



September 2016

CLIMATE CHANGE

Information on NOAA's Support for States' Marine Coastal Ecosystem Resilience Efforts

Accessible Version

GAO Highlights

Highlights of [GAO-16-834](#), a report to congressional requesters

Why GAO Did This Study

Coastal areas—home to over half of the U.S. population—are increasingly vulnerable to catastrophic damage from floods and other extreme weather events that are expected to become more common and intense, according to the 2014 Third National Climate Assessment. This assessment further indicated that less acute effects from changes in the climate, including sea level rise, could also have significant long-term impacts on the people and property along coastal states. Marine coastal ecosystems—including wetlands and marshes—can play an important role in strengthening coastal communities' resilience to the impacts of climate change, such as protecting eroding shorelines from sea level rise. Under the CZMA, NOAA is responsible for administering a federal-state partnership that encourages states to balance development with the protection of coastal areas in exchange for federal financial assistance and other incentives.

GAO was asked to review federal efforts to adapt to potential climate change effects on coastal ecosystems. This report provides information about NOAA's actions to support states' efforts to make marine coastal ecosystems more resilient to the impacts of climate change and states' views of those actions. GAO reviewed the CZMA and relevant NOAA policies and guidance; interviewed officials from NOAA headquarters and six regional offices; and conducted structured interviews with officials from the 25 state coastal zone management programs in all 23 marine coastal states.

NOAA provided technical comments on this report.

View [GAO-16-834](#). For more information, contact Anne-Marie Fennell at (202) 512-3841 or fennella@gao.gov.

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What GAO Found

The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) is taking a variety of actions to support states' efforts to make their marine coastal ecosystems more resilient to climate change, and states generally view NOAA's actions as positive steps. The Coastal Zone Management Act (CZMA) provides a foundation for managing these ecosystems and partnering with states to work towards the agency's goals of achieving resilient coastal communities and healthy coastal ecosystems, according to NOAA officials. Through the federal-state partnership established under the CZMA, GAO found that NOAA has taken actions, including:

- **Financial incentives.** NOAA has targeted some of its financial incentives for activities aimed at addressing the impacts of climate change. For example, NOAA designated coastal hazards—physical threats to life and property, such as sea level rise—as the focus of CZMA competitive grants. States competed for a total of \$1.5 million in grants in fiscal year 2016. Officials from all 25 state programs that GAO interviewed said funding provided by NOAA has been critical for planning projects related to ecosystem resilience, but also expressed concern that the amount of funding is insufficient to address states' needs in implementing projects. For instance, officials from 15 state programs further indicated that coastal zone management grants have been a primary source of funding from NOAA, but that they generally cannot be used to purchase land or for construction projects, activities states identified as important for improving coastal resilience.
- **Technical assistance.** NOAA has provided assistance largely through technical information, guidance, and training to help states better understand and address the potential impacts of climate change on marine coastal ecosystems. For example, NOAA helped develop an interactive digital tool to simulate different sea level rise scenarios. NOAA also developed guidance to help identify ways ecosystems may be used to enhance the resilience of coastal areas, such as using natural shorelines to buffer the effects of erosion. In addition, NOAA developed training on topics such as assessing the vulnerability of coastal areas. State managers GAO interviewed had generally positive views of the technical assistance provided by NOAA. For example, officials from all 25 state programs said that the technical information NOAA provides has generally helped them incorporate climate information into their state programs.
- **National Estuarine Research Reserve System.** NOAA, in partnership with coastal states, manages 25 marine-based estuary reserves, in part, to study natural and man-made changes to estuaries (bodies of water usually found where rivers meet the sea), including the potential impacts of climate change. For example, in 2014, one state used its research reserve to study and map marsh migration patterns across the state's coastline to determine how these ecosystems may respond to rising sea levels. Officials from 19 of the 25 state programs said that work carried out through the research reserves plays an important role in furthering their understanding of how climate change may affect the structure and function of estuarine ecosystems.

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Abbreviations

NOAA National Oceanic and Atmospheric Administration
CZMA Coastal Zone Management Act

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September 28, 2016

The Honorable Sheldon Whitehouse
Ranking Member
Subcommittee on Fisheries, Water, and Wildlife
Committee on Environment and Public Works
United States Senate

The Honorable Robert Menendez
United States Senate

The Honorable Jeff Merkley
United States Senate

Coastal areas are home to more than half of our nation’s population and contribute more than \$6.6 trillion to the annual U.S. gross domestic product. Coastal areas are increasingly vulnerable to catastrophic damage from floods, drought, and other extreme weather events that are expected to become more common and intense as a result of climate change, according to the U.S. Global Change Research Program’s 2014 Third National Climate Assessment.¹ This assessment further indicated that less acute effects from changes in the climate, including sea level rise, could also have significant long-term impacts on the people and property along marine coastal states. In 2013, we concluded that the increasing number and severity of weather-related events are a key source of fiscal exposure for the federal government.² For example, in 2013, Congress appropriated about \$50 billion for expenses related to the consequences of Superstorm Sandy, which caused significant damage to hundreds of thousands of homes and properties in mid-Atlantic and

¹Jerry M. Melillo, Terese (T.C.) Richmond, and Gary W. Yohe, eds., *Climate Change Impacts in the United States: The Third National Climate Assessment*, U.S. Global Change Research Program (Washington, D.C.: 2014).

²The term fiscal exposure refers to the responsibilities, programs, and activities that may either legally commit the federal government to future spending or create the expectation for future spending. See *GAO Fiscal Exposures: Improving Cost Recognition in the Federal Budget*, [GAO-14-28](#) (Washington, D.C.: Oct. 29, 2013). See also [GAO’s Federal Fiscal Outlook webpage](#).

northeastern coastal states.³ Limiting the federal government’s fiscal exposure by better managing climate change risks has been on our high risk list since 2013, in part, because of concerns about the increasing costs of disaster response and recovery efforts.⁴

Coastal ecosystems provide a variety of environmental and economic benefits, including protecting shorelines from erosion and inundation, reducing flood and storm damage, providing habitat for commercially and recreationally important species, and offering opportunities for recreation and commerce. Marine coastal ecosystems—including wetlands, marshes, and mangroves—can also play an important role in strengthening coastal communities’ resilience to the impacts of climate change. Recognizing this role, in October 2014, the Executive Office of the President released the *Priority Agenda: Enhancing the Climate Resilience of America’s Natural Resources*, which identified enhancing ecosystem resilience, among other things, as a national priority for federal agencies in managing the effects of climate change.⁵ The priority agenda defined “resilience” as the ability to anticipate, prepare for, and adapt to changing conditions and withstand, respond to, and recover rapidly from disruptions.⁶

Enhancing resilience also means reducing potential future losses rather than waiting for an event to occur and paying for recovery afterward, as we found in 2013.⁷ Enhancing resilience may create additional up-front costs, but it may also reduce potential future damages from climate-

³See GAO, *Hurricane Sandy: An Investment Strategy Could Help the Federal Government Enhance National Resilience for Future Disasters*, [GAO-15-515](#) (Washington, D.C.: July 30, 2015).

⁴Limiting the Federal Government’s Fiscal Exposure by Better Managing Climate Change Risks in GAO, *High Risk Series: An Update*, [GAO-13-283](#) (Washington, D.C.: Feb. 14, 2013).

⁵Executive Office of the President, Council on Climate Preparedness and Resilience, *Priority Agenda: Enhancing the Climate Resilience of America’s Natural Resources* (Washington, D.C.: October 2014).

⁶This definition was also used in Executive Order 13653, *Preparing the United States for the Impacts of Climate Change* (Washington, D.C.: November 2013).

⁷GAO, *Climate Change: Future Federal Adaptation Efforts Could Better Support Local Infrastructure Decision Makers*, [GAO-13-242](#) (Washington, D.C.: Apr. 12, 2013).

related events that could otherwise constrain federal programs. As stated in a 2010 National Research Council report, increasing the nation's ability to respond to a changing climate can be viewed as an insurance policy against climate change risks.⁸

The Department of Commerce's National Oceanic and Atmospheric Administration (NOAA) plays a key role in federal efforts to make marine coastal ecosystems more resilient in the face of a changing climate. NOAA's Office for Coastal Management has identified resilient coastal communities and healthy coastal ecosystems as goals in its strategic plan, in line with NOAA's overall vision for resilient communities, economies, and ecosystems.⁹ The Office for Coastal Management works toward these goals in part through its administration of the Coastal Zone Management Act, as amended (CZMA). The CZMA created a voluntary federal-state partnership, known as the National Coastal Zone Management Program, to balance the often competing demands for economic growth and development with the need to protect coastal resources.¹⁰ As of the date of this report, 22 of 23 marine coastal states are participating in the National Coastal Zone Management Program.¹¹

You asked us to review federal efforts to adapt to the observed and projected effects of climate change on coastal ecosystems. This report provides information about actions NOAA is taking with its CZMA authority to support states' efforts to make marine coastal ecosystems more resilient to the impacts of climate change and states' views of those actions.

⁸National Research Council, Panel on Adapting to the Impacts of Climate Change, *America's Climate Choices: Adapting to the Impacts of Climate Change* (Washington, D.C.: 2010). The National Research Council is now known as the National Academies of Sciences, Engineering, and Medicine.

⁹NOAA's overall vision is outlined in *NOAA's Next-Generation Strategic Plan* (Washington, D.C.: December 2010).

¹⁰Pub. L. No. 92-583, 86 Stat. 1280 (1972) (codified as amended at 16 U.S.C. §§ 1451-1466).

¹¹Alaska does not currently participate in the National Coastal Zone Management Program. Program participants also include 5 U.S. territories and the 7 states along the Great Lakes, for a total of 34 participants.

To conduct our work, we reviewed the CZMA; NOAA policies, strategic plans, and other guidance on the National Coastal Zone Management Program; and scientific studies and other documentation on climate change and ecosystem resilience. We reviewed documentation from and conducted interviews with NOAA officials in the Office for Coastal Management from its headquarters and six regional offices (the Mid-Atlantic, Northeast, Southeast, Gulf Coast, Pacific Island, and West Coast) about actions they are taking to support states' efforts to make marine coastal ecosystems more resilient to the impacts of climate change.¹² We interviewed officials from all 25 state coastal zone management programs in the 23 marine coastal states.¹³ Specifically, we conducted structured interviews with state coastal zone managers, and others who have responsibility for overseeing aspects of their states' coastal zone management programs, about actions NOAA is taking to support their efforts to enhance ecosystem resilience in light of a changing climate.¹⁴ We analyzed state responses and reviewed associated documentation to identify common themes and summarize states' views on NOAA's actions. In addition, to better understand how NOAA works on coastal resilience issues across its various offices and programs, we interviewed officials from NOAA's Office of Oceanic and Atmospheric Research and National Marine Fisheries Service. To obtain broader perspectives on coastal resilience issues, we identified (through our interviews and review of documentation) and interviewed representatives from a nongeneralizable sample of stakeholders selected to represent a variety of local, state, and national organizations, including the Coastal States Organization, National Association of Counties,

¹²We focused our review specifically on marine coastal ecosystems (and the corresponding 23 marine coastal states) because through our research we found that marine coastal ecosystems are uniquely sensitive to small changes in the environment and face threats unique to the marine environment, such as sea level rise. See Melillo, Richmond, and Yohe, *Third National Climate Assessment*.

¹³Though not participating in the National Coastal Zone Management Program, Alaska maintains a state coastal program. In interviewing Alaska state officials, we determined that NOAA provides technical assistance and guidance to the state, and we therefore included Alaska officials' responses in our analysis of states' responses. Additionally, California has three distinct coastal zone management programs. We interviewed state officials from these three programs separately and analyzed their responses separately, which brings the total number of state programs to 25.

¹⁴In this report, we use the term "state coastal zone managers" to refer generally to state officials with responsibilities for administering their states' coastal zone management programs.

National Wildlife Federation, The Nature Conservancy, and Georgetown Climate Center.¹⁵

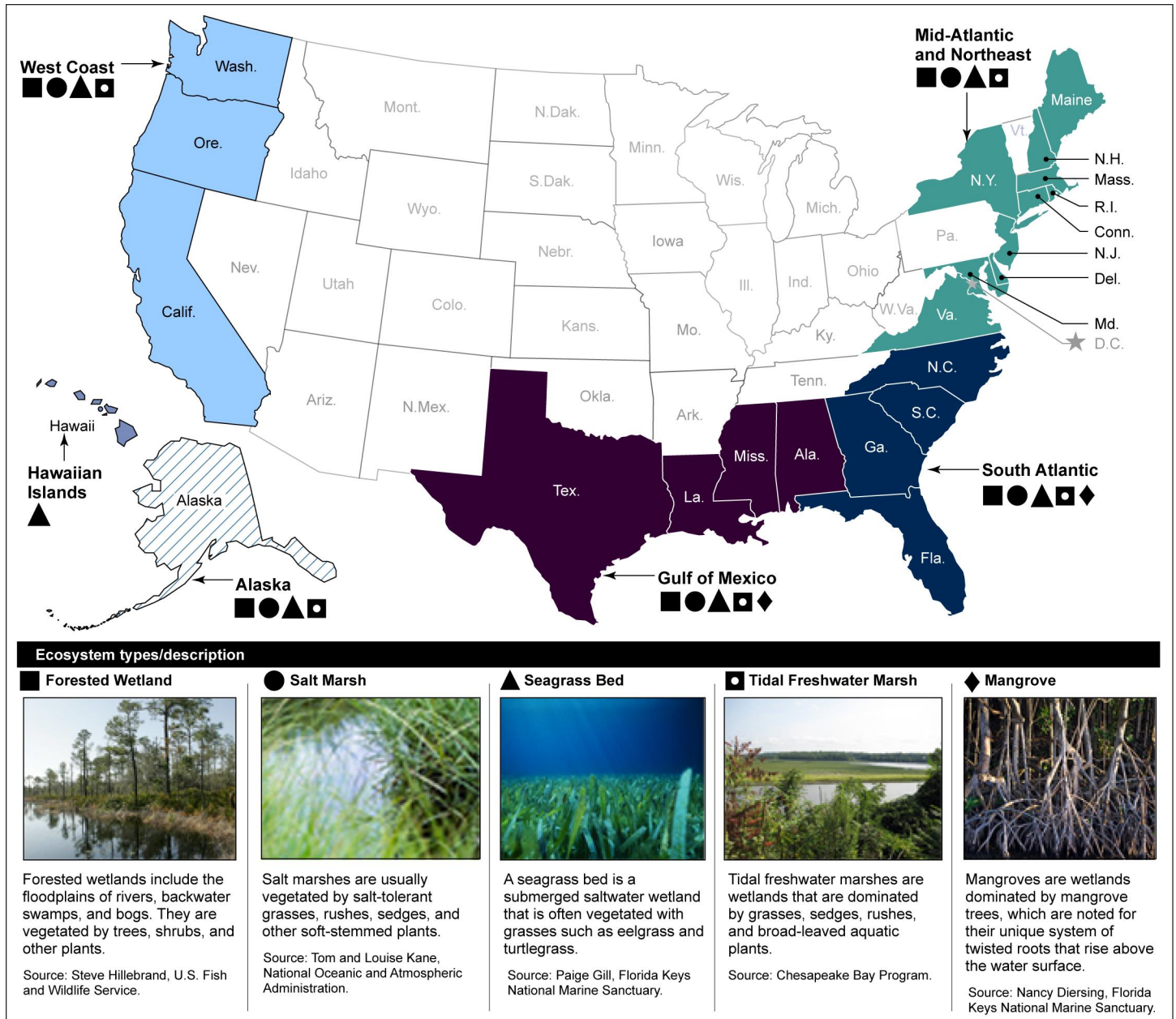
We conducted this performance audit from November 2014 to September 2016 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

Approximately 88,000 miles in length, the nation's marine coastline is composed of a variety of coastal ecosystem types (see fig. 1). The potential effects of climate change on these ecosystems are complex and often difficult to predict, according to the 2014 National Climate Assessment. For example, climate scientists have indicated high confidence that climate change will increase the frequency and intensity of coastal storms, but the exact location and timing of these events is unknown. Similarly, the effects of sea level rise are expected to vary considerably from region to region and over a range of temporal scales, according to the assessment.

¹⁵The information and perspectives we obtained from these interviews provide illustrative examples and are not generalizable to other groups.

Figure 1: Predominant Marine Coastal Ecosystem Types Across Geographic Regions of the United States



Sources: GAO (analysis); National Oceanic and Atmospheric Administration, U.S. Department of Commerce (data); Map Resources (image). | GAO-16-834

The 2014 National Climate Assessment further indicated that marine coastal ecosystems are dynamic and sensitive to small changes in the environment, including warming air and ocean temperatures and sea-level rise. Climate change may cause shifts in species' distributions and ranges along coasts that may impact ecosystem character and functioning, according to the assessment. For example, eel grass, one type of submerged vegetation that provides coastal protection from storm surges, may die if water temperatures exceed its maximum tolerance level. Ecosystems along the coast are also vulnerable to climate change because many have been altered by human stresses, and climate change will likely result in further reduction or loss of the services that these ecosystems provide, according to the assessment.

The federal government has a limited role in project-level planning central to helping increase the resiliency of marine coastal ecosystems to climate change because state and local governments are primarily responsible for managing their coastlines. However, the federal government plays a critical role in supporting state government efforts to increase resiliency to climate change, according to the President's State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience. The federal role includes ensuring that federal policies and programs factor in potential risks from climate change, providing financial incentives for enhancing resilience, and providing information and assistance to help states and others better understand and prepare for climate risks.¹⁶

NOAA, as a key federal agency whose mission is, in part, to manage and conserve marine coastal ecosystems, has identified enhancing ecosystem resilience as an important part of its broader goal of building community resilience.¹⁷ NOAA works toward this goal, in part, through its administration of the CZMA. Specifically, NOAA's Office for Coastal Management administers the National Coastal Zone Management Program.¹⁸ To participate, states are to submit comprehensive

¹⁶The President's State, Local, and Tribal Leaders Task Force on Climate Preparedness and Resilience, *Recommendations to the President* (Washington, D.C.: November 2014).

¹⁷Several other federal agencies also play a role in managing and conserving marine coastal ecosystems, including the Environmental Protection Agency, the Department of Defense (including the U.S. Army Corps of Engineers), and the Department of the Interior.

¹⁸See GAO, *Coastal Zone Management: Opportunities Exist for NOAA to Enhance Its Use of Performance Information*, [GAO-14-592](#) (Washington, D.C.: July 16, 2014).

descriptions of their coastal zone management programs—approved by states’ governors—to NOAA for review and approval. As specified in the act, states are to meet the following requirements, among others, to receive NOAA’s approval for their state programs:

- designate coastal zone boundaries that will be subject to state management;
- define what constitutes permissible land and water use in coastal zones;
- propose an organizational structure for implementing the state program, including the responsibilities of and relationships among local, state, regional, and interstate agencies; and
- demonstrate sufficient legal authorities for the management of the coastal zone in accordance with the program, which includes administering land and water use regulations to control development to ensure compliance with the program and resolve conflicts among competing uses in coastal zones.

The act provides the states flexibility to design programs that best address states’ unique coastal challenges, laws, and regulations, and participating states have taken various approaches to developing and carrying out their programs. States’ specific activities also vary, with some states focusing on permitting, mitigation, and enforcement activities, and other states focusing on providing technical and financial assistance to local governments and nonprofits for local coastal protection and management projects. If states make changes to their programs, such as changes to their coastal zone boundaries, enforceable policies, or organizational structures, states are to submit those changes to NOAA for review and approval. NOAA officials are responsible for, among other things, approving state programs and any program changes; administering federal funding to the states; and providing technical assistance to states, such as on the development of 5-year coastal zone enhancement assessment and strategy reports that identify states’ priority needs and projects.

One primary incentive to encourage states to develop coastal zone management programs and participate in the National Coastal Zone Management Program is states’ eligibility to receive federal grants from NOAA to support the implementation and management of their programs. Specifically, NOAA provides two primary types of National Coastal Zone Management Program grants to participating states:

-
- Coastal zone management grants support the administration and management of state programs and require states to match federal contributions.¹⁹
 - Coastal zone enhancement grants support improvements in state programs in specified enhancement areas.²⁰ Coastal zone enhancement grants do not require state matching funds and include both formula and competitive grants for projects of special merit. To be eligible for coastal zone enhancement grants, state coastal zone management programs are to develop an assessment of each of nine enhancement areas for their state every 5 years, including those areas that are a priority for the state. In conjunction with the assessment, state programs are to also develop a strategy for addressing the high priority needs for program enhancement within one or more enhancement area(s).²¹ NOAA reviews and approves this “assessment and strategy” document for each state and, if approved, states are eligible for formula grants and may also apply annually for competitive grants.

In fiscal year 2016, a total of almost \$50 million was allocated to the 22 participating marine coastal states for these two types of grants.²² By statute, a maximum of \$10 million of the amount appropriated for CZMA management grants may be used for the coastal zone enhancement formula and competitive grants. States received a maximum of approximately \$0.9 to \$2.7 million per state for the two types of grants

¹⁹Coastal zone management grants are authorized by sections 306 and 306A of the CZMA. Section 306 grants support costs such as the cost of personnel, equipment, supplies and overhead, and feasibility studies and preliminary engineering reports. Section 306A grants are resource management improvement grants that can be used for specific purposes, such as land acquisition, certain low-cost construction projects, and establishment of shoreline stabilization measures.

²⁰Coastal zone enhancement grants are authorized by section 309 of the CZMA.

²¹The nine enhancement areas are wetlands protection, restoration, or enhancement; reducing and managing coastal hazards; increased public access to the coast; reduction of marine debris along the coast; control of cumulative and secondary impacts of development; special area management planning and implementation; planning for the use of ocean and Great Lakes resources; facilitating the siting of energy and government facilities and related activities; and facilitating siting of aquaculture facilities.

²²States may also contribute funds for their state coastal zone management programs, in addition to the matching funds required for the coastal zone management grants. We did not collect information on states' contributions to their programs.

under the National Coastal Zone Management Program in fiscal year 2016. In addition, the CZMA authorizes NOAA to provide technical assistance, including by entering into financial agreements, to support the development and implementation of state coastal zone management program enhancements.

The CZMA also established the National Estuarine Research Reserve System—a network of 28 coastal estuary reserves (25 of which are located in marine coastal states) managed through a state-federal partnership between NOAA and coastal states.²³ NOAA provides financial assistance, coordination, national guidance for program implementation, and technical assistance, and coastal states are responsible for managing reserve resources and staff, providing matching funds, and implementing programs locally.²⁴ The reserve system was established on the principle that long-term protection of representative estuaries provides stable platforms for research and education and the application of management practices that will benefit the nation's estuaries and coasts, according to its 2011-16 strategic plan.²⁵

State coastal zone managers may take various actions to manage marine coastal ecosystems and help increase their resilience to the potential effects of climate change. For example, managers may target land acquisition and conservation activities to areas of higher ground adjacent to coastal wetlands, mangroves, and other natural habitats to allow the habitats to migrate so they do not disappear if sea levels rise. In addition, state coastal zone managers may remove physical barriers, such as concrete structures, that prevent beach migration over time in favor of installing living shorelines along areas with a low impact from waves. Living shorelines are natural habitats, or a combination of natural habitat and manmade elements, put in place along coastal shorelines to reduce

²³Estuaries and their surrounding wetlands are bodies of water usually found where rivers meet the sea. Estuaries are home to unique plant and animal communities that have adapted to brackish water—a mixture of fresh water draining from the land and salty seawater.

²⁴In fiscal year 2016, NOAA allocated about \$23 million to support operations under the National Estuarine Research Reserve System.

²⁵NOAA, National Estuarine Research Reserve System Strategic Plan 2011-2016 (Silver Spring, MD: 2010).

shoreline erosion. Management decisions about what actions may be appropriate for a specific area often depend upon detailed information about the current and expected future conditions of the area in question, such as shoreline elevation data, expected rates of sea level rise, and how the ecosystem may be expected to respond to future environmental changes. As we concluded in our 2009 report on climate change and strategic federal planning, new approaches may be needed to match new realities, and old ways of doing business—such as making decisions based on the assumed continuation of past climate conditions—may not work in a world affected by climate change.²⁶

NOAA Is Taking a Variety of Actions to Support States' Efforts to Enhance Marine Coastal Ecosystem Resilience, and States Have Generally Positive Views of NOAA's Actions

NOAA is taking a variety of actions under the CZMA to support states' efforts to make their marine coastal ecosystems more resilient to climate change, and states generally view NOAA's actions as positive steps. According to NOAA officials, the agency's actions are largely embedded in its broader efforts to build community resilience, and through these efforts NOAA has emphasized the importance of healthy ecosystems, as there is increasing recognition of the critical role that ecosystems play in supporting resilient communities. The CZMA provides a foundation for managing marine coastal ecosystems and partnering with states to work towards the agency's goals of achieving resilient coastal communities and healthy coastal ecosystems, according to the officials. Within this context, NOAA is taking such actions as providing financial incentives and technical assistance and supporting research through the National Estuarine Research Reserve System to help coastal states understand the potential effects of climate change and plan or implement projects to respond to these effects and enhance marine coastal resilience. We found that state coastal zone managers generally had positive views of the actions NOAA is taking.

Financial Incentives

NOAA has targeted some of the financial incentives it provides to states under the CZMA for activities aimed at addressing the impacts of climate change and enhancing marine coastal resilience. For example, within the National Coastal Zone Management Program for fiscal years 2016 to

²⁶GAO, *Climate Change Adaptation: Strategic Federal Planning Could Help Government Officials Make More Informed Decisions*, [GAO-10-113](#) (Washington, D.C.: Oct. 7, 2009).

2020, NOAA designated coastal hazards—physical threats to life and property, such as sea level rise—as an enhancement area of national importance. In so doing, NOAA indicated that coastal zone enhancement competitive grants would be focused on projects that will further support approved state strategies related to this enhancement area. NOAA also increased the total amount available for these competitive grants from \$1 million in fiscal years 2014 and 2015 to \$1.5 million for fiscal year 2016.²⁷ NOAA officials said that many of the applications they received in 2015 and 2016 were for projects that were intended to directly or indirectly address climate risks and enhance the resilience of states’ coastal ecosystems. For example, in 2015, NOAA awarded one grant for about \$200,000 to a state to undertake a mapping study to identify vulnerable habitats along its coastline and use the results of the study to prioritize those habitats considered most vulnerable to climate change for the state’s restoration and resilience efforts.

In addition, starting in fiscal year 2015, NOAA initiated a Regional Coastal Resilience Grant Program to fund projects that focus on regional approaches to helping coastal communities address vulnerabilities to extreme weather events, climate hazards, and changing ocean conditions using resilience strategies.²⁸ State and local governments, nonprofit organizations, and others are eligible to apply for these grants. NOAA awarded six applicants grants totaling \$4.5 million in each of fiscal years 2015 and 2016, according to NOAA officials.²⁹ Projects eligible for grants

²⁷ NOAA officials said that they awarded a total of \$2.0 million to 13 applicants for fiscal years 2014 and 2015. For fiscal year 2016, NOAA officials said they awarded a total of \$1.5 million to 7 applicants.

²⁸ According to NOAA officials, “regional” refers to any project that demonstrates the existence of multiple partners working across jurisdictions in close collaboration with each other. These officials said that applicants are given the flexibility to define “regional” at a scale that is appropriate for the goals of the proposed project.

²⁹ For fiscal year 2017, the President’s budget request proposed increasing the amount available for the grant program from nearly \$4.5 million to \$20 million. In addition, the President’s budget request proposed consolidating this grant program with the Coastal Ecosystem Resiliency Grant Program, a program administered by the National Marine Fisheries Service to fund projects to restore habitats to support healthy fish populations and provide ecosystem functions that reduce hazards and risks associated with extreme weather events and a changing climate, among other things. As of the date of this report, NOAA’s fiscal year 2017 appropriation had not been enacted so no decision regarding consolidation of the two grant programs had been made.

may be targeted to a variety of efforts that support resilience, including actions focused on marine coastal ecosystem resilience. For example, in 2016, NOAA awarded one grant for nearly \$900,000 to a regional partnership of state governments, nonprofit organizations, and academia involved in a project aimed at mitigating the impacts of weather events on natural resources, among other things. Specifically, the project intends to assess potential coastal storm impacts and increase the implementation of nature-based infrastructure approaches to buffer the effects of coastal storms, among other things.

Officials from all 25 state coastal zone management programs said that financial assistance provided by NOAA has been critical for planning projects designed to enhance marine coastal ecosystem resilience and reduce the potential impacts of climate change. Officials from nearly all state coastal zone management programs expressed concern, however, that the amount of financial assistance available is insufficient to address states' needs in implementing projects. For example, officials from 15 of the 25 state programs said that coastal zone management grants have been the primary source of funding from NOAA that they have used for efforts related to ecosystem resilience. However, these grants generally cannot be used to purchase land or for construction projects—activities the states identified as important for improving the resilience of their coastlines.³⁰ In addition, officials from 20 of the 25 state programs said that they have had to leverage funds from multiple sources, such as state funds, nonprofit organizations, or other federal agencies, to implement projects aimed at enhancing ecosystem resilience. NOAA officials agreed that there is a high demand for funding for these types of projects, noting, for example, that the Regional Coastal Resilience Grant Program received 132 qualified applications requesting a total of \$105 million during its first application period in fiscal year 2015, when a total of \$4.5 million was available for the grants.

³⁰Section 306 grants cannot be used for land acquisition or construction. 15 C.F.R. § 923.93(b). Section 306A grants can be used for certain low-cost construction projects or acquisition of land, among other things. 16 U.S.C. § 1455a(c)(2). According to NOAA officials, section 306A grants generally do not exceed \$100,000. While section 306A grants can be used to support small restoration and land acquisition projects that have ecosystem resilience benefits, NOAA officials said that given the limited amounts, section 306A grants are not a significant source of funding for on-the-ground ecosystem resilience projects.

Technical Assistance

Through its administration of the National Coastal Zone Management Program, NOAA has also provided technical assistance to coastal states to help them understand and address the potential impacts of climate change on marine coastal ecosystems. NOAA officials said they work regularly with state coastal zone managers and they look for opportunities to provide assistance to help the states take actions designed to enhance resilience. For instance, through their reviews of states' 5-year coastal zone enhancement assessment and strategy reports, NOAA officials said they identify information needs and priorities of state coastal zone management programs. For example, NOAA officials said they found that states had a common interest in knowing more about valuing the economic benefits of coastal ecosystems, such as estimating the financial benefit that ecosystems provide for flood control. As a result, NOAA officials said they presented information on this topic at a 2016 annual meeting with state coastal zone managers. This type of information can help states develop cost-benefit analyses that may more accurately capture the value of services provided by coastal ecosystems—as opposed to man-made infrastructure such as seawalls and levees—when states are exploring options for coastal projects, according to the officials. NOAA officials also said they share the states' needs and priorities that they identify with other NOAA offices, as well as with external partners such as other federal agencies and nonprofit organizations, to increase the awareness of state program needs and priorities and facilitate coordination and the alignment of resources across programs.

NOAA provides a wide range of technical assistance in the form of technical information, guidance, and training related to better understanding and addressing the potential impacts of climate change on marine coastal ecosystems, including:

- **Technical information.** NOAA has provided various types of technical information to states to help them understand and incorporate climate information into their state coastal zone management programs. For example, in 2007, in partnership with nonprofit entities, NOAA helped develop a publically available repository of information—called the Digital Coast—to help state coastal zone managers and others analyze potential climate risks and

determine how to address those risks.³¹ The Digital Coast provides information and tools on such topics as climate models and statistical analyses that coastal managers can use to incorporate climate information into their management activities. For instance, the Digital Coast contains an interactive tool that allows users to estimate sea level rise and simulate different sea level rise scenarios using elevation and surface data to help identify coastal areas that may be affected by rising sea levels in a changing climate. Coastal zone managers from one state said they used this tool to determine the vulnerability of their state's shoreline to potential sea level rise, which has helped them better target financial assistance to areas they identified as most vulnerable.

Officials from all 25 state coastal zone management programs said that the technical information NOAA provides has generally helped them incorporate climate information into their state programs. However, officials from 20 of the 25 state programs said they often need more local or site-specific information for planning and implementing projects. The information NOAA provides is mostly at a national or regional scale, given staffing and resource levels, according to NOAA officials. These officials added that data available through the Digital Coast may be used as a starting point for coastal managers to modify and build in more site-specific elements. For example, one state customized a Digital Coast tool for estimating sea level rise to create a map outlining potential coastal flooding areas under various sea level rise scenarios at a site-specific scale within its state.

- **Guidance.** NOAA has developed several guidance documents to help state coastal zone managers and others identify specific ways marine coastal ecosystems may be used to help withstand the potential impacts of climate change and enhance the resilience of coastal areas. For example, in 2015, NOAA developed its Guidance for Considering the Use of Living Shorelines to provide information on how to use natural ecosystems, such as oyster reefs or marshes, to reduce coastal erosion caused by intense storms, wave erosion, or

³¹In addition to NOAA, the following partners helped develop the Digital Coast: the American Planning Association, Association of State Floodplain Managers, Coastal States Organization, National Association of Counties, National Estuarine Research Reserve Association, National States Geographic Information Council, The Nature Conservancy, and Urban Land Institute.

sea level rise.³² In addition, in 2016, NOAA issued a Guide for Considering Climate Change in Coastal Conservation.³³ The guide provides coastal managers a step-by-step approach to considering climate change in coastal conservation planning, with links to relevant tools, information, and other resources.

Officials from 19 of the 25 state coastal zone management programs said NOAA's guidance was generally useful, but officials from 14 of these programs said that NOAA's guidance alone is not sufficient to plan or implement actions that enhance ecosystem resilience and address climate change risks. Officials from one state, for example, said that NOAA's guidance on using living shorelines is helpful for general purposes such as educating the public on the benefits of this technique, but that the guidance does not cover all shoreline types, such as gravel beaches, exposed rocky shores, or tidal flats. NOAA officials said that using living shorelines as a strategy to enhance coastal resilience is a relatively new technique, and as coastal managers gain more experience with its use on different types of shorelines, NOAA plans to incorporate this information into the assistance it provides to coastal states. NOAA officials also said that the guidance was not intended to be a comprehensive source of technical information on living shoreline techniques, but rather to provide information on key technical and policy considerations in planning and designing shoreline management projects.

- **Training.** NOAA has developed instructor-led and online training on topics such as the use of marine coastal ecosystems for improving community resilience and understanding how to use the tools found in the Digital Coast as a way to plan for and take action to address the potential impacts of climate change. For example, from 2014 to 2016, NOAA provided training to over 250 state coastal zone managers and other state practitioners across the country on identifying various types of flooding in coastal areas and methods for mapping potential flooding scenarios. Similarly, during the same time period, NOAA officials said they offered 11 3-day climate adaptation workshops

³²NOAA, *Guidance for Considering the Use of Living Shorelines* (Washington, D.C.: 2015).

³³NOAA, *Guide for Considering Climate Change in Coastal Conservation* (Washington, D.C.: 2016).

across the country that covered a variety of climate-related topics including methods for assessing the vulnerability of coastal areas and options for using ecosystems, such as wetlands, to provide flood protection.

Officials from 16 of the 25 state coastal zone management programs told us that they viewed the training provided by NOAA on topics related to climate change and ecosystem resilience as helpful. NOAA officials said they take steps to ensure their training topics meet states' needs by discussing potential training topics with state coastal zone managers before developing courses and by collecting participant feedback after training courses are provided. For example, NOAA officials said they reach out to all training participants after each course to ask the participants the extent to which they believe they will be able to apply the training to their work.

National Estuarine Research Reserve System

NOAA officials said that the National Estuarine Research Reserve System is important for marine coastal ecosystem resilience, in part, because the reserves serve as "living laboratories" for the study of estuaries and natural and man-made changes, including the impacts of climate change. For example, in 2014, coastal zone managers from one state partnered with the state's research reserve staff, along with NOAA and others, to study and map marsh migration patterns across the state's coastline to determine how marsh ecosystems may respond to rising sea levels. The study results were then incorporated into state efforts to help local communities plan for and take action to adapt to the effects of climate change, according to a state coastal zone manager. In the research reserve system's 2011-16 strategic plan, NOAA and the states identified climate change as one of three strategic areas of focus and investment for the 5-year period. Activities identified in the plan include, among others, generating and disseminating periodic analyses of water quality, habitat change, and the effects of climate change and other stressors at local and regional scales.

Officials from 19 of the 25 state coastal zone management programs said that the work carried out through their respective research reserves plays an important role in furthering their understanding of how climate change

may affect the structure and function of estuarine ecosystems.³⁴ NOAA officials agreed that this research plays a critical role in supporting states' efforts to enhance coastal resilience to climate change. The officials said they are updating the reserve system's strategic plan for 2017, which they expect to complete in January 2017, and plan to continue highlighting climate change and resilience as key issues to focus their research at the reserves.

Agency Comments

We provided the Department of Commerce a draft of this report for review and comment. NOAA provided technical comments, which we incorporated as appropriate.

We are sending copies of this report to the appropriate congressional committees, the Secretary of Commerce, and other interested parties. In addition, the report is available at no charge on the GAO website at <http://www.gao.gov>.

If you or your staff members have any questions about this report, please contact me at (202) 512-3841 or fennella@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff members who made key contributions to this report are listed in appendix I.



Anne-Marie Fennell
Director, Natural Resources and Environment

³⁴There are 25 research reserves located in 20 marine coastal states (3 marine coastal states do not have a research reserve).

Appendix I: GAO Contact and Staff Acknowledgments

GAO Contact

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Staff Acknowledgments

In addition to the contact named above, Alyssa M. Hundrup (Assistant Director), Michelle Cooper, John Delicath, Cindy Gilbert, Jeanette M. Soares, and Rajneesh Verma made key contributions to this report. Also contributing were Michael Hill, Armetha Liles, Christopher Pacheco, Janice Poling, Steve Secrist, and Joseph Dean Thompson.

Appendix II: Accessible Data

Accessible Text

Accessible Text for Figure 1: Predominant Marine Coastal Ecosystem Types Across Geographic Regions of the United States

Ecosystem types/description:

Forested Wetland:

Forested wetlands include the floodplains of rivers, backwater swamps, and bogs. They are vegetated by trees, shrubs, and other plants.

Source: Steve Hillebrand, U.S. Fish and Wildlife Service.

Salt Marsh:

Salt marshes are usually vegetated by salt-tolerant grasses, rushes, sedges, and other soft-stemmed plants.

Source: Tom and Louise Kane, National Oceanic and Atmospheric Administration.

Seagrass Bed:

A seagrass bed is a submerged saltwater wetland that is often vegetated with grasses such as eelgrass and turtlegrass.

Source: Paige Gill, Florida Keys National Marine Sanctuary.

Mangrove:

Mangroves are wetlands dominated by mangrove trees, which are noted for their unique system of twisted roots that rise above the water surface.

Source: Nancy Diersing, Florida Keys National Marine Sanctuary.

	States	Forested Wetland	Salt Marsh	Seagrass Bed	Tidal Freshwater Marsh	Mangrove
West Coast	WA, OR, CA	Yes	Yes	Yes	Yes	No
Mid-Atlantic and Northeast	ME, NH, MA, RI, CT, NY, VA, NJ, DE, MD	Yes	Yes	Yes	Yes	No
South Atlantic	NC, SC, GA, FL	Yes	Yes	Yes	Yes	Yes
Gulf of Mexico	TX, LA, MS, AL	Yes	Yes	Yes	Yes	Yes
Alaska	AK	Yes	Yes	Yes	Yes	No
Hawaiian Islands	HI	No	No	Yes	No	No

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