Grant Information

Title of Project
Enhancing Coastal Resilience on Virginia's Eastern Shore

Total Amount Requested	$ 1,460,000.00
Matching Contributions Proposed	$ 295,131.59
Proposed Grant Period	08/18/ 2014 - 08/18/ 2016

Project Description
This project will engage stakeholders and provide tangible science-based tools to affect the development of more effective climate-hazard mitigation and risk reduction strategies on the Eastern Shore.

Project Abstract
This project will provide the scientific framework, decision-making support tools and examples of real world, nature-based solutions needed to avoid costly, ineffective management decisions that could have unintended negative consequences for Virginia's Eastern Shore—a true "resilience hub" in the Sandy-impacted region. Specific objectives are to: (1) provide managers, planners, and communities with decision-making knowledge and tools that, in turn, can be used to mitigate hazards and reduce risks while taking into account diverse interests and management objectives; and (2) demonstrate the cost and design efficacy of nature-based solutions to increase the likelihood that decision-makers will adopt these strategies to mitigate climate change hazards and enhance resilience. The following outcomes are expected: (a) establishment of collaborative stakeholder process for coastal resilience; (b) combined sea-level rise and storm surge scenarios that account for marsh migration and enable the collaborative evaluation of management strategy options; (c) development of Barrier Island Inlet Model System and evaluation of mitigation strategies generated under a range of climate and management scenarios; (d) Creation of Eastern Shore version of Coastal Resilience tool; (e) at least three acres of oyster reef collectively restored with documented storm protection benefits, and a model that measures wave attenuation benefits of oyster reefs.

Organization and Primary Contact Information

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Other Keyword(s)	Planning

Hurricane Sandy Coastal Resiliency Competitive Grants Program Full-proposal Project Narrative
Enhancing Coastal Resilience on Virginia's Eastern Shore

A. Geographic Context

The Eastern Shore of Virginia, located at the southern end of the Delmarva Peninsula and flanked by the Atlantic Ocean to the east and the Chesapeake Bay to the west, includes Accomack and Northampton Counties and over a dozen incorporated towns. While rural in character, the Eastern Shore is an increasingly important economic engine for the Mid-Atlantic. The region is home to the National Aeronautics and Space Administration's Wallops Flight Facility (NASA), with over $1 billion of mission-critical infrastructure on Wallops Island; the Chincoteague National Wildlife Refuge (CNWR) and the Assateague Island National Seashore (AINS), which collectively are visited by 2.2 million tourists annually; the nation's largest clam aquaculture industry; and scores of traditional waterfront villages and towns, including the town of Chincoteague, which is a major tourist destination.

Assateague Island and over a dozen barrier islands to the south form one of the world's longest expanses of naturally functioning barrier island and coastal bay ecosystem, which is largely protected. Over the past 40 years, The Nature Conservancy (TNC), the U.S. Fish and Wildlife Service (FWS), the National Park Service (NPS), the Commonwealth of Virginia, and other partners have invested over $100-million to protect, enhance, and restore 133,000 acres of coastal and mainland habitats on the Eastern Shore, including 14 barrier islands owned by The Nature Conservancy. Because of this legacy of land conservation, the Eastern Shore is the subject of intensive scientific research. Since 1986, the University of Virginia has received funding from the National Science Foundation (NSF) for the development of the Virginia Coast Reserve Long-Term Ecological Research (LTER) site, one of only 26 NSF-funded LTER sites in the nation.

This unique geographic and socioeconomic setting, in which economic development, national and state interests, and natural ecosystems intersect, is situated in a hotspot of coastal erosion caused by intensifying storms and accelerated sea-level rise—three to four times above the global average. These climate-induced changes are increasing the vulnerability of natural and human communities, including billions of dollars of critical infrastructure. Our proposed work seeks to address the following critical concerns: (1) cooperative strategies do not currently exist to confront the effects of these growing threats to humans, the economy, and the natural environment; and (2) past and current strategies are, in many cases, inadequate and exacerbating the area's vulnerability to changing conditions. Addressing these concerns for the Eastern Shore will provide a framework for addressing similar problems emerging along all Sandy-impacted U.S. coastlines.

B. Project Narrative

1. Project Goals

In partnership with the Accomack-Northampton Planning District Commission, LTER, NASA, and CNWR, The Nature Conservancy seeks support **to engage stakeholders and provide tangible science-based tools in developing more effective climate-hazard mitigation and risk reduction strategies on the Eastern Shore**. This project will provide the scientific framework, decision-making support tools, and examples of real world, nature-based solutions needed to avoid costly, ineffective, management decisions that could have unintended consequences for this unique stretch of coast—a true "resilience hub" in the Sandy-impacted region. The outcomes of this project will enhance coastal resilience by directly informing and influencing the following: the revision of the Eastern Shore hazard mitigation plan; upcoming actions on federal lands that require National Environmental Policy Act environmental review; and the comprehensive planning process for towns and localities.

The specific objectives of this project are to: (1) provide local land use managers, planners, and communities with decision-making knowledge and tools that can be used to mitigate hazards and reduce risks as they take into account diverse interests and management objectives; and (2) demonstrate the cost and design efficacy of nature-based solutions so that decision-makers are more likely to adopt such practices as key components in their efforts to mitigate climate change hazards and enhance resilience.

To accomplish these goals, we propose the following tasks and associated outcomes:

1. Engage key decision-makers through the Eastern Shore Climate Adaptation Working Group in a participatory and collaborative stakeholder process regarding science, tools, and practices that can enhance the resilience of human communities, the economy, and the surrounding ecosystem. **Outcome: Establishment of collaborative stakeholder process for coastal resilience.**
2. Gather the best available science and data to populate, test, and run models that simulate the effects of physical processes (i.e., sea-level rise, storm surge, and marsh migration) on the coastal system with the goal of enabling stakeholders to evaluate a range of future management options. As part of this effort, we will implement long-term field studies of mainland marsh migration to improve these models' capability over time. **Outcome: Development of combined sea-level rise and storm surge scenarios that account for marsh migration and enable the collaborative evaluation of management strategy options.**
3. Develop a Barrier Island–Inlet Modeling System (BIIMS) to investigate the coupled natural-physical evolution of Wallops, Chincoteague, and south Assateague Islands under a range of potential sea-level rise, storm surge, and management scenarios. Use the model's output to help stakeholders and the community better evaluate the potential consequences of an array of mitigation strategies. **Outcome: Development of BIIMS and evaluation of mitigation strategies generated under a range of climate and management scenarios.**
4. Deliver and communicate model outputs to stakeholders via a state-of-the art online decision-support tool called *Coastal Resilience* (see section 4). The tool allows the visualization and comparison of different sea-level rise, storm surge, and management scenarios in relation to models of barrier island-inlet evolution and marsh migration for use in climate-related hazard mitigation planning. **Outcome: Create Eastern Shore version of *Coastal Resilience* tool.**
5. Promote natural infrastructure solutions by demonstrating the storm protection benefits of oyster reef restoration projects at three strategic locations. In addition, set up long-term experimental field studies to document the wave attenuation effects of oyster reefs and pilot an oyster reef wave attenuation model to measure benefits of current and future reef projects. **Outcome: (a) Collective restoration of at least three acres of oyster reef with documented storm protection benefits; and (b) development of a model that measures wave attenuation benefits of oyster reefs.**

We define success as the collaborative engagement of stakeholders and scientists in a comprehensive, integrated, and science-based assessment of a range of coastal management scenarios that are designed to reduce the vulnerability of the coast and to enhance its socio-economic and ecological resilience as the climate changes.

2. Priority

The Eastern Shore contributes significantly to regional and state economies, which is driven in large part by NASA, CNWR, AINS, the town of Chincoteague, and a thriving shellfish aquaculture industry. A 2011 study determined that expenditures by NASA (FY 2010) and related tourism generated $188 million in economic impact in the region and created 2,341 jobs. Furthermore, the federal government, the states of Virginia and Maryland, and the commercial space industry have all increased their investments at NASA Wallops over the past several years and this trend is expected to continue. An economic study of CNWR by Fish and Wildlife Service in 2006 estimates that the total annual spending associated with tourism at the refuge is $315 million and supports 3,766 jobs. A similar study of the clam aquaculture industry by the Virginia Institute of Marine Science shows the industry's economic impact exceeds $61 million per year and creates almost 700 jobs.

In addition to the region's economic value, however, the Eastern Shore is a conservation jewel—one of the last remaining expanses of coastal wilderness on the Atlantic. The region boasts recognition as a United Nations International Man and the Biosphere Reserve, a U.S. Department of the Interior National Natural Landmark, a Western Hemisphere International Shorebird Reserve Network Site, and an Atlantic Coast Joint Venture Focus Area. The sustained efforts by TNC, FWS, NPS, the Commonwealth of Virginia, and other conservation organizations have protected 133,000 acres here over the last 40 years, including more than 70 miles of Atlantic Ocean beachfront and 14 barrier islands. Together with academic partners and the state, we have collectively restored approximately 60 acres of oyster reef, designated 2,000 acres of oyster reef sanctuaries, established 5,000 acres of eelgrass meadows—the largest seagrass restoration project in the world—and reintroduced bay scallop to the coastal bays, a species that disappeared from the system 80 years ago due to habitat loss.

Because much of the area is not directly affected by human activities, its coastal system is one of the world's best environments for scientists to conduct state-of-the-art research on the impacts of climate change on aquaculture, seagrass, marshes, and so on. The opportunity it provides for fundamental understanding of coastal systems is why the National Science Foundation designated the area as one of its prestigious LTER sites. All LTER sites are dedicated to long-term ecological research, the goal being to provide society with the kind of in-depth knowledge it needs to advance the health, productivity, and welfare of the global environment. For 28 years, LTER researchers on the Eastern Shore have conducted long-term experiments and published over a thousand peer-reviewed journal articles that have furthered the scientific understanding of the dynamics of coastal barrier ecosystems.

The Eastern Shore has a long track-record of expensive, temporary, piecemeal, and often ineffective attempts to adapt to sea-level rise and extreme storms. Tens of millions of dollars have been spent over decades to protect valuable infrastructure from rising seas, storms, coastal flooding, and erosion, often compromising the integrity of surrounding natural ecosystems. For instance, since the 1960s, NASA has tried to unsuccessfully prevent shoreline retreat on Wallops Island by employing an array of wooden groins, seawalls, and geotextile tubes. One of their more recent options they considered was to construct a 500-foot terminal groin on the southern end of Wallops Island. The idea was abandoned after an outside review by scientists and engineers concluded that the groin may interrupt the sediment transport processes that sustain the downdrift barrier islands owned by FWS, NPS, TNC, and the state. Instead, however, NASA spent $43 million to install a mile-long protective seawall and replenish the beach, a quarter of which was swept away when Hurricane Sandy hit soon after the project was completed. NASA had to seek an additional $10.5 million to replace the lost sand. CNWR's challenges in maintaining a beachfront parking lot on the southern end of Assateague Island are another example of costly, ineffective attempts to stabilize the coast. Stakeholders in the area have deemed beach access as critical to the economic prosperity of the region. However, the parking lot has been replaced five times during the past ten years as a result of major storms, including Hurricane Sandy. Repairs to the parking lot cost tax payers roughly $800,000 per incident. The costs and potential conflicts for CNWR and NASA, as well as for AINS, the towns, and property owners will only increase as sea level continues its accelerated rise and as larger and more frequent storms threaten critical infrastructure. The piecemeal and reactive approaches employed in the past are not sufficient to address the mounting challenges of climate-related hazards along the Eastern Shore. For them to adapt, their management decisions must consider an integrated landscape context, the science and value of coastal ecosystems, and appropriate current and future human uses.

In 2008 The Nature Conservancy (TNC) launched a comprehensive stakeholder-based initiative that characterized the current understanding of potential climate change impacts on the Eastern Shore and identified strategies to enhance resilience and facilitate adaptation of natural and human communities. One of the most significant outcomes of this workshop was the formation of the Eastern Shore Climate Adaptation Working Group (CAWG). This grass-roots group is led by the Accomack-Northampton Planning District Commission (A-NPCD) and is composed of representatives of more than a dozen local organizations including NASA, CNWR, AINS, the town of Chincoteague, TNC, LTER, and other

community members. These stakeholders all share the urgent need for understanding and interpreting the best available science to inform difficult decisions that face them.

3. Sustained Benefits

Agencies, organizations, and localities participating in the Eastern Shore Climate Adaptation Working Group (CAWG) are the primary stakeholder audience that we seek to benefit through the tasks and outcomes of this project. Specifically, the project will provide CAWG members with the best available science and models in the *Coastal Resilience* (*CR*) decision support tool that will facilitate more effective adaptation planning into the foreseeable future. One of the most important long-term benefits of the project will be to more permanently formalize and institutionalize CAWG as the regional forum dedicated to collaborative evaluation of management responses to climate hazards in the context of coastal ecosystem functions and processes. Another sustainable benefit will be the development an Eastern Shore version of the *CR* tool, will continue to be hosted by TNC on the Amazon Cloud for a negligible annual cost. Likewise, model outputs included in *CR* can be updated as needed with minimal cost. Under the Section E.3, we propose developing a long-term monitoring plan to measure the extent to which new management strategies implemented in the future as a result of this project lead to reduced vulnerability and enhanced resilience of the coastal system and economy on the Eastern Shore.

Oyster reef restoration at three sites will also provide sustainable benefits by demonstrating and quantifying how natural infrastructure can mitigate the impacts of coastal hazards. Once built, these oyster reefs will continue to accrete vertically, thereby increasing their storm protection capacity, water quality benefits, and habitat functionality over time at no cost. As stakeholders see the risk reduction benefits of such nature-based solutions, they will be more likely to adopt and replicate such practices, and, we hope, become advocates for such approaches. We anticipate that this scenario will, in turn, lead to policy changes that incentivize the incorporation of natural infrastructure mitigation approaches at local, state, and federal levels.

4. Leveraging

By funding this proposed project, NFWF and the Department of Interior (DOI) will directly leverage four projects funded via the internally-funded DOI Hurricane Sandy Coastal Resilience projects:

- Evaluating Ecosystem Resilience: Assessing wetland ecosystem functions and processes in response to Hurricane Sandy (U.S. Geological Service [USGS]-National Wetlands Research Center [NWRC])
- Linking Coastal Processes and Vulnerability—Assateague Island Regional Study (USGS)
- Estuarine Physical Response to Storms, Including Chincoteague Bay, DE/MD/VA (USGS)
- Living Shoreline-Oyster Reef Restoration and Construction at Chincoteague National Wildlife Refuge, Virginia (FWS)

The Nature Conservancy and LTER are partners on the DOI-funded USGS-NWRC study. The proposed project will bolster the existing USGS-NWRC project by contributing funding to establish additional long-term research sites that will study the transition zone between mainland salt marsh and the upland edge in response to sea-level rise and storms. This empirical data will significantly improve our ability to model marsh migration at a regional scale, a major goal of this project. In addition, our project will both benefit from and augment the USGS Assateague Island Regional Study (AIRS) and the separately-funded USGS effort to address island evolution using a statistical approach. Data collected by the USGS team will ultimately help to inform the Barrier Island–Inlet Modeling System (BIIMS). In turn, by addressing the evolution of barrier islands and inlets under a range of sea-level rise and storm scenarios using BIIMS, this proposal addresses the onshore components not addressed by USGS AIRS. Results from BIIMS—which will include the otherwise unaddressed but critical effects of the two-way coupling between physical processes and human interventions—as well as the results of marsh edge erosion studies and storm surge modeling—could provide valuable inputs to the USGS statistical models of island evolution. The USGS Estuarine Physical Response study will provide significant model outputs on storm hazard effects on the sediments and wetlands of Chincoteague Bay. These outputs will be coordinated with

efforts to model barrier island/inlet change and marsh migration. Finally, we intend to supplement the living shoreline-oyster reef restoration project at the Chincoteague National Wildlife Refuge by restoring additional reef in Tom's Cove, scaling up the storm protection benefits of the project.

NFWF/DOI also has a great opportunity to benefit from major investments made by TNC and partners to design and support the *Coastal Resilience* decision support tool. This tool is an online mapping platform where ecological, social, and economic information can be visualized alongside sea-level rise and storm surge scenarios in specific geographies so that users may develop risk reduction and restoration solutions. *CR* was first launched in 2008. It was developed and is maintained by TNC, the Natural Capital Project, National Oceanic and Atmospheric Administration (NOAA), USGS, University of Southern Mississippi, Association of State Floodplain Managers, and others. Now in version 2.0, *CR* is a highly cost-efficient and well-vetted delivery mechanism for data and models needed by Eastern Shore stakeholders. In addition, its sophisticated multi-scale platform architecture will enable us to seamlessly integrate the Eastern Shore version with existing and new *CR* geographies that have been proposed for development under this NFWF/DOI grant opportunity, including those for the State of Maryland and the East Coast.

Beyond this, the proposed project will leverage the past six years of sustained climate adaptation efforts initiated by TNC and maintained by A-NPDC's leadership of CAWG. The proposed project is also a tremendous opportunity for NFWF/DOI to leverage the 28 years of the LTER's extensive research, including site-specific data sets and models, to benefit the coastal communities of the Eastern Shore.

5. Speed to Functionality

This project is ready to go and will immediately begin to provide lasting benefits. Key participants will experience early benefits through their input, review, and vetting of scenarios and draft model output and as they test the functionality and usability of the *CR* tool. These benefits will multiply by the end of the project when the model outputs are incorporated into a fully tested and functional *CR*. Once released upon completion of the two-year grant project, stakeholders can immediately begin to apply and use the *CR* tool for planning and decision-making regarding climate-related hazards. In addition, by the end of the grant timeline we will have three oyster reef projects fully implemented with at least a one season of oyster recruitment to demonstrate storm buffering benefits.

C. Youth and/or Veteran Engagement

Our academic partners will employ undergraduate and graduate students from their associated universities to develop and run models and to design experimental field studies. Specifically, undergraduate and graduate students will be employed to set up and monitor experiments designed to measure oyster reef wave attenuation effects and marsh-upland transition zones in response to storms and sea-level rise in addition to helping design and run the Barrier Island–Inlet Modeling System. Additional students will be recruited as volunteers and will gain field experience by helping to deploy oyster castles at each of the three reef restoration sites.

D. Collaboration and Partnerships

The outcomes proposed for this project have evolved from years of collaboration with all the partners included in the proposal. For example, the Virginia Seaside Heritage Program Partnership is a highly successful collaboration between TNC, Virginia Coastal Zone Management Program, and other state agencies and academic institutions that has garnered close to $10 million to restore coastal bays on the Eastern Shore over the last 15 years. Also of note is the Southern Tip Ecological Partnership, a memorandum of understanding between FWS, TNC, and state agencies dedicated to the protection and restoration of migratory bird habitat that has conserved approximately 10,000 acres since 2002.

For years, TNC, CNWR, NASA, and LTER have jointly sought funding for the barrier island-inlet models focused on the Chincoteague-Assateague-Wallops nexus to help solve the enormous management challenge of maintaining rocket launch facilities on Wallops Island and beachfront parking at the refuge

while preserving the resilience of the greater coastal barrier island system. The enthusiasm among these partners for this modeling effort is high, and we all consider it a necessary first step toward changing current ineffective management of valuable infrastructure on these islands.

In addition, CAWG has showed strong interest in the models and *CR* tool proposed for this project. Stakeholders in this group have repeatedly expressed the need for higher resolution inundation, storm surge, and marsh migration models as well as for a better understanding of barrier island-inlet dynamics. Most of the group's members do not have the resources or skills to create such models, and all see the urgent need for better, more readily assessable information to drive planning for climate-related hazards.

TNC will provide a direct non-federal match of $295,132, which is broken out as follows: $95,000 from the Volgenau Foundation; $90,188.08 in private contributions to be raised by TNC; $107,993.92 for indirect costs; and $1,950 in in-kind support.

E. Work Plan & Logistics

1. Project Team

The Nature Conservancy's mission is to conserve the lands and waters on which all life depends. With the support of more than one million members, TNC has protected more than 120 million acres and 5,000 river miles worldwide. It has more than 150 marine conservation projects in 32 countries and every U.S. coastal state. On the Eastern Shore, TNC has been working to conserve, protect, and restore coastal and marine habitats for the benefit of nature and people since the late 1960s, launching a major adaptation initiative to enhance coastal resilience on the shore in 2008. TNC project staff: **Gwynn Crichton,** *Senior Project Scientist,* lead grant project manager; **Jill Bieri,** *Virginia Coast Reserve Program Director,* stakeholder outreach and project support; **Jim McGowan,** *Land Protection Manager,* stakeholder outreach and project support; **Chris Bruce,** *GIS Manager*, lead on building *CR* tool; **Zach Ferdaña,** *Senior Marine Conservation Planner,* advisor on *CR* tool development and models; **Bowdoin Lusk,** *Marine Steward,* manager of oyster restoration projects.

The LTER project, funded by NSF and led by University of Virginia (UVA) since 1986, brings together a multidisciplinary, multi-institution group of researchers to examine the response of coastal barrier ecosystems to climate change, sea-level rise, and intensified human use. Coastal geologists and modelers from the University of North Carolina (UNC) Chapel Hill and Randolph Macon College—both part of the LTER—as well as UNC Wilmington and Duke University are on the proposal team. Researchers and associated academics involved with the project: **Dr. Karen McGlathery** *(UVA), Professor, Department of Environmental Sciences, and Lead Principal Investigator, LTER,* grant project co-manager; **Dr. Patricia Wiberg** *(UVA), Professor and Chair, Department of Environmental Sciences, part of LTER,* lead on QAPP, consultant on marsh migration and wave attenuation models and lead on experiments on oyster reef wave attenuation and mainland marsh-upland edge; **Dr. John Porter** *(UVA), Associate Research Professor (UVA), Department of Environmental Sciences, information manager for LTER*; consultant on marsh migration and liaison for LTER data; **Dr. Linda Blum** *(UVA), Associate Research Professor, Department of Environmental Sciences, part of LTER*; consultant on marsh migration**; Dr. Art Schwarzschild** *(UVA), Site Director, Anheuser-Busch Coastal Research Center, and LTER Education/Outreach Director*; on-site supervisor of undergraduate and high-school students and consultant on marsh migration model; **Dr. Matt Kirwan,** *Marsh Ecologist*; consultant on marsh migration model; **Dr. Michael Fenster** *(Randolph-Macon College), Professor, Geology and Environmental Studies, part of LTER,* data coordinator for barrier island and inlet modeling; **Dr. Dylan McNamara** *(UNC-Wilmington), Assistant Professor, Department of Physics and Physical Oceanography,* humans/landscape coupling modeler for barrier island-inlet modeling; **Dr. Laura Moore** *(UNC-Chapel Hill), Assistant Professor, Department of Geological Sciences, part of LTER,* lead on barrier island-inlet modeling; **Dr. Brad Murray** *(Duke University), Professor of Geomorphology and Coastal Processes,* coastline dynamics modeler for barrier island-inlet modeling.

The A-NPDC is a regional organization that provides planning, community development and housing services to Accomack County, Northampton County, the town of Chincoteague, and other incorporated towns on the Eastern Shore of Virginia. The A-NPDC assists various jurisdictions with diverse community development projects and provides regional planning assistance and support for initiatives like CAWG. A-NPDC staff involved in the project: **Curtis Smith,** *Director of Planning and Lead of CAWG,* grant project co-manager and stakeholder outreach co-lead.

NASA Wallops' Education and Leadership Development Program is part of the Suborbital and Special Orbital Projects Directorate of the NASA Goddard Space Flight Center/Wallops Flight Facility in Virginia. The education programs at Wallops strengthen student involvement and public awareness of its scientific goals and missions. NASA staff involved with the project: **Dr. Joyce Winterton,** *Senior Advisor for Education,* stakeholder outreach; **Dr. Deborah Bronson,** *NASA Consultant,* stakeholder outreach.

Other project team contractors include: Dr. Greg Guannel, *Coastal Engineer,* oyster wave attenuation modeler; **Chip Hitchens**, *Director of Operations,* Azavea, *Coastal Resilience* framework developer; **Barry Nickel,** *Director, Center for Integrated Spatial Research, University of California at Santa Cruz,* oyster wave attenuation model programmer; **Jonathon Clough,** *CEO, Warren-Pinnacle Consulting, Inc.*, marsh migration modeler; **Dr. John Atkinson,** *Arcadis U.S., Inc.*, storm surge modeler; **Dr. Jim Wesson,** *Oyster Restoration Manager, Virginia Marine Resources Commission*, oyster reef restoration manager.

Additional project collaborators and advisors: Kevin Holcomb, *Supervisory Wildlife Biologist, FWS, CNWR;* **Caroline Massey,** *Assistant Director, Management Operations, NASA Wallops;* **Darlene Finch**, *Mid-Atlantic Regional Coordinator, NOAA Coastal Services Center;* **Tom Walker,** *CEO, J.C. Walker Brothers Inc.;* **Dr. Elijah Ramsey III,** *Oceanographer, USGS National Wetland Research Center;* **Dr. E. Robert Thieler,** *Researcher, USGS Coastal and Marine Geology Program;* **Dr. Neil Ganju,** *Researcher, USGS Coastal and Marine Geology Program.*

2. Work Plan

We propose a two-year project beginning in September 2014 and ending in September 2016. The first 12 to 18 months of the project will focus on stakeholder engagement, building the models to address stakeholder information needs, and setting up long-term experimental research projects. The second year of the project will focus on refining the models and developing, populating, and testing the Eastern Shore version of the *Coastal Resilience (CR)* tool and training stakeholders and the community to use the tool. Oyster reef projects will be implemented by the end of the first year. Sequential tasks associated with the outcomes listed under "Project Goals" in the Project Narrative are detailed below. Lead entity for task each and the expected completion date (using a 24-month calendar) are in parenthesis next to task or sub-task listed below.

Task 1. Hold an initial workshop with CAWG stakeholders and project team (*A-NPDC, TNC; Month 3*).

1) Brief the group on project objectives and outcomes, overview of modeling process and anticipated outputs, science behind models, and potential applications of models in *CR* tool.
2) Determine the stakeholder's highest priority information and management needs for use in models.
3) Establish best communication venues such as a list serve and website for communication and provision of outreach and learning resources.
4) Conduct pre- and post-workshop surveys regarding stakeholders' perceptions of the project's relevance and utility for solving their climate-hazard related challenges.

Task 2. Develop, run, and test initial models to assess vulnerability and resilience to climate hazards.

1) Refine existing NOAA Coastal Services sea-level rise inundation maps (*TNC; Month 8*).
2) Run and verify Sea-Level Affecting Marsh Migration (SLAMM) under various sea-level rise scenarios using custom rule set and parameters-based, long-term studies of mainland marsh transgression on Eastern Shore (*Warren-Pinnacle Consulting, UVA, Matt Kirwan, TNC; Month 12*).

- Establish experimental research sites designed to measure the stability and composition of marsh-upland transition zones and their response to storms and sea-level rise and to ground-truth and refine the model over time (*UVA; Month 12*).

3) Run and verify outputs of Advanced Circulation Model for Oceanic, Coastal and Estuarine Waters (ARCIRC) storm surge model to create stakeholder-defined scenarios (*Arcadis U.S., Inc; Month 12*).
4) Develop the Barrier Island–Inlet Modeling System (BIIMS) for Chincoteague Barrier Island-Inlet system, producing outputs that project how the system may evolve over time (including coastal shape, migration and configuration) under a range of sea-level and storm surge scenarios and stakeholder-selected human intervention/ management scenarios (*UNC-Chapel Hill, UNC-Wilmington, Duke, Randolph-Macon; Month 12*).
5) Pilot oyster reef wave attenuation model in six coastal bays using the physical characteristics of reefs to illustrate wave attenuation benefits now and in the future under various sea-level rise and storm surge scenarios (*Dr. Greg Guannel, UVA, TNC, University of California at Santa Cruz; Month 12*).
    - Develop QAPP and then establish oyster reef experimental research sites designed to measure wave attenuation benefits of reefs in response to storms and to ground-truth and refine the model over time (*UVA; Month 12*).

Task 3. Develop Eastern Shore version of *CR* tool (*TNC, Azavea, University of California at Santa Cruz; Month 12*).

1) Build and populate the online data viewing portal portion of *CR* with informative data layers related to coastal vulnerability, hazards, and resilience.
2) Create custom modules in *CR* to deliver the outputs from the models described above. Modules will include: (a) Flooding and Sea-Level Rise, (b) Future Habitats (includes BIIMS and SLAMM model outputs, respectively), and (c) Coastal Defense (oyster wave attenuation model).

Task 4. Build three oyster reefs along eroded shorelines in Tom's Cove and the village of Oyster.

1) Plan, design, and conduct pre-construction monitoring and obtain permits for three reef restoration projects (*TNC; Month 6*).
2) Build reefs at each site with mix of planted shell (contract) and oyster castles (volunteers) (*TNC, VMRC; Month 13*).
3) Conduct monitoring of reference sites at time of restoration and one year later (*TNC; Month 12, Month 23*).

Task 5. Re-convene CAWG stakeholders and project team for workshop(s) to report interim project progress (*A-NPDC, TNC; Month 14*).

1) Present initial model runs and outputs to solicit feedback.
2) Present beta *CR* tool and conduct usability testing; solicit feedback.
3) Present oyster restoration project and solicit feedback.
4) Conduct pre- and post-workshop surveys as described under Task 1.

Task 6. Revise initial models/output and seek informal peer review of model methodology and outputs.

1) Fully document methods and metadata for all models (*model leads under Task 2; Month 23*).
    - Produce reports on establishing long-term experimental research sites for oyster reefs and marsh-upland edge, including first year baseline data collection results and potential implications for corresponding models (*UVA; Month 23*).
2) Seek informal peer review of each model by at least two qualified reviewers outside project team (*model leads under Task 2; Month 23).*

Task 7. Update, test and improve the *CR*'s usability, functions, and content (*TNC, NASA; Month 23*).

1) Conduct additional phased testing and evaluation with individual stakeholders.
2) Conduct two *CR* train-the-trainer workshops and support six *CR* trainings with Eastern Shore communities and homeowners.

3) Develop a long-term maintenance and upgrade plan for *CR* to ensure optimal performance and support beyond the grant period.
4) Ensure that all data layers included in *CR* will have readily available and fully-documented metadata.

Task 8. Convene CAWG stakeholders and the project team for presentation of final project outcomes (*A-NPDC, TNC; Month 24*).
1) Highlight revisions and changes to models and *CR* based on CAWG feedback and peer review.
2) Present first-year monitoring and research results from oyster-wave attenuation and marsh-upland edge studies.
3) Develop CAWG follow-up plan for communications, funding, and other next steps to leverage outcomes of NFWF grant, including long-term monitoring plan.
4) Conduct pre- and post-workshop surveys as under Task 1.

3. Monitoring and Measuring Performance

Ultimately, our proposed project aims to enable people to make better decisions regarding climate hazard mitigation in ways that enhance both the socioeconomic and ecological health and resilience of the region. In addition, we intend to set up experimental research projects for which baseline data will be collected using grant funding but by design will yield research results for years to come. Given the long-term nature of this work, we propose a two-tiered monitoring strategy for this project: (1) measure immediate activity and outcomes over the two-year lifespan of the grant; and (2) measure changes to the economic and ecological resilience of the region that result from this project over five-ten years.

Tier 1 Monitoring Plan

Monitoring Objective 1: Ensure maximum participation and input of key stakeholders in model and tool development by holding at least three workshops over two years.
Progress indicators:
- Number of stakeholders (measured as individuals and organizations/agencies) actively participating in each workshop.
- Results of workshop surveys regarding understanding and utility of subject matter.

Monitoring Objective 2: Ensure that best available published and peer-reviewed research informs the development of models, that the model outputs are fully documented with complete metadata, and that the models are informally peer-reviewed by at least two qualified subject matter experts. In addition, ensure that 6 to 8 youth participate in field research activities and modeling work.
Progress indicators:
- Number of peer-reviewed long-term studies/empirical data sets used to parameterize, inform, or ground-truth barrier island-inlet, marsh migration, and oyster wave attenuation models.
- Number of qualified peer reviewers for each model.
- Completed Federally Geographic Data Committee compliant metadata for each model.
- Confidence levels evaluated for model outputs.
- Number of long-term recurring experimental research sites designed and established to measure wave attenuation benefits of oyster reefs and stability and composition of marsh-upland transition zone in response to storms and sea-level rise.
- Number of youth participating in research and modeling activities of project.

Monitoring Objective 3: Ensure all members of CAWG and six communities are trained and registered to use *CR* and can directly apply *CR* models and information in least three planning and decision- making contexts that are either starting up or currently underway.
Progress indicators:
- Number of individuals and entities trained and registered to use the *CR* tool.
- Activity level on the *CR* tool indicated by number of visits, average visit duration, and so on.
- Number and type of local or state planning processes or federal environmental assessments where *CR*

is applied.

Monitoring Objective 4: Plant at least three acres of oyster shell and castles collectively across three different sites which results in a density of 800 live oysters/m2 and 18-mm average length of after the first year of recruitment. Ensure at least 30 volunteers deploy oyster castles at three sites. In addition, ensure that at three additional oyster restoration projects are initiated by project stakeholders to protect eroding shorelines.

Progress indicators:

- Number of acres of reef constructed.
- Density (#/m2) and size (shell length) of live and dead oysters in reference and restoration sites.
- Number of other oyster restoration projects initiated to protect shorelines.

Tier 2 Monitoring Plan

A deliverable of the proposed project will be to develop a comprehensive monitoring plan to measure the longer term social, economic, and ecological impacts caused by coastal hazard mitigation actions taken by key economic actors as a result of this project. This plan will develop specific criteria to evaluate future decisions that use the *CR* tool to estimate risk exposure to critical infrastructure, post-storm recovery costs, and ecosystem health and integrity. In addition, the plan will develop criteria to monitor the value and adoption of nature-based solutions in mitigating climate hazard risks. Whereas NFWF/DOI grant funds would be used to develop such a plan, other funds will be raised to implement it.

4. Return on Investment

Through this project, we plan to institutionalize the use of integrated and science-driven solutions to climate-related hazards. This holistic approach can potentially save taxpayers hundreds of millions of dollars by preventing ill-fated shoreline armoring or other coastal engineering projects that may inadvertently damage the very coastal systems upon which the economy and environment depend. Specifically, DOI stands to benefit by improved future management of CNWR and the AINS, two of its most important assets on the East Coast. NASA and DOD will benefit because they have the most valuable infrastructure and assets at risk. The Federal Emergency Management Agency also will see a significant return on investment if the incorporated towns and localities are empowered, through better information, to undertake meaningful risk reduction actions in their hazard mitigation planning efforts.

5. Risk

The greatest risk with the project is that key community and economic stakeholders in the region do not invest the time, institutional resources and effort needed to engage in a regional approach to climate hazard mitigation. However, the high level of stakeholder self-interest, the extensive damage from recent coastal storms, and the broad participation in CAWG give us confidence that the project will be enthusiastically received. The key to success will be ensuring that stakeholders perceive a strong alignment between the project and their needs, and that the *CR* tool is relevant, accessible and easily understood.

6. Permits and Approvals

TNC will submit a Joint Permit Application for oyster restoration projects to the Habitat Management Division of the Virginia Marine Resources Commission, a streamlined local, state, and federal permit application.

7. Safety

TNC and contractors shall compliance with all Occupational Safety and Health Administration requirements and U.S. Coast Guard regulations during oyster reef construction.

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Enhancing Coastal Resilience on Virginia´s Eastern Shore: Project Map