Pilot Study is to develop a methodology to assess the long term, regional storm sequence regime at any location using relative wave energy forcing.

Dr. Beth Sciaudone and Dr. Ayse Karanci (North Carolina State University): Wave Runup on a Constructed Berm: Implications for Dune Design investigates the way in which a constructed beach nourishment berm can potentially reduce wave runup impacting protective coastal dunes. The insights from this project will enable designers to appropriately design smaller (less costly) protective dunes in locations where the distance between coastal infrastructure and the shoreline is minimal.