BOLD THINKERS DRIVING REAL-WORLD IMPACT

Case Study: Advancing Coastal Resilience Science through Data, Mapping, and Modeling in the Hurricane Sandy Coastal Resilience Program

Contract # 5359

PREPARED FOR:

National Fish and Wildlife Foundation
1133 Fifteenth Street, N.W., Suite 1000
Washington, DC 20005

U.S. Department of the Interior
1849 C Street, NW
Washington, DC 20240

SUBMITTED BY:

Abt Associates
6130 Executive Blvd.
Rockville, MD 20852

IN PARTNERSHIP WITH:
Virginia Institute of Marine Science,
Center for Coastal Resources Management
Crucial Economics Group, LLC

FINAL

2019

Case Study: Advancing Coastal Resilience Science through Data, Mapping, and Modeling in the Hurricane Sandy Coastal Resilience Program

Prepared by Abt Associates, September 2019

Summary

Purpose

This case study forms part of a larger 2019 evaluation of the Hurricane Sandy Coastal Resilience Program (Hurricane Sandy Program) of the U.S. Department of the Interior (DOI) and the National Fish and Wildlife Foundation (NFWF). It provides an analysis of the contributions of coastal resilience science projects to the program's overall objectives.

Scope

We examined 86 coastal resilience science projects in the Hurricane Sandy Program portfolio that produced scientific knowledge to identify key risks and vulnerabilities to coastal storms, and to inform resilience-related decision-making in the region. The scientific activities included in this case study -- including data, mapping, and modeling projects -- were not conducted to support the implementation of a specific on-the-ground restoration project. Instead, their results were intended to help guide future storm response, restoration, and resilience actions.

Findings

Key findings identified using archival materials, a survey and interviews of project leads, and websites and media reports include:

- Coastal resilience science projects resulted in the creation of more than 700 deliverables, including presentations, reports, manuscripts, datasets, maps, and models.
- Nearly all of the projects have successfully completed their proposed activities.
- The information provided by these projects has filled key knowledge gaps and, in some cases, directly improved resilience-related decision-making.
- The ultimate impact of some coastal resilience science activities could be enhanced by providing more direct outreach to relevant decision-makers.
- More time is needed to observe the uptake of the coastal resilience science products into decision-making processes; depending on the decision, additional time may then be needed to observe the impact on coastal resilience.

Conclusion

Hurricane Sandy Program investments in coastal resilience science projects have filled key knowledge gaps and helped to directly improve resilience-related decision-making. These projects have led to notable successes including, for example, an online coastal hazards portal that has already been used to track and predict coastal impacts of multiple hurricanes, tropical storms, and severe winter storms. Overall, these projects were highly productive and generated more than 700 deliverables, including presentations, reports, manuscripts, datasets, maps, and models. However, more time is needed for decision-makers to incorporate the scientific products and information generated through the program into additional decisions beyond the individual examples described in this case study. An issue that may constrain the impact of some of these projects is the limited outreach to decision-makers to raise awareness, and to ensure the suitability and usability of the data and tools being developed.

1. Introduction

This case study forms part of a larger 2019 evaluation of the DOI and NFWF Hurricane Sandy Coastal Resilience Program (Hurricane Sandy Program). Between 2013 and 2016, the Hurricane Sandy Program, administered through DOI and NFWF, invested over $302 million to support 160 projects designed to improve the resilience of ecosystems and communities to coastal storms and sea level rise.[1] The program supported a wide array of activities, including aquatic connectivity restoration, marsh restoration, beach and dune restoration, living shoreline creation, community resilience planning, and coastal resilience science to inform decision-making. Each of these activities has a distinct impact on ecosystem and community resilience.

DOI and NFWF drafted the following questions to serve as the focus of the evaluation:

1. To what extent did projects **implement activities** as intended? What factors facilitated or hindered project success?
2. What **key outcomes** were realized for habitat, fish and wildlife, and human communities?
3. Is there evidence that investments in green infrastructure are **cost-effective** compared to gray infrastructure?
4. Did investments in tools and knowledge related to resilience **improve decision-making**?
5. What **information is needed** to better understand the long-term impacts of investments in resilience?

The evaluation includes six case studies, each providing a deeper level of analysis on a subset of the projects.

1.1 Purpose

This case study provides an in-depth analysis of projects focused on resilience-related science activities, including those that collected data or developed maps or models to support resilience-focused decision-making. Hereafter, the projects in this case study are collectively referred to as either “coastal resilience science” projects or “data, mapping, and modeling” projects. This case study focused on evaluation questions #1, #4, and #5 (above). It identifies key findings regarding science project implementation and examines the available evidence about the impact of these projects on resilience-related decision-making to date.

1.2 Scope

We examined 86 coastal resilience science projects in the Hurricane Sandy Program portfolio. Projects in this category produced scientific knowledge that can be used to identify key risks and vulnerabilities to coastal storms, and to inform resilience-related decision-making in the region. To be included in this category, a project must have generated new scientific knowledge (e.g., collected new field data, analyzed or reprocessed existing data, developed new models/simulations) with the intention of informing resilience decisions. Projects that collected data, produced maps, or built models to support the implementation of specific on-the-ground restoration projects were included in other case studies that focused on the relevant restoration action (e.g., enhancing aquatic connectivity, beach and dune restoration). See Section 3 for a

[1] The evaluation covers these 160 projects. In some cases DOI and NFWF reinvested unspent funds in new, additional projects after the December 2016 cutoff date. These new projects are not included in the evaluation.

more detailed description of the portfolio of coastal resilience science projects; and Appendix A for a full list of the 86 projects.

1.3 Organization

The remainder of this document is organized as follows:

- Section 2 provides an overview of the methods and information sources used for this case study
- Section 3 provides a detailed overview of the coastal resilience science projects included in the Hurricane Sandy Program
- Section 4 discusses key case study findings, organized by evaluation question and topic
- Section 5 provides a brief conclusion.

2. Methods Overview

This case study integrates information from the following information sources:

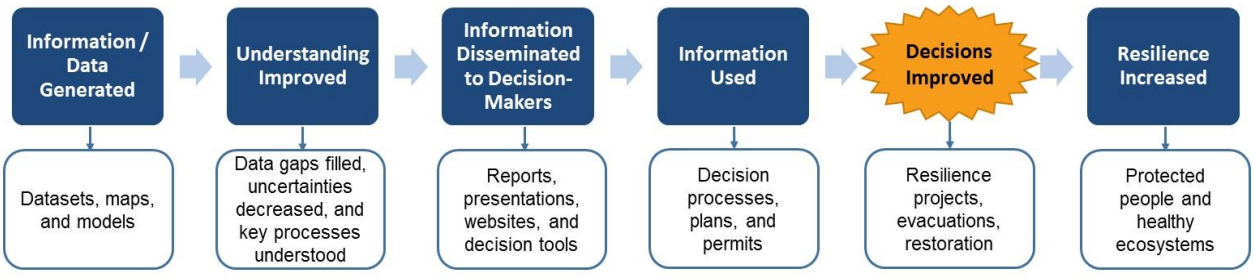
- Archival materials from Hurricane Sandy Program project files (e.g., proposals, interim and final reports)
- A survey of project leads via a web-based instrument
- A review of websites and media reports covering project execution and outcomes
- Interviews with NFWF and DOI staff, and individual project leads.

A more detailed description of evaluation methods can be found in Abt Associates (2019).

3. Overview of Projects

Improving scientific knowledge through making investments in coastal resilience science can fill key data gaps, decrease uncertainties, and increase understanding of key biophysical and ecological processes related to resilience. When this information is insufficient, sound decision-making related to resilience can be constrained. For example, it can be difficult to know how to prioritize coastal restoration projects over the long-term without understanding which areas are most vulnerable to coastal erosion during storms. When a storm is predicted, insufficient information about where the impact of that storm is likely to be focused can hamper efforts to effectively allocate emergency response resources. If relevant scientific activities are properly designed, implemented, and shared with relevant decision-makers, they can improve resilience-related decision-making and, ultimately, increase resilience (see Figure 1).

Figure 1. Logic model showing how coastal resilience science projects can support improved decision-making, with relevant examples from each step in the logic chain.



The Hurricane Sandy portfolio supported 86 projects that conducted data, mapping, and modeling in whole or in part to improve coastal resilience. Overall, the Hurricane Sandy Program invested more than $82.5 million in coastal resilience science in 86 projects (Table A.1), 3 of which also included other resilience activities; the total funding provided by the program for all of the activities in the 86 projects was $87.8 million.[2] The projects were distributed among a subset of bureaus within DOI, as follows (with the amount of funding provided specifically to coastal resilience science activities in parentheses):

- Bureau of Ocean Energy Management (BOEM) (17 projects, $9.7 million)
- National Park Service (NPS) (29 projects, $10.7 million)
- U.S. Geological Survey (USGS) (24 projects, $42.9 million)
- U.S. Fish and Wildlife Service (USFWS) (7 projects, $14.1 million)
- NFWF (9 projects, $5.1 million).

These projects addressed a broad range of science topics with the potential to inform resilience decision-making. To better understand and convey the scope covered by the projects, we further categorized them into seven topic areas, adapted from topic areas the USGS used to organize its projects (Buxton et al., 2013; see Table 1).[3]

In Table 2, we summarize the number of projects in the seven topic areas described below, as well as the total funding allocated to those projects; we also show the number of projects funded in each topic area by each DOI Bureau and NFWF. Archival materials show that the types of research conducted within each of the bureaus were consistent with its overall mission and key activities. For example, BOEM regulates the use of off-shore sand resources, and its projects were focused on improving understanding of the nature and location of those resources and how well they match beaches or dunes in need of nourishment. As another example, a key activity of USGS is to provide information about the impacts of coastal storms; a few of its projects have focused on expanding and improving the organization's ability to provide real-time information about potential storm surge in the Northeast.

[2] Table A.1 presents the amount of project funding specifically allocated to coastal resilience science activities. For 83 projects, this was the full project funding amount. For three projects, this is a subset of the total project funding. The allocation was based on available project documentation.

[3] USGS organized its 24 coastal resilience science projects into 5 topic areas based on impact types and information needs. We categorized the non-USGS projects into these topic areas (which we modified slightly for simplicity) based on the topics addressed and the products produced. For projects with multiple components that addressed different topic areas, we applied our best judgment to determine the primary project focus and categorized the project into that topic area. We also added topic areas six and seven to categorize a few projects that did not fit into the five original USGS topic areas.

Table 1. Project topic areas covered by coastal resilience science projects.

Topic area	Examples of relevant project activities
1. Elevation Data	• Collected high-resolution elevation data. • Produced maps and hydrologic models based on these data.
2. Coastal Change	• Collected and examined pre- and post-storm shoreline data. • Produced maps, models, and forecasts of coastal change. • Created visualization tools showing historical and potential future coastal changes. • Developed reports assessing trends and vulnerabilities.
3. Storm Surge and Hydrology	• Developed real-time monitoring networks and tools for describing meteorological conditions. • Gathered and analyzed data regarding water levels and inundation rates. • Produced maps, impact models, and inventories of vulnerable resources and infrastructure. • Improved storm-vulnerability predictions and evaluated best practices for addressing those vulnerabilities.
4. Environmental Quality	• Examined data on water quality, contamination, and health and ecological risks resulting from Hurricane Sandy. • Produced maps, visualization tools, and publications assessing the occurrence, distribution, transport processes, and trends of contaminants and risks.
5. Ecosystem Impacts	• Collected data on vegetation, animal species and their habitats, and the responses of both to storm impacts. • Produced reports, inventories, maps, and models of ecosystems and ecological processes. • Developed improved monitoring methods, online tracking data and visualization tools, and tools to evaluate or prioritize restoration methods.
6. Sand Resources	• Identified and characterized sand resources. • Identified sand resources to avoid due to contamination or insufficient resources. • Produced reports, inventories of resources and needs, maps and geographic databases, and ratings or classifications of the available resources
7. Coordination and Communication	• Supported collaboration and coordination among researchers and other stakeholders, primarily focused on Jamaica Bay, New York. • Developed reports, publications, presentations, and communication tools.

Table 2. Coastal resilience science projects by bureau and topic area. Dollars rounded to nearest hundred.

Topic area	Bureau (number of projects)					Total count	Allocated award
	BOEM	NPS	USGS	USFWS	NFWF		
1. Elevation Data	–	2	4	–	–	**6**	$9,280,700
2. Coastal Change	–	3	7	2	2	**14**	$26,441,400
3. Storm Surge and Hydrology	–	5	4	1	4	**14**	$12,520,500
4. Environmental Quality	–	2	3	–	–	**5**	$5,229,500
5. Ecosystem Impacts	2	12	6	4	2	**26**	$22,320,700
6. Sand Resources	15	–	–	–	–	**15**	$3,963,700
7. Coordination and Communication	–	5	–	–	1	**6**	$2,769,700
Total	**17**	**29**	**24**	**7**	**9**	**86**	$82,526,200

4. Findings

Topic: Project Implementation (PI)

Finding PI.1: Nearly all the projects have successfully completed their proposed activities, with typically minimal changes in scope or timeline.

Nearly all of the coastal resilience science projects (82 of 86) were completed by the time of this evaluation, and an additional 4 are expected to be completed by December 2019. Of the 82 projects completed, 5 were completed in 2015, 49 in 2016, 8 in 2017, and 20 in 2018.

In the survey, about half (48%) of the project leads indicated that there was a change in the scope of their projects. Nearly all changes, however, were reportedly minor and involved increases in the amount or changes in the type of data collected, as opposed to decreases in project activities or outputs or delays in the work performed.

Topic: Improved Decision-making (ID)

Finding ID.1: Coastal resilience science projects resulted in the creation of more than 700 deliverables, including presentations, reports, manuscripts, datasets, maps, and models.

Using information from archival materials, we estimate that the coastal resilience science projects funded through the Hurricane Sandy Program produced more than 700 deliverables (Table 3). The types of deliverables produced are consistent with the scientific nature of the projects: presentations and publications were the two most commonly created products, along with datasets, models, and maps. More than 60 communication products were also produced, but more than half of these products were developed by projects in topic area 7, which is focused on coordination and communication. Projects in the other topic areas produced fewer communication products.

Table 3. Coastal resilience science products and deliverables.

Product or deliverable	Topic area (# of products)							Total
	1. Elevation Data	2. Coastal Change	3. Storm Surge and Hydrology	4. Environmental Quality	5. Ecosystem Impacts	6. Sand Resources	7. Coordination and Communication	
Presentations	9	37	20	14	84	12	59	**235**
Publications[a]	1	60	13	16	31	23	20	**164**
Data Sets/Databases	10	30	23	2	9	24	39	**137**
Outreach/Communications Products	0	6	11	1	9	0	36	**63**
Models/Software	1	4	6	0	11	0	10	**32**
Maps/Visualization Tools	6	3	3	2	10	3	1	**28**
Websites	2	4	2	1	4	0	4	**17**
Education/Training	1	0	1	0	5	0	9	**16**
Enhanced Monitoring Systems	0	2	6	0	0	0	8	**16**
Procedures/Management Practices	0	0	7	0	1	0	6	**14**
Analyses/Forecasts	0	2	0	0	2	0	0	**4**
Photos/Videos	1	3	0	0	0	0	0	**4**
Total	**31**	**151**	**92**	**36**	**166**	**62**	**192**	**730**

a. The publication count does not include draft publications at the time of project reporting.

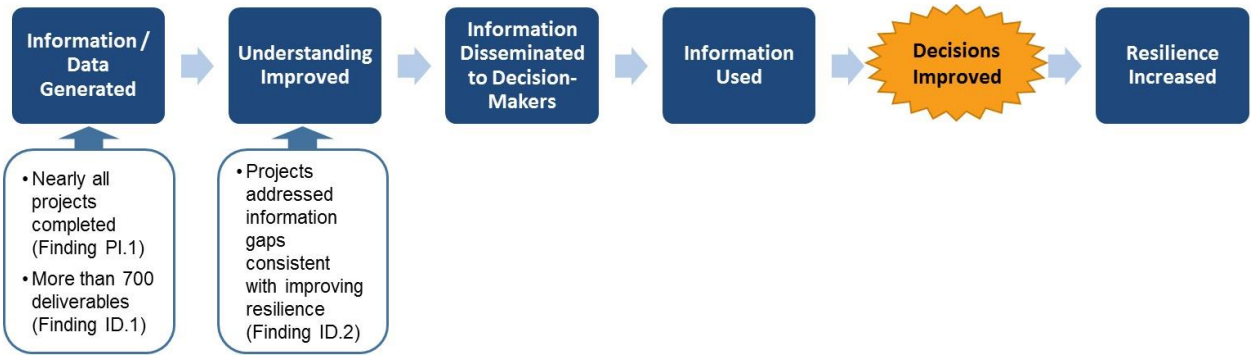
Finding ID.2: Coastal resilience science projects were designed to address key knowledge gaps consistent with the program's focus on improving coastal resilience.

Our examination of archival materials suggests that the types of science projects funded by the Hurricane Sandy Program are consistent with the goal of supporting efforts to improve coastal resilience in the region. For example, the coastal resilience science projects and deliverables address the seven coastal resilience topic areas described in Table 1, and all have the potential to inform resilience decision-making, thereby improving resilience over various time scales. More specifically, the projects are improving the understanding of coastal elevation, storm surge dynamics, storm-related ecosystem vulnerabilities, potential contaminant risks associated with coastal storm damage, and sand resources that can be used to protect natural and human communities. Using information from archival materials, the project lead survey, and interviews, we summarized the key data gaps that these projects are addressing, and describe how project-generated information can improve resilience decision-making (Table 4). Figure 2 shows the relevance of this finding, and previous findings, to the logic model introduced above.

Table 4. How coastal resilience science projects are addressing key data gaps relevant to resilience-related decision-making, by project topic area.

Topic area	Information gap	Relevance to resilience
1. Elevation Data	More extensive, high-quality coastal elevation data	• Improved elevation data will support improved models (e.g., groundwater, hydrologic, sediment transport, and flood inundation). • Improved process models will better inform decisions about flood risk management, infrastructure construction, restoration management, water supply and quality management, agricultural practices, and adaptation to sea level rise and storm surge.
2. Coastal Change	Improved understanding and communication of key coastal vulnerabilities to storms	• Improved data, models, and tools can improve the ability to understand and visualize key coastal vulnerabilities. • Better information about coastal change and vulnerabilities can guide decisions about zoning, building codes, and where and where not to build infrastructure; establish coastal protection structures; nourish beaches and dunes; dredge or modify channels; or restore wetlands.
3. Storm Surge and Hydrology	More comprehensive coastal monitoring, and real-time updates about key meteorological variables and near-shore storm hydrodynamics	• Improved data, models, and tools can improve the ability to identify, in real time, where storm damage is likely to be concentrated. • Better data, models, and tools can inform decisions about emergency response during a storm (e.g., when and where to issue storm and flood warnings, when and where to evacuate, where to position emergency response equipment).
4. Environmental Quality	Improved understanding of storm impacts on human and wildlife exposure to contaminants	• Improved understanding can inform decisions about where water quality monitoring should be concentrated, and where potential wildlife or fishery impacts might be the greatest. • Can also be used to identify projects that would most effectively mitigate the impacts of storms on water quality.
5. Ecosystem Impacts	Improved understanding of key ecosystem and species vulnerabilities to storms and sea level rise	• Better information can inform land use planning, development, tourism, and wildlife conservation and ecosystem restoration actions. • These more informed decisions will mitigate risks to ecosystems from coastal storms and sea level rise, making them more resilient.
6. Sand Resources	More information about the location and composition of off-shore sand resources	• Improved information can guide decisions about where to find compatible sand resources for beach replenishment and re-nourishment projects, which are key to community and ecosystem storm protection in many areas.
7. Coordination and Communication	Enhanced coordination of resilience-related actions	• These projects directly aided in planning and coordinating a variety of decisions, including community development, restoration actions, climate change adaptation, and hazard mitigation.

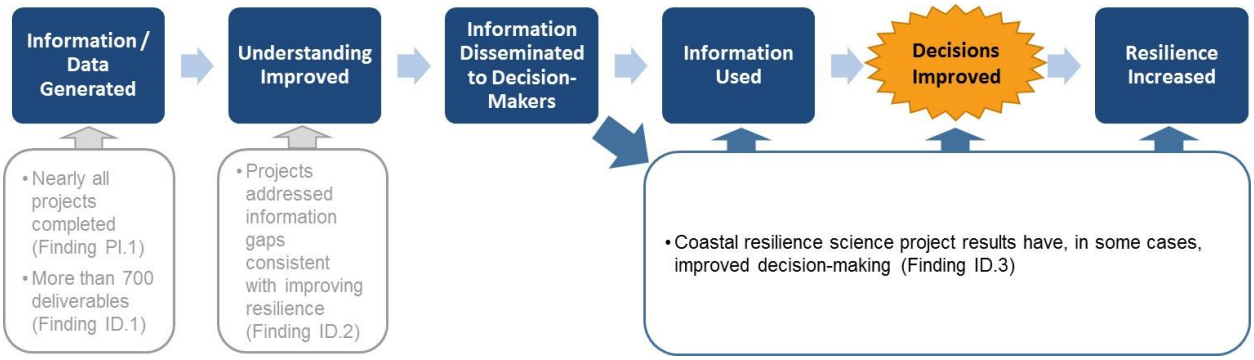
Figure 2. Coastal resilience science projects filled key data gaps and resulted in improved understanding.



Finding ID.3: Coastal resilience science efforts, in some cases, have directly improved resilience-related decision-making.

In some cases, there was evidence in project or media reports, or project lead interviews of the direct application of project data, maps, or tools in important decision-making processes. We share key highlights from relevant projects below in Boxes 1–3, focusing on coastal resilience science project activities, respectively. Figure 3 shows these cases in the context of the logic model introduced above.

Figure 3. Coastal resilience science projects have, in some cases, improved decision-making.



Box 1. Data-focused project activities: Examples of project-generated information used to improve resilience.

The Hurricane Sandy Program supported **expanding an existing USGS monitoring network of sensors** that measure storm tide, waves, and other meteorological parameters (i.e., **Surge**, **Wave, and Tide Hydrodynamics or SWaTH**). More specifically, the project created a virtual "storm-tide center" in the region to improve the number and utility of network sensors. Network ehancements have made storm data more readily available to local emergency responders and the Federal Emergency Management Agency (FEMA), which use these data to inform decisions about road closures, evacuations, and recovery operations. The **SWaTH network was deployed for a nor'easter in January 2016** and during **Hurricane Hermine** to predict where the storm damage would be concentrated.

Figure: SWaTH sensor. Source: USGS.

USFWS supported the creation of the **North Atlantic Aquatic Connectivity Collaborative (NAACC)** – a network of partners in 13 states working to improve road-stream crossings. The NAACC provides a central database of road-stream crossing infrastructure, protocols, and training sessions for infrastructure assessments; and web-based tools for prioritizing upgrades. The creation of the **NAACC led to a collaborative effort among Essex County, The Nature Conservancy (TNC), and the USFWS to replace a problematic culvert** with a design that would **improve both onsite flooding and fish passage**.

Figure: Culvert restoration in North Elba, NY. Source: TNC.

A BOEM project in Massachusetts developed **topographic profiles** and conducted **grain-size analyses** on sediment samples in **18 beaches** that are currently experiencing erosion. Samples were taken during the summer and winter to evaluate seasonal and spatial variability. The information gathered through these activities is being used to **match native-beach material** with compatible **offshore sand resources for potential beach nourishment projects**.

Figure: Sand sampling transect at Humarock Beach, Scituate, MA. Source: BOEM.

Box 2. Mapping-focused project activities: Examples of project-generated information used to improve resilience.

The official **maps of the Coastal Barrier Resources System (CBRS)** were first created more than 35 years ago, having used what are now outdated base maps and cartographic techniques. The **Hurricane Sandy Program supported USFWS in revising these maps** to fix technical mapping errors; add missing areas; and make the data more accessible and user-friendly for public officials, surveyors, real estate agents, developers, and others planning coastal infrastructure projects, habitat conservation efforts, and flood risk mitigation measures. As of February 15, 2019, **FEMA** has **updated its flood insurance rate maps to use the new, dynamically updated digital CBRS boundaries.** The revised boundaries have gone through a period of public review and are being prepared for consideration by Congress to be adopted into law.

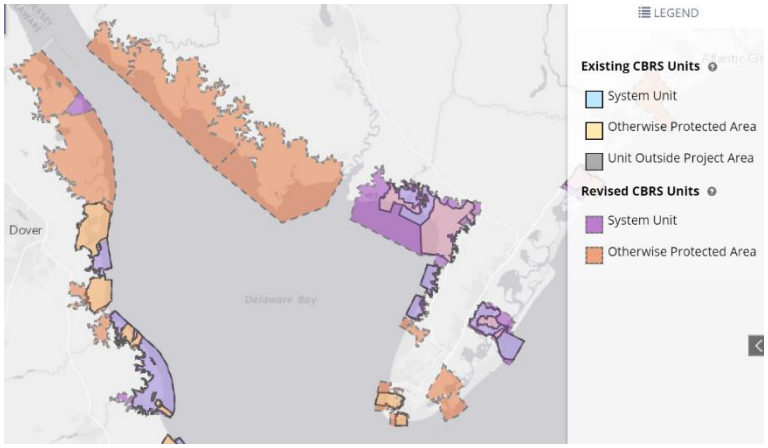


Figure: Example of CBRS map from Delaware Bay. Source: USFWS.

The Hurricane Sandy Program supported the creation of the **Virginia Eastern Shore Coastal Resilience Tool** (https://maps.coastalresilience.org/virginia/), which serves as a resource for understanding key threats to coastal systems and the resilience actions that can reduce vulnerability. The **Accomack-Northampton Planning District Commission** recently **revised its Eastern Shore Hazard Mitigation Plan using this tool**. Rather than solely focusing on historical flood risks, the commission has begun to incorporate future risk of storm surge in concert with rising sea level projections to plan for future hazards due to coastal flooding. The tool has also been **adopted by the Southern Tip Ecological Partnership** to **inform** its **conservation and protection priorities** related to migratory bird habitat and other coastal conservation lands. The tool was also used in the development of the **Chincoteague National Wildlife Refuge/Assateague Island National Seashore Comprehensive Conservation Plan** and Environmental Assessment.

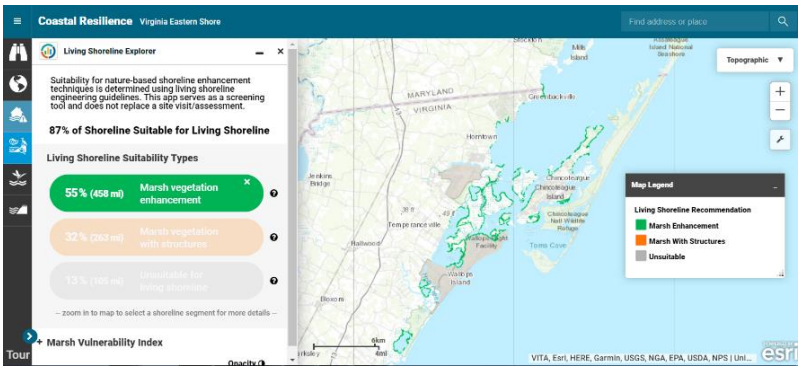


Figure: Screenshot of Virginia Eastern Shore Coastal Resilience Tool.

Box 3. Modeling-focused project activities: Examples of project-generated information used to improve resilience.

Three USGS projects supported the development of the **Coastal National Elevation Database (CoNED)** Topographic and Bathymetric Digital Elevation Model (TBDEM). Data from this model improved a **coastal resilience tool** developed by **TNC** for New Jersey, enabling the state to **support critical decision-making regarding coastal habitat restoration**.

Photo: Staff collect high-resolution elevation data. Source: URI.

USGS developed an online **Coastal Change Hazards Portal (CCHP)** with tools to visualize coastal changes caused by major storms, chronic erosion, and sea level rise for resource managers and others. Real-time applications of the CCHP have included **tracking and predicting coastal impacts of Hurricanes Matthew and Joaquin, Tropical Storm Colin, and severe winter storms (nor'easters) in 2015 and 2016**. "The ability to easily locate and access USGS research and data through the new Coastal Change Hazards Portal is of great value for coastal managers," said Massachusetts Office of Coastal Zone Management Director Bruce Carlisle. "This information directly supports our work with local cities and towns to assess risk and communicate current and future hazards."

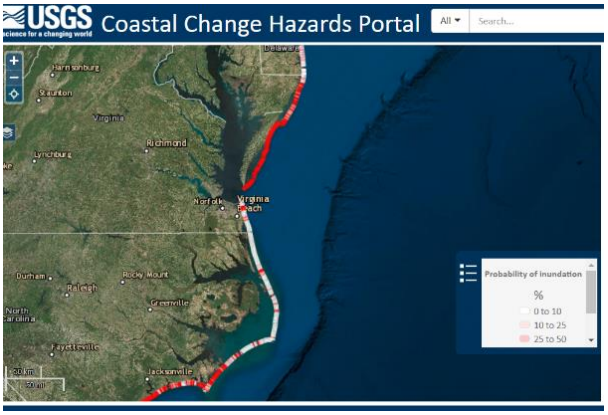
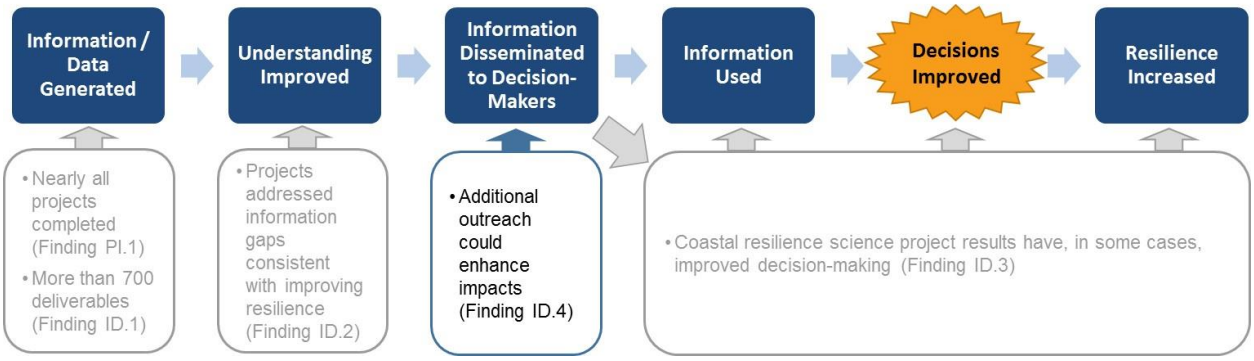


Figure: Screenshot of CCHP used to visualize the likelihood of inundation during a storm. Source: USGS.

Finding ID.4: The ultimate impact of coastal resilience science activities could be enhanced by supporting more outreach to relevant decision-makers.

While projects were generally successful in meeting their goals of developing the datasets, maps, and models that they had proposed and there were some instances of improved decision-making, most projects ended their activities once deliverables had been developed (e.g., reports, manuscripts, presentations). Few projects had integrated plans to reach out to potential users of their data, maps, models, or tools, either during or after project implementation. As a result, even though the research being done has the potential to inform resilience decisions (and is consistent with a given DOI bureau's mission), the products delivered by some projects may not be known by, appropriate for, or accessible to people who will ultimately influence on-the-ground decision-making. Figure 4 shows this finding in the context of the logic model.

Figure 4. Additional outreach could enhance the impacts of coastal resilience science activities.



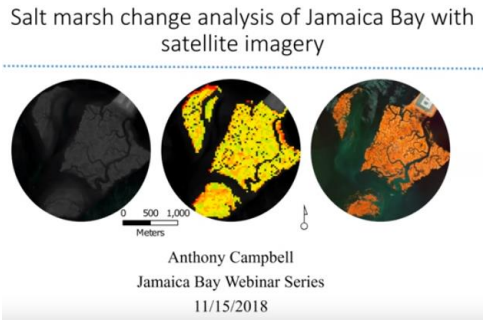
In the survey, several project leads acknowledged that limited outreach was a key challenge in applying the knowledge produced by projects to on-the-ground decision-making. For example, 14% of survey respondents noted that insufficient outreach with decision-makers, the public, or other scientists, was a key factor constraining project success.

This finding is also supported by the data shown in Table 3 shown earlier. The data show that the majority of coastal resilience science project outputs were in the form of presentations (74% of which were to scientific conference or student audiences) and publications, instead of more direct forms of outreach; but there were some outreach and communication products, two of which are included in Box 4.

Box 4. Examples of active decision-maker outreach for coastal resilience science project outputs.

Workshops on the **Greater Baltimore Wilderness Coalition** provided a final summary of the project's work to over 300 local area professionals and staff from agencies and local governments.

Photo: Workshop participants. Source: The Conservation Fund.



A mid-project symposium by the **Science and Resilience Institute at Jamaica Bay** brought together project teams with public agency decision-makers, stakeholders, and researchers. Approximately 70 people attended, including representatives from 6 public agencies, 8 community or environmental nonprofit organizations, and 11 universities.

Figure: Cover slide for a symposium presentation. Source: Science and Resilience Institute.

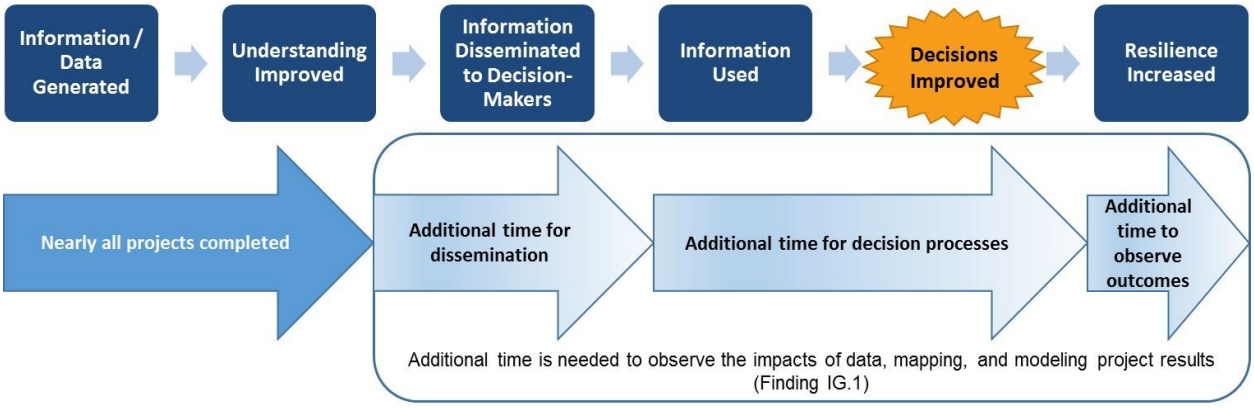
Different factors may have facilitated or accelerated uptake by decision-makers in the cases identified in Finding ID.3. For example, the SWaTH project expanded an existing sensor network and the CBRS project updated existing maps, both of which were already in use by decision-makers. The CCHP project was already underway when the Hurricane Sandy Program funding became available, making it a more mature project from the outset and thus more primed for the project's data uptake. For the NAACC, information sharing was intrinsic to its design, and thus it created a network of individuals from different agencies and organizations that could and were likely to immediately use the project's outputs. A key uptake-related recommendation from the team that created the Virginia Eastern Shore Coastal Resilience Tool was to "designate more time and resources for communicating results….Ratio of model/tool building to communicating/training should be 1:4."

Topic: Information Gaps (IG)

Finding IG.1: More time is needed to observe the uptake of the coastal resilience science products into decision-making processes; depending on the decision, additional time may then be needed to observe the impact on coastal resilience.

As with on-the-ground interventions (e.g., marsh or beach/dune restoration), the direct resilience benefits of coastal resilience science may take time to fully materialize. For example, it may take time for decision-makers to become aware of relevant new scientific knowledge, particularly when direct outreach is limited (see Finding ID.4). It may take even longer for an opportunity to apply that information to policies or specific decisions. For example, information products that enhance the ability to detect and predict storm surge impacts may be utilized very soon after they are created, but products that are designed to inform decisions about long-term investments in coastal restoration (e.g., National Wildlife Refuge Comprehensive Conservation Plans) may take longer to be applied. Furthermore, depending on the specific decision informed (e.g., climate change adaptation plan, restoration of a marsh), more time may be required before resilience impacts of the decision are realized. Therefore, longer-term assessments of the application of coastal resilience science project information are needed to fully understand their resilience-related impacts. Figure 5 shows the additional time needed in the context of the logic model.

Figure 5. Additional time is needed to observe the impacts of coastal resilience science project results in many cases.



5. Conclusion

Hurricane Sandy Program investments in coastal resilience science projects have filled key knowledge gaps and helped to directly improve resilience-related decision-making. These projects have led to notable successes, including an online coastal hazards portal that has already been used to track and predict coastal impacts of multiple hurricanes, tropical storms, and severe winter storms. Overall, these projects were highly productive and generated more than 700 deliverables, including reports, presentations, manuscripts, datasets, maps, and models. However, more time is needed for decision-makers to incorporate the scientific products and information generated through the program into additional decisions beyond the individual examples described in this case study. An issue that may constrain the impact of some of these projects is the limited outreach to decision-makers to raise awareness, and to ensure the suitability and usability of the data and tools being developed.

6. References

Abt Associates. 2019. Evaluation of Hurricane Sandy Coastal Resilience Program. Abt Associates, Rockville, MD.

Buxton, H.T., M.E. Andersen, M.J. Focazio, J.W. Haines, R.A. Hainly, D.J. Hippe, and L.J. Sugarbaker. 2013. Meeting the Science Needs of the Nation in the Wake of Hurricane Sandy – A U.S. Geological Survey Science Plan for Support of Restoration and Recovery. U.S. Geological Survey Circular 1390. Available: https://pubs.usgs.gov/circ/1390/. Accessed 9/2/2019.

Appendix A. Coastal Resilience Science Projects

Exhibit A.1. Coastal resilience science projects supported through the Hurricane Sandy Program. All dollars rounded to the nearest hundred.

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
BOEM-M13AC00012	Ecological function and recovery of biological communities within dredged ridge-swale habitats and in the South-Atlantic bight	FL	University of Florida; Bureau of Ocean Energy Management	$4,300,000	$0
BOEM-M13AC00031	Natural habitat association and the effects of dredging on fish at the Canaveral Shoals, east-central Florida	FL	United States Navy; National Aeronautics and Space Administration; Bureau of Ocean Energy Management	$1,473,000	$0
BOEM-M14AC00001	Sand needs and resources offshore New York	NY	New York Department of State; Bureau of Ocean Energy Management	$400,000	$0
BOEM-M14AC00002	Post Hurricane Sandy offshore New Jersey sand resources investigations	NJ	New Jersey Department of Environmental Protection; Bureau of Ocean Energy Management	$400,000	$60,000
BOEM-M14AC00003	Delaware offshore sand resource investigation	DE	University of Delaware; Bureau of Ocean Energy Management	$200,000	$0
BOEM-M14AC00004	Modernizing the Reconnaissance Offshore Sand Search (ROSS) database and a review and synthesis of existing geophysical data from selected areas on the Outer Continental Shelf (OCS Region) along Florida's central Atlantic Coast	FL	Florida Department of Environmental Protection; Bureau of Ocean Energy Management	$200,000	$0
BOEM-M14AC00005	Geospatial sand resource assessment for Georgia coastal recovery and resiliency	GA	University of Georgia; Bureau of Ocean Energy Management	$200,000	$58,900
BOEM-M14AC00006	Sand resource assessment at critical beaches on the Massachusetts Coast	MA	University of Massachusetts; Bureau of Ocean Energy Management	$199,600	$31,700

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
BOEM-M14AC00007	Conversion of Maryland's offshore mineral resources data for geographic information system applications and baseline acoustic seafloor classifications of offshore borrow areas	MD	Maryland Department of Natural Resources; Bureau of Ocean Energy Management	$199,400	$0
BOEM-M14AC00008 (note, shown as 00013-2 in some sources)	Exploration and habitat classification: Tools for building resiliency in Maine	ME	Maine Department of Agriculture; Bureau of Ocean Energy Management	$195,200	$245,500
BOEM-M14AC00009	Assessing sand resources for North Carolina: inventory, needs assessment and reanalysis for post-Hurricane Sandy recovery and future resilience	NC	East Carolina University; Bureau of Ocean Energy Management	$200,100	$10,000
BOEM-M14AC00010	Assessment of offshore sand and gravel for beach nourishment in New Hampshire	NH	University of New Hampshire; Bureau of Ocean Energy Management	$200,000	$9,300
BOEM-M14AC00011	Identification of sand/gravel resources in Rhode Island waters while working toward a better understanding of storm impacts on sediment budgets	RI	University of Rhode Island; Bureau of Ocean Energy Management	$200,000	$0
BOEM-M14AC00012	South Carolina offshore sand resources: Data inventory, digital data conversion, and needs assessment	SC	South Carolina Department of Natural Resources; Bureau of Ocean Energy Management	$200,000	$195,600
BOEM-M14AC00013-1	Assessment of offshore sand resources for Virginia beachfront restoration	VA	Virginia Department of Mines, Minerals, and Energy; Bureau of Ocean Energy Management	$199,500	$101,100
BOEM-M14PC00006	Geological and geophysical data acquisition: Inventory of potential beach nourishment and coastal restoration sand sources on the Atlantic Outer Continental Shelf	Multi: CT, DE, FL, GA, MA, MD, ME, NC, NH, NJ, NY, RI, SC, VA	CB&I Federal Services LLC; Bureau of Ocean Energy Management	$500,000	$0

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
BOEM-M15PS00030 (in some cases shown as M15PG00005)	Propagation characteristics of high-frequency sounds emitted during high-resolution geophysical surveys: Open water testing	ME	Naval Undersea Warfare Center Division; Bureau of Ocean Energy Management; U.S. Geological Survey	$470,000	$0
NFWF-41931	Developing self-sustaining oyster population in Jamaica Bay, New York	NY	New York City Department of Environmental Protection	$100,000	$37,500
NFWF-42551	Green infrastructure in Accomack and Northampton counties, Virginia	VA	The Nature Conservancy	$1,034,100	$209,000
NFWF-42878	Assessing coastal impoundment vulnerability and resilience in the Northeast	Multi: CT, DE, MA, MD, ME, NH, NJ, NY, RI, VA	New Jersey Audubon Society	$470,000	$170,000
NFWF-43129	Creating green stormwater infrastructure resiliency in Greater Baltimore and Annapolis watersheds, Maryland	MD	The Conservation Fund	$583,600	$222,700
NFWF-43308	Developing a green infrastructure plan and network for the Lafayette River Watershed, Virginia	VA	City of Norfolk	$725,600	$40,200
NFWF-43752	Creating a three dimensional wetland model for the Bombay Hook National Wildlife Refuge, Delaware	DE	University of Delaware	$400,000	$148,500
NFWF-43932	Improving and quantifying wetlands' potential to reduce storm surge impacts, Virginia	VA	George Mason University	$440,000	$93,800
NFWF-44017	Developing Rhode Island's coastal resiliency program	RI	University of Rhode Island	$870,000	$380,700

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
NFWF-44212	Improving Northeast Coast storm-related data interpretation and accessibility	Multi: CT, DC, DE, MA, MD, NH, NJ, NY, OH, PA, RI, VA, WV	Northeastern Regional Association of Coastal and Ocean Observing Systems	$520,000	$133,300
NPS-3-1	Modification to acquisition coordination, compilation, data management and change analysis of LiDAR and other geospatial data collected pre- and post-hurricane (subproject)	Multi: MD, NJ, NY, VA	University of Rhode Island; National Park Service	$565,700	$0
NPS-3-2	Field technician support for elevation mapping of NPS salt marshes and other sites for sea level rise planning and post- and future-storm evaluation (subproject)	Multi: MD, NJ, NY, VA	University of Rhode Island; National Park Service	$768,900	$0
NPS-3-3	Collection of high resolution topographical data and development of metrics associated with superstorm sandy impacts, recovery, and coastal geomorphological resiliency (subproject)	Multi: NJ, NY	Rutgers University; National Park Service	$161,900	$0
NPS-3-4	Tide-telemetry and coastal-flood-warning system Fire Island National Seashore (subproject)	NY	U.S. Geological Survey New York Water Science Center; National Park Service	$84,200	$0
NPS-3-5	Modeling salt marsh condition and resiliency in four National Parks based local sea level rise predictions to assist park managers in understanding local conditions and to develop mitigation strategies (subproject)	Multi: MA, MD, NJ, NY	University of South Carolina; National Park Service	$248,000	$0
NPS-14-1	Detecting water quality regime shifts in Jamaica Bay (subproject)	NY	Brooklyn College (CUNY); National Park Service	$283,000	$0
NPS-14-2	Health and resiliency of salt marshes in Jamaica Bay (subproject)	NY	Stony Brook University; National Park Service	$276,000	$0

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
NPS-14-3	Monitoring and evaluation of restoration and resilience: Jamaica Bay Unit, shoreline and geomorphology (subproject)	NY	Rutgers University; National Park Service	$328,700	$0
NPS-14-4a	Acidification, hypoxia, and algal blooms: Barriers to current and future ecosystem restoration and climate change resilience in Jamaica Bay (subproject)	NY	Stony Brook University; National Park Service	$246,500	$0
NPS-14-4b	Restoration of Jamaica Bay fringing habitats: Post-Sandy status and new approaches for a resilient future (subproject)	NY	Rutgers University; National Park Service	$482,900	$0
NPS-14-5	The Jamaica Bay Observing system: Process studies and groundwork for long-term ecosystem research and resilience (subproject)	NY	Brooklyn College (CUNY); National Park Service	$789,800	$0
NPS-14-6	Coastal adaptation impacts on Jamaica Bay water quality, waves and flooding (subproject)	NY	Stevens Institute of Technology; National Park Service	$700,000	$0
NPS-14-8	Science and Resilience Institute at Jamaica Bay: Coordination of DOI and NPS sandy resilience projects (subproject)	NY	City University of New York; National Park Service	$85,000	$0
NPS-14-9	The environmental history of Jamaica Bay: A foundational monograph (subproject)	NY	City University of New York; National Park Service	$47,000	$0
NPS-35-1	Assessing the response of juvenile and adult hard clams to the new breach in Great South Bay: Post-Hurricane Sandy study (subproject)	NY	Stony Brook University; National Park Service	$98,200	$0
NPS-35-2	Assessing the response of the Great South Bay plankton community to Hurricane Sandy (subproject)	NY	Stony Brook University; National Park Service	$594,100	$0

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
NPS-35-3	Assessing the response of the Great South Bay estuarine fauna to Hurricane Sandy: Focus on nekton utilization of seagrass habitats (subproject)	NY	Stony Brook University; National Park Service	$327,600	$0
NPS-35-4	Effects of storm induced barrier breach on community assemblages and ecosystem structure within a temperate lagoonal estuary (subproject)	NY	Stony Brook University; National Park Service	$150,000	$0
NPS-35-5	Impact of Hurricane Sandy on the Fire Island National Seashore water quality and seagrass resources (subproject)	NY	Stony Brook University; National Park Service	$177,000	$0
NPS-35-6	Assessing the response of indicator bacteria in Great South Bay to Hurricane Sandy (subproject)	NY	Stony Brook University; National Park Service	$50,000	$0
NPS-35-7	Science communication: Hurricane Sandy video project (subproject)	NY	Harpers Ferry Center, National Park Service	$68,600	$0
NPS-35-8	Continuation of post-Hurricane Sandy physical monitoring of the Old Inlet breach, Fire Island National Seashore: Phase two (subproject)	NY	Stony Brook University; National Park Service	$174,800	$0
NPS-49-1	Assess groundwater resources at Assateague Island National Seashore (subproject)	MD	U.S. Geological Survey; National Park Service	$330,000	$0
NPS-49-2	Assess groundwater resources at Fire Island National Seashore (subproject)	NY	U.S. Geological Survey; National Park Service	$212,800	$0
NPS-49-3	Assess groundwater resources at Sandy Hook Unit of Gateway National Recreation Area (subproject)	NJ	U.S. Geological Survey; National Park Service	$460,000	$0
NPS-72-1	Submerged marine habitat mapping, Fire Island National Seashore (subproject)	NY	University of Rhode Island; National Park Service	$865,000	$0
NPS-72-2	Submerged marine habitat mapping, Gateway National Recreation Area (subproject)	NJ	Rutgers University; National Park Service	$810,000	$0

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
NPS-72-3	Submerged marine habitat mapping, Assateague Island National Seashore (subproject)	MD	University of Delaware; National Park Service	$790,000	$0
NPS-72-4	Submerged marine habitat mapping, Cape Cod National Seashore (subproject)	MA	Center for Coastal Studies; National Park Service	$510,000	$0
USFWS-17	Building a predictive model for submerged aquatic vegetation prevalence and salt marsh resiliency in the face of Hurricane Sandy and sea level rise	Multi: CT, DE, MD, NJ, NY, RI, VA	U.S. Fish and Wildlife Service	$216,700	$45,300
USFWS-24	Decision support for Hurricane Sandy restoration and future conservation to increase resiliency of tidal wetland habitats and species in the face of storms and sea level rise	Multi: CT, DE, MA, MD, ME, NH, NJ, NY, RI, VA	U.S. Fish and Wildlife Service	$2,200,000	$1,604,300
USFWS-30	A stronger coast: Three USFWS Region 5 multi-National Wildlife Refuge projects to increase coastal resilience and preparedness	Multi: CT, DE, MA, ME, NJ, NY, RI, VA	U.S. Fish and Wildlife Service	$2,060,000	$1,143,500
USFWS-32	Resilience of the tidal marsh bird community to Hurricane Sandy and assessment of restoration efforts	Multi: CT, DE, MA, MD, NJ, NY, RI, VA	U.S. Fish and Wildlife Service	$1,574,000	$2,050,400
USFWS-63	Collaboratively increasing resiliency and improving standards for culverts and road-stream crossings to future floods while restoring aquatic connectivity	Multi: CT, DE, MA, MD, ME, NH, NJ, NY, PA, RI, VA, VT, WV	Wildlife Management Institute	$1,270,000	$350,000
USFWS-64	Coastal barrier resources system comprehensive map modernization: Supporting coastal resiliency and sustainability following Hurricane Sandy	Multi: CT, DE, MA, MD, NJ, NY, RI, VA	U.S. Fish and Wildlife Service	$5,000,000	$2,000,000

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
USFWS-67	Decision support for Hurricane Sandy restoration and future conservation to increase resiliency of beach habitats and species in the face of storms and sea level rise	Multi: CT, DE, MA, MD, ME, NH, NJ, NY, RI, VA	U.S. Fish and Wildlife Service	$1,750,000	$2,059,500
GS1-1a	Establish a Sandy Region Coastal National Elevation Database (CoNED)	Multi: CT, DE, MA, MD, NC, NJ, NY, PA, RI, VA	U.S. Geological Survey	$550,000	$0
GS1-1b	Topographic surveys (LiDAR) for impact area assessment and reconstruction	Multi: DE, MD, NC, NJ, NY, PA, VA	U.S. Geological Survey; National Oceanic and Atmospheric Organization	$3,100,000	$0
GS1-1c	Delivery systems for hazards, topographic and bathymetric elevation data	Multi: CT, DE, MA, MD, NC, NJ, NY, RI, VA	U.S. Geological Survey; National Oceanic and Atmospheric Organization	$650,000	$0
GS1-2a	Coastal mapping products & impact assessments: Pre- and post-storm mapping of coastal impacts and vulnerability	Multi: CT, DE, MA, MD, NC, NJ, NY, PA, RI, VA; NJ and NY priority	U.S. Geological Survey	$2,075,000	$0
GS1-2b	Impacts to and vulnerability of coastal beaches: Develop coastal impact forecast models	Multi: CT, DE, MA, MD, NC, NJ, NY, PA, RI, VA; NJ and NY priority	U.S. Geological Survey	$1,950,000	$0

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
GS1-2c	Coastal hazards information and decision support portal	Multi: CT, DE, MA, MD, NC, NJ, NY, PA, RI, VA	U.S. Geological Survey	$750,000	$0
GS1-3a	Storm surge response, data collection, and data delivery	Multi: CT, DE, MA, MD, NC, NJ, NY, PA, RI, VA; NJ and NY priority	U.S. Geological Survey	$2,350,000	$0
GS1-3b	Storm tide monitoring networks and data analysis	Multi: CT, DE, MA, MD, NC, NJ, NY, PA, RI, VA; NJ and NY priority	U.S. Geological Survey	$1,400,000	$0
GS1-4a	Ecological contaminant exposures	Multi: NJ, NY	U.S. Geological Survey	$1,700,000	$0
GS1-4b	Human contaminant exposures	Multi: NJ, NY	U.S. Geological Survey	$1,000,000	$0
GS1-5a	Assess storm impact to wetland integrity and stability to assist recovery decisions	Multi: CT, DE, MA, MD, NC, NJ, NY, RI, VA	U.S. Geological Survey	$1,205,000	$0
GS1-5b	Assess storm impact to waterfowl and migratory birds to support conservation	Multi: CT, DE, MA, MD, NC, NJ, NY, RI, VA	U.S. Geological Survey	$730,000	$0
GS1-5c	Assess coast-wide storm impacts to forest habitats in coastal parks and refuges	Multi: MD, NJ, NY, VA	U.S. Geological Survey	$365,000	$0

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
GS1-5d	Develop data-driven models and ecological monitoring networks to support recovery and resilience	Multi: CT, DE, MA, MD, NC, NJ, NY, RI, VA	U.S. Geological Survey	$700,000	$0
GS2-1A	Topographic surveys for priority watershed and ecological assessments	Multi: CT, DE, MA, MD, NC, NJ, NY, RI, VA	U.S. Geological Survey; National Oceanic and Atmospheric Organization	$4,050,000	$0
GS2-2A	Barrier island and estuarine wetland physical change assessment	Multi: DE, MD, NJ, VA	U.S. Geological Survey	$1,350,000	$0
GS2-2B	Linking coastal processes and vulnerability, Fire Island Regional Study	NY	U.S. Geological Survey	$4,800,000	$0
GS2-2C	Coastal vulnerability and resource assessment, Delmarva Peninsula	Multi: DE, MD, NY, VA	U.S. Geological Survey	$4,000,000	$0
GS2-2D	Estuarine response to storm forcing	Multi: DE, MD, NJ, NY, VA	U.S. Geological Survey	$2,200,000	$0
GS2-3A	Enhance storm tide monitoring, data recovery, and data display capabilities	Multi: CT, DE, MA, MD, NC, NJ, NY, RI, VA	U.S. Geological Survey	$2,200,000	$0
GS2-3B	Storm surge science evaluations to improve models, vulnerability assessments, and storm surge predictions	Multi: CT, DE, MA, MD, NC, NJ, NY, RI, VA	U.S. Geological Survey	$1,500,000	$0
GS2-4A	Mapping, measuring, and predicting vulnerability from contaminant hazards from Hurricane Sandy and other storms in the Northeast Coastal zone	Multi: CT, DE, MA, MD, NC, NJ, NY, RI, VA	U.S. Geological Survey	$2,000,000	$0

Project identification number	Project title	Project state	Project lead organization	Award amount	Reported matching funds
				Values represent coastal resilience science activities only[a]	
GS2-5A	Evaluating ecosystem resilience	Multi: CT, DE, MA, NJ, NY, RI, VA	U.S. Geological Survey	$1,240,000	$0
GS2-5D	Forecasting biological vulnerabilities	Multi: CT, DE, MD, NC, NJ, NY, RI, VA	U.S. Geological Survey	$1,025,000	$0

a. Costs in the table do not represent the full cost of the project and may not reflect the total match.