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HEARING ON
FROM GRAY TO GREEN: ADVANCING THE SCIENCE OF NATURE-BASED INFRASTRUCTURE

BEFORE THE
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENVIRONMENT

MARCH 2, 2022

INTRODUCTION

Chairman Sherrill, Ranking Member Bice, and Members of the Subcommittee, thank you for the opportunity to submit this statement for the record and to testify today on advancing the science of nature-based infrastructure. My name is Dr. Steven Thur, and I am the Director of the National Centers for Coastal Ocean Science in the National Oceanic and Atmospheric Administration's National Ocean Service. It is my honor to be here along with my colleagues from the Department of Agriculture and Army Corps of Engineers.

I appreciate the Subcommittee's interest in exploring the long-term benefits of natural and nature-based infrastructure compared to, and in some cases in conjunction with, equivalent gray infrastructure strategies and associated research gaps. My testimony today will highlight natural infrastructure, associated research gaps, and how NOAA science is currently and will continue supporting research on the effective design and use of natural infrastructure to enhance coastal resilience.

The evidence is clear: weather and climate disasters are already devastating our communities and we must better prepare ourselves for the impacts to come. In 2021, there were 20 billion-dollar disasters in the United States, and total damages were approximately $145 billion, the costliest being Hurricane Ida at $75 billion. Along the coast, sea level rise, hurricanes, harmful algal blooms, flooding, and other ocean-related climate risks increasingly threaten people and infrastructure. At the same time, coastal ecosystems that provide natural protection from coastal

flooding and erosion are shrinking and degrading due to coastal development, warming waters, and more.

NOAA is committed to combating these challenges, and one of the tools to do so is natural and nature-based infrastructure. NOAA defines *natural* infrastructure in NOAA Administrative Order (NAO) 216-117: NOAA National Habitat Policy as "healthy ecosystems, including forests, wetlands, floodplains, dune systems, and reefs, which provide multiple benefits to communities, including storm protection through wave attenuation or flood storage capacity and enhanced water services and security." Similarly, NOAA defines *nature-based* infrastructure as "engineered systems where natural features are combined with more hard or structural engineering approaches to create a hybrid system." Whether it is called nature-based infrastructure, nature-based solutions, or green infrastructure, it all refers to the use of natural landscape features to produce economic, environmental, and other benefits.

While traditional hardened infrastructure will remain a key tool in mitigating some risks, solutions that reduce the impacts of coastal hazards require innovative methods and multi-benefit approaches.

NATURAL INFRASTRUCTURE: NOAA'S ROLES

NOAA's National Geodetic Survey is integral in defining and providing access to a consistent, underlying coordinate framework across the Nation – known as the National Spatial Reference System (NSRS). The NSRS defines the foundation for all geospatial datasets that support surveying, mapping, and charting and many activities including construction. Its Continuously Operating Reference Stations (CORS) network is creating a more consistent worldwide spatial reference frame to improve forecasts of global sea level rise and inform coastal infrastructure planning. NOAA's National Water Level Observation Network is the nation's permanent network of stations that allow for monitoring changes in coastal and Great Lakes water levels over time. These foundational data provide the underpinning for ensuring that our built infrastructure, including the natural and nature-based projects, are planned and constructed to withstand current and future environmental conditions.

Other NOAA programs have a variety of roles related to natural infrastructure, such as reviewing, initiating, funding projects, and providing underlying data for decision making. Historically, NOAA has engineered nature-based infrastructure features in the context of habitat restoration and conservation. Reducing storm risks to people and property while protecting and restoring coastal ecosystems are the co-benefits that communities receive when implementing natural and nature-based solutions. For example, NOAA's Office of Habitat Conservation works to restore habitat for coastal and marine species, which also provides natural infrastructure for communities. Habitats like tidal marshes, coral reefs, and seagrass beds provide multiple benefits

to communities which may include storm risk management through wave attenuation or flood storage capacity, and enhanced water services, and habitat for fish, wildlife, and plants.

NOAA's Office of Coastal Management has promoted use of natural infrastructure for both habitat creation and flood risk management as part of the National Coastal Resilience Fund that is administered with the National Fish and Wildlife Foundation and through other programs under the Coastal Zone Management Act and Coral Reef Conservation Act. Additionally, the healthy mangrove forests, seagrass beds, coral reefs, and kelp forests found within NOAA's National Marine Sanctuary System provide risk management from coastal storm surge and wave and tidal impacts among other services such as carbon capture and storage, tourism and recreation, and habitat for economically and culturally important species.

Whether a particular project is described as engineering with nature, green infrastructure, a nature-based solution, a coastal resilience initiative, or habitat restoration is often simply a function of the program from which Federal support came. Certain Federal programs have been created to reduce flood risks to homes, businesses, and public infrastructure. For projects funded by these programs, the primary objective is to help manage the flood risk and, when nature-based features are incorporated, the environmental and recreational aspects are ancillary benefits. Other Federal programs exist to restore our nation's natural resources. For projects funded by these programs, the primary objective may be fisheries production, recovery of threatened and endangered species, or the preservation of a special place for future generations, with the flood risk reduction aspects as ancillary benefits.

The use of nature-based infrastructure offers the potential for scenarios with multiple benefits. For instance, in many situations, it is possible to design nature-based features that are as or more effective than traditionally-engineered "gray" solutions in reducing the flood risk to nearby communities. Both nature-based and traditional solutions may satisfy the requirements of programs designed to reduce such risk. However, nature-based solutions may also enable the same funding to advance multiple objectives holistically such as endangered species recovery, fisheries production, climate adaptation, and/or access for recreational use. Some of these natural infrastructure solutions may involve an increase in the cost of the project relative to what would be strictly necessary for just the flood risk reduction benefits. Such modifications and potential increased expenditures may be a more efficient use of Federal funding overall through design changes to yield the maximum net benefits to society. Single-purpose coastal projects have been the primary approach for the past half-century for water management and environmental programs. For the next half-century, nature-based or green infrastructure projects provide an opportunity to simultaneously address multiple priorities while reducing the unintended, economic, environmental, and other costs sometimes associated with gray infrastructure.

INCREASING CAPACITY

When communities want to incorporate natural infrastructure into their flood mitigation projects, they need help knowing what kind of features are appropriate, and when and where they should be placed for maximum flood risk reduction and ecosystem benefits. NOAA, along with our interagency colleagues, recently released the 2022 Sea Level Rise Technical Report. This report updates sea level rise scenarios out to year 2150, and key findings show that we will see a century of sea level rise in the next 30 years. The report speaks to ongoing impacts to coastal infrastructure and specifically how flood risk will change in the next 30 years if no action is taken.

The application of natural and nature-based features has grown steadily over the past 20 years. Technical advancements in support of natural infrastructure are increasingly the subject of peer-reviewed and other technical literature. By using natural infrastructure such as marshes, dunes, reefs, islands, and mangroves to reduce flood risks to coastal communities, we can also conserve or restore coastal habitats that support commercially important fish, enhancing marine life and provide opportunities for aquaculture.

To that end, NOAA was a partner in producing the *International Guidelines on the use of Natural and Nature-Based Features for Flood Risk Management*. These guidelines represent the international state of the science on conceptualizing, planning, designing, engineering, implementing, and maintaining natural infrastructure - as an alternative to conventional hardened infrastructure - for the purpose of flood and coastal storm risk reduction. The guidelines also identify gaps in scientific and engineering knowledge to focus future actions, investment, and collaboration pertaining to practice, research, and development.

NOAA also offers free training on natural infrastructure, including Nature Based Solutions to Coastal Hazards, Living Shorelines Guidelines, Economic Guidance for Coastal Management Professionals, and Using Economics to Inform Decisions.[1] NOAA is also part of the Network for Engineering With Nature, a community of practice to expand and accelerate natural infrastructure practices in the public and private sectors.

The National Sea Grant College Program engages in the spectrum of natural infrastructure to nature-based solutions including those related to blue carbon; living shorelines; restoration aquaculture; marine debris; water quality and emerging contaminants; water levels, chronic flooding, and sea level rise; ocean acidification; and additional climate and weather impacts and adaptation. By May 2022, New Jersey Sea Grant Consortium will release a Request for Proposals for a competitive research program to examine innovative techniques and the use of

[1] https://coast.noaa.gov/digitalcoast/training/nbs-basics.html, https://www.habitatblueprint.noaa.gov/living-shorelines/, https://coast.noaa.gov/digitalcoast/training/econ-guidance.html

low-impact development and green infrastructure practices for mitigating runoff and pollution impacts on freshwater systems and their downstream environments.

RESEARCH AND RESEARCH NEEDS

One barrier to increased implementation of natural-based approaches to flood management is the lack of data on its value, performance, benefits, and impacts. Even where this data does exist[2], many communities lack the knowledge and capacity to use environmental-economic statistics in benefit cost analysis. Full adoption of these approaches requires robust benefit-cost analysis and guidelines on which approaches are best for various geographies. Federal and state legislation also has a role in promoting nature-based approaches.

NOAA has a growing role in conducting the research and monitoring to provide performance, value and cost-benefit data, often in partnerships with the U.S. Army Corps of Engineers, Department of Transportation, Federal Emergency Management Agency, and other agencies responsible for implementing large scale natural infrastructure and flood risk management projects. This next section articulates the key research needs, what NOAA is doing to address them, and where more work is needed.

1. Assessing Performance

There are perceived uncertainties in the performance and benefits of nature-based infrastructure as compared to conventional hard infrastructure like seawalls and jetties. Indeed, uncertainties in the value, performance, benefits, and impacts of natural infrastructure are often cited as a barrier to implementing natural infrastructure.

Uncertainties in how nature and nature-based infrastructure will evolve and perform over time, and how it performs during storm events, are often cited as barriers to implementing natural versus gray infrastructure. However, there is a similar lack of performance data for gray infrastructure, and we know that, unlike natural infrastructure, gray infrastructure cannot evolve to keep up with sea level rise. To address this research gap NOAA is partnering with Federal and state agencies implementing natural infrastructure strategies to evaluate the less-understood aspects of their effectiveness.

NOAA is working to close a major decision gap surrounding when and how coastal nature-based infrastructure should be used as an alternative to traditional, hardened approaches is due to limited understanding of how these features perform during storm events. In FY 2021, NOAA's National Centers for Coastal Ocean Science's Effects of Sea Level Rise program competitively awarded $2.5 million to evaluate and quantify the ability of natural infrastructure to mitigate the effects of sea level rise and inundation (storm surge, nuisance flooding, and/or wave actions).

[2] https://coast.noaa.gov/digitalcoast/data/marine-economy.html

Two of the new projects, co-funded by the Federal Highway Administration (FHWA), focus on mitigating sea level rise impacts to ports, road, public transportation, and rail infrastructure. Three projects will assess sea level rise vulnerabilities and the efficacy of natural and nature-based features in protecting coasts in Texas and along the East Coast.

The same program includes an Event Response Program component that funds data collection prior to, during, and/or immediately after storm events. Modest funding is available to augment current or prior research to help offset costs of immediate mobilization of response and/or assessment efforts. Specific project activities of interest include pre- and/or post-event monitoring and/or modeling activities.

NOAA's National Coastal Centers for Ocean Science has partnered with FHWA to bring the science of coastal change to the science of planning, maintaining, and reducing the risk of damage to coastal infrastructure in a storm. In a recent funding opportunity–developed by NOAA with input from FHWA–selected projects will investigate the effectiveness of natural or restored coastal habitats and partially engineered designs to enhance coastal resilience and advance our understanding of pavement deterioration.

To better understand how nature-based infrastructure will evolve and perform over time, NOAA's National Centers for Coastal Ocean Science will soon start evaluating how some historical natural infrastructure projects have evolved since their initial construction. This effort will focus on analysis of habitat creation and restoration projects that were implemented more than five years ago, including those for which a post-construction survey was conducted. In our experience, most of these projects may not have extensive associated monitoring data, but comparison of current conditions (e.g., shoreline position, surface topography, vegetative cover) to as-built conditions will allow for an assessment of how the feature has performed over time. In addition, while traditional gray infrastructure systems are often designed to be static and require periodic maintenance and rebuilding, some or many green infrastructure systems may have the ability to grow, including recovering functionality following disturbances, as they develop further through time such as by expansion of the fringing mangroves, accretion of marsh height, or through growth of a reef.

2. Quantifying Ecosystem Benefits

There is limited empirical data quantifying the benefits of restored marshes beyond their primary purpose of flood risk management, despite common assumptions that these marshes also provide habitat, carbon sequestration, and other ecosystem benefits. To support that data collection, NOAA's National Centers for Coastal Ocean Science entered into an Interagency Agreement with the U.S. Army Corps of Engineers. Under that agreement, the National Centers for Coastal Ocean Science is monitoring newly installed U.S. Army Corps of Engineers projects, collecting empirical data on long-term effectiveness of nature-based features in improving ecosystem

services. NOAA also is conducting research on carbon sequestration in a variety of coastal habitats, and funding blue carbon valuation studies. For example, NOAA's National Estuarine Research Reserve System Science Collaborative, which supports user-driven, collaborative research in the Reserve System, is funding a feasibility study for Pacific Northwest blue carbon finance project, which demonstrated the feasibility of including carbon finance, i.e., placing a financial value on carbon emissions and credits, in funding strategies that support the conservation and restoration of tidal wetlands, eelgrasses, and coastal lowland sea level rise buffer areas in the Pacific Northwest. The project advanced local stakeholders' understanding of next steps for blue carbon management and financing opportunities for land management actions in coastal communities.

NOAA works with our partners at the national, state, and international level to foster the integration of blue carbon in greenhouse gas inventories. NOAA's Climate Program Office, supported by NOAA's Marine Protected Areas Center, leads the recently established NOAA Blue Carbon Inventory Project, harnessing the expertise of multiple U.S. agencies and partners to advance the development of tools, approaches and capacity for integrating coastal blue carbon in the preparation of greenhouse gas inventories and develop productive connections to coastal resilience in select developing countries.

3. Social Science: Valuing Flood Protection Benefits and Addressing Public Perception

NOAA is actively working to provide more information for coastal decision-makers to understand and quantify the benefits and costs of natural and nature-based infrastructure.

New research is starting to put a dollar value on the risk management benefits provided by natural infrastructure. For example, NOAA, the United States Geological Survey, and University of California Santa Cruz surveyed Puerto Rico and Florida's coral reefs after Hurricanes Irma and Maria. They calculated that damage to natural coral reefs increased future coastal flood risk by more than $180 million annually.[3] That flood risk will grow as reefs continue to degrade. Indeed, by 2100, the size of the 100-year floodplain in Florida is projected to increase by 16% and flood risk will increase by $1 billion every year (in 2021 dollars) from reef loss alone.[4] Conversely, restoring these reefs could help to avoid over $270 million in flood damages *every year*.

Additional resources include the Guide to Assessing Green Infrastructure Costs and Benefits for Flood Reduction and Nature-Based Solutions: Benefits, Costs, and Economic Assessments.[5] The Digital Coast also includes resources from partner organizations, such as the Bluevalue.org

[3] https://doi.org/10.3133/ofr20211056
[4] https://doi.org/10.3133/ofr20211055
[5] https://coast.noaa.gov/digitalcoast/training/gi-cost-benefit.html, https://coast.noaa.gov/digitalcoast/training/gi-practices-and-benefits.html

database, which contains benefits and costs of various ecosystem services evaluated through case studies and organized by nature-based solution type.

Understanding and addressing perception about the effectiveness of nature-based solutions is needed in parallel with valuation studies. As green infrastructure has been used less commonly than traditionally engineered coastal projects in recent decades, there is sometimes hesitancy to use nature-based solutions because they are less familiar. Social science research, including that associated with perceptions of and attitudes about nature-based features, is a current gap that may help decision-makers to effectively communicate and overcome such hesitancy.

CONCLUSION

Nature-based solutions have a significant role to play in infrastructure systems. Our national discussion on infrastructure investment must incorporate the elements of sustainability, to provide fully for the health, welfare, economic vitality, and socially just climate resilience of our coastal communities. NOAA will continue to conduct and support natural infrastructure research, and projects, as well as work with our federal and non-federal partners to support natural infrastructure activities and efforts. However, there are additional gaps to fill, needs to address, and partnerships to enhance as we work to sustain and support our coastal communities.

From NOAA's perspective, an exclusively gray infrastructure approach is not an appropriate option. We want to sustain and provide equitable access to our coasts, beaches, and estuaries. An approach that relies only on traditional engineering and gray infrastructure would undermine those efforts.

Thinking beyond short-term solutions offers opportunities for social and economic improvements over the medium-and longer-terms as communities build the necessary resilience to climate change while improving social justice and quality of life.

Steven Thur, Ph.D.

Dr. Steven Thur's career with the National Oceanic and Atmospheric Administration (NOAA) has focused on applying science to the management, restoration, and conservation of marine resources. He has a particular emphasis on how both the biophysical and social sciences are used to sustain coastal ecosystems and the vibrant human communities that depend upon them for livelihoods, recreation, and as a place for connecting with nature.

Since 2017, Dr. Thur has been the Director of NOAA's National Centers for Coastal Ocean Science (NCCOS) and was the NCCOS Deputy Director from 2013 to 2017. NCCOS's mission is to deliver ecosystem science solutions for stewardship of the nation's ocean and coastal resources to sustain thriving coastal communities and economies. Dr. Thur oversees the work of approximately 270 staff in ten states and the operations of four marine laboratories with an annual budget of $70 to $80 million. NCCOS's priority research areas include marine spatial ecology, environmental stressors and their impacts, ecological forecasting, climate change's effects along our coasts, and social science.

From 2007 to 2013, Dr. Thur was the Coordinator of NOAA's Coral Reef Conservation Program (CRCP). The CRCP is the nation's premier coral reef science program, dedicating its $26 to $30 million annual budget to studying and providing management support for the nation's imperiled but vitally important coral ecosystems. Dr. Thur oversaw the development of the National Coral Reef Monitoring Program, the first nationwide effort that combined physical, biological, and human community monitoring in an integrated manner. He also served as the Co-Chair of the Steering Committee for the interagency, intergovernmental U.S. Coral Reef Task Force.

From 2003 to 2007, Dr. Thur was an Economist for the NOAA Office of Response and Restoration. He worked on natural resource damage assessments following oil spills, chemical releases, and vessel groundings with the goal of recovering funds from those responsible to restore the injured natural resources.

Dr. Thur is a graduate of NOAA's Leadership Competencies Development Program. As part of that program, he had short-term assignments as the Deputy Director of the NOAA Office of Sustainable Fisheries, Deputy Director of the NOAA Beaufort Lab in coastal North Carolina, and with the Florida Keys National Marine Sanctuary in Key West.

Steve received his Ph.D. in marine policy from the University of Delaware's Graduate College of Marine Studies in 2003. His dissertation research was on sustainable financing mechanisms for coral reef marine protected areas. He holds Bachelor's degrees in biology and economics from St. Mary's College of Maryland.