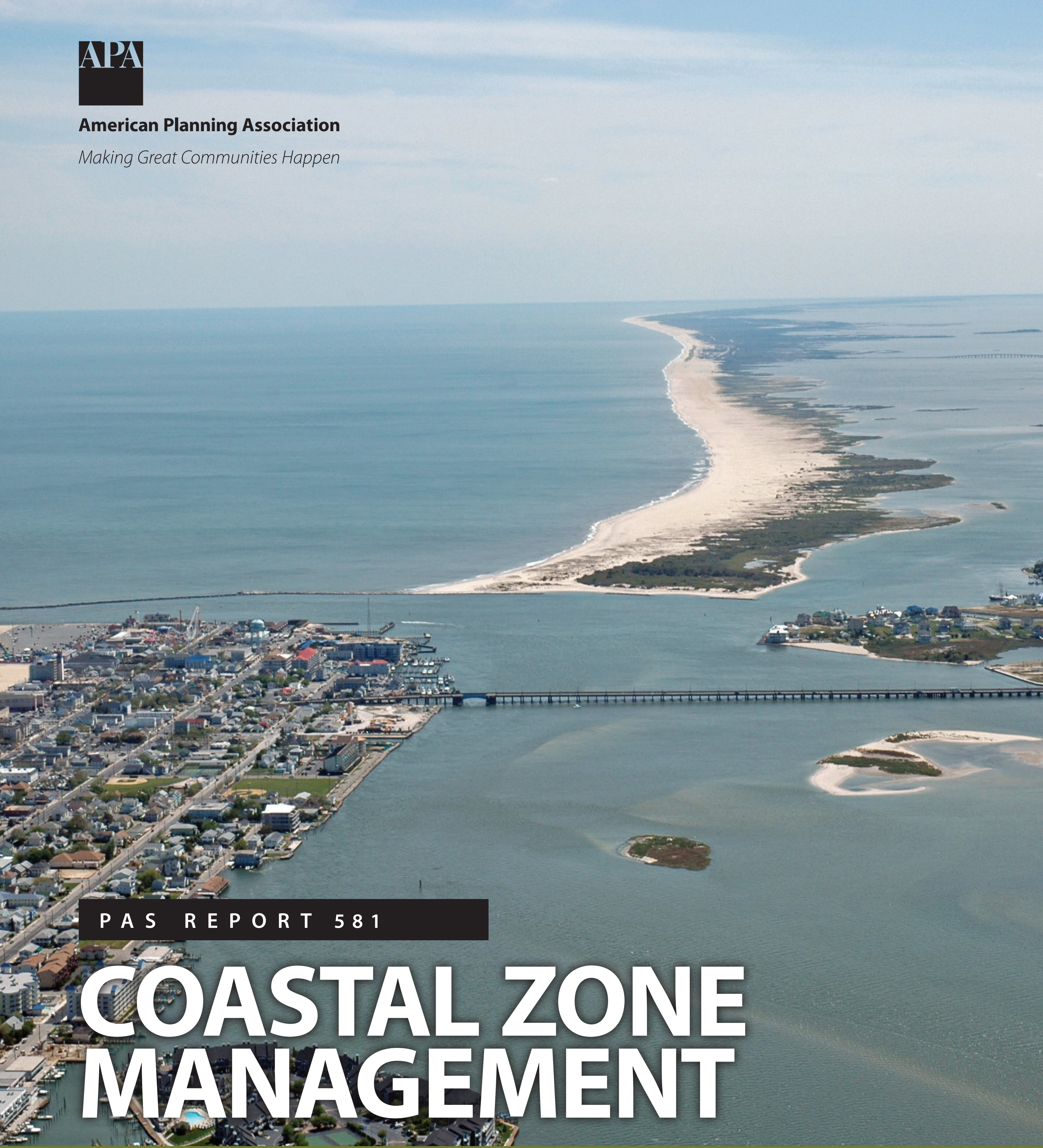

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PAS REPORT 581

# COASTAL ZONE MANAGEMENT

Elizabeth Felter and Marya Morris

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Aerial view of the Ocean City Inlet from the Isle of Wight Bay in Maryland (*Jane Thomas, Integration and Application Network, University of Maryland Center for Environmental Science*)

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## EXECUTIVE SUMMARY

Coastlines are physically dynamic environments that are continually being shaped and reshaped by tides, waves, erosion, storms, flooding, and climate change. They are also the most densely populated places in the United States. Coastal tourism and waterborne industries, like commercial fishing and energy production, are obviously dependent upon a healthy and well-functioning natural environment. Planners in coastal areas are presented with a wide range of challenges in their efforts to balance protection of these sensitive natural environments with the intense and increasing impacts of human and economic activity.

## FACTS ABOUT COASTLINES

Coastal shoreline counties are contained entirely within the inland extent of coastal watershed counties, making up 53 percent of the total land area of coastal watershed counties. However, coastal shoreline counties exhibit a much higher population density than coastal watershed counties, as they contain 75 percent of the total population in this area. In 2010 more than 123 million people, or 39 percent of the nation's population, lived in coastal shoreline counties. These counties make up less than 10 percent of the land area in the United States (excluding Alaska).

Coastal states account for more than three-quarters of US domestic economic activity. In 2011, 45 percent of the US gross domestic product was generated in counties adjacent to an ocean or Great Lakes coast. This economic activity accounted for 51 million jobs and $2.8 trillion in wages. This economic activity includes waterborne cargo, commercial and recreational fishing, and tourism.

## COASTAL ZONE MANAGEMENT PROGRAMS

Coastal zone management is a collective effort on the part of planners, environmental scientists, elected officials, and environmental advocates to manage natural and human-made systems in a way that minimizes risks to people, property, and the environment. There is a wide array of federal, state, and local programs and regulations in place that are addressing every aspect of the activities that occur along coastlines.

### Federal

Coastal zone management at the federal level most notably began with the Coastal Zone Management Act (CZMA) of 1972. The purpose of the law is to "preserve, protect, develop, and where possible, to restore or enhance the resources of the Nation's coastal zone for this and future generations" (16 U.S.C. §§ 1451–1465). The CZMA established the National Coastal Zone Management Program and tasked the Office of Ocean and Coastal Resource Management of the National Oceanic and Atmospheric Administration (NOAA) with overseeing the program. (NOAA's Office for Coastal Management currently oversees the program.) The federal program delegates authority to states, which receive funding to prepare coastal zone management plans.

Each year NOAA evaluates how well states are meeting the federal CZMA goals using five performance standards: (1) government coordination and decision making, (2) public access, (3) coastal habitat, (4) coastal hazards, and (5) coastal dependent uses and community development. The Office for Coastal Management also supports states and local and regional agencies with data, technology, and management strategies to meet their coastal zone management goals. The National Coastal Zone Management Program and its state partners regularly collaborate with other federal agencies and programs that are invested in coastal zone management, including the National Flood Insurance Program, the Coastal Nonpoint Pollution Control Program, the National Estuary Program, the US Fish and Wildlife Services's Coastal Program, the National Park Service, and the US Environmental Protection Agency.

### State

States develop programs that adhere to basic standards and the following broad national goals:

- Protect and restore significant coastal resources
- Prevent, reduce, or remediate polluted runoff to coastal waters
- Improve public access to the coast
- Minimize the loss of life and property in coastal hazard areas
- Promote sustainable growth in coastal communities
- Provide for priority water-dependent uses
- Improve government coordination and decision making

Each state is given broad discretion to design and implement programs and initiatives that address the state's specific coastal zone issues. State coastal zone management programs are voluntary federal-state partnerships through which states receive federal funds for program implementation. States have much flexibility in program design in order to address their particular cultural, environmental, and political needs. While coastal management program components vary greatly from state to state, all state coastal agencies collaborate formally and informally with different levels of government and other organizations. Of the 35 eligible coastal and Great Lakes states and territories, 34 participate in the National Coastal Zone Management Program. Washington was the first state to join, and Illinois the most recent.

### Local

Planners are involved at every step in the development of coastal zone management programs and, in particular, at the local level where decisions about land use, development intensity, transportation, and conservation are made. Local planners have experience tackling complex problems of growth and development and are experts in bringing residents and stakeholders together to work positively and productively on planning issues. Planners in coastal communities get involved in coastal zone management through programs and projects that are funded by state coastal zone management programs. These efforts involve other regional and local agencies and nongovernmental entities working together on a variety of initiatives, including erosion and sedimentation control, habitat protection, nonpoint source pollution prevention, and hazard mitigation.

Outside of the context of federal and state regulatory and funding programs, there is a long history in coastal communities of waterfront revitalization planning, coastal environmental protection and restoration efforts, and planning for future growth and development in general. Waterfront manufacturing uses have experienced a steady decline that roughly parallels the overall decline of manufacturing uses in the United States since the 1970s and 1980s. Many coastal cities, however, began to recognize their former industrial waterfronts as assets they could use to leverage city or regional economic comebacks. This sparked the preparation and implementation of waterfront revitalization plans all over the country. Most of these sought to catalyze tourism development and recreational uses, but many also had goals to protect and maintain the remaining viable waterfront industrial uses, ports, and commercial fishing facilities. Such plans have been developed as standalone special area plans and also as adopted as elements or chapters of citywide comprehensive plans.

## ADAPTATION AND RESILIENCE PLANNING

Adaptation plans look at all aspects of communities that are both susceptible to the effects of climate change and that are contributors to and causes of it. These aspects include—at the very minimum—population trends, development patterns, infrastructure, greenhouse gas emissions, energy production and consumption, and natural resources. Existing planning and regulatory frameworks are also analyzed to determine what current trends and future projections will affectand be affected by climate change.

Comprehensive and effective adaptation planning is part of what communities do to build resilience. In coastal areas, NOAA defines resilience as "building the ability of a community to 'bounce back' after hazardous events such as hurricanes, coastal storms, and flooding—rather than simply reacting to impacts" (NOAA 2015f). Resiliency planning includes the ability to understand potential impacts and to take appropriate action before, during, and after a particular event to minimize negative effects and maintain the ability to respond to changing conditions.

Resilience strategies involve evaluating and upgrading the lifeline systems infrastructure—communication, power, transit—that are essential immediately following a disaster. Resilience also involves protective infrastructure, including built systems (e.g., seawalls and breakwaters) and natural systems (e.g., salt marshes and dunes). Hybrid strategies, a combination of green and gray infrastructure strategies, may provide the most effective outcome as they balance the range of planning and engineering considerations.

CHAPTER 1

# ESSENTIAL FACTS ABOUT COASTLINES

The only thing that is constant is change. Nowhere is that old adage truer than on the coastlines of the Atlantic and Pacific Oceans and the shorelines of the five Great Lakes. Coastlines are physically dynamic environments that are continually being shaped and reshaped by tides, waves, erosion, storms, flooding, and climate change. They are also the most densely populated places in the United States. Coastal tourism and waterborne industries, like commercial fishing and energy production, are obviously dependent upon a healthy and well-functioning natural environment. Planners in coastal areas are presented with a wide range of challenges in their efforts to balance protection of these sensitive natural environments with the intense and increasing impacts of human and economic activity.

## POPULATION

Coastal shoreline counties are contained entirely within the inland extent of coastal watershed counties, making up 53 percent of the total land area of coastal watershed counties (Figure 1.1). However, coastal shoreline counties exhibit a much higher population density than coastal watershed counties, as they contain 75 percent of the total population in this area. In 2010 more than 123 million people, or 39 percent of the nation's population, lived in coastal shoreline counties. These counties make up less than 10 percent of the land area in the United States (excluding Alaska). The density of population in coastal areas is two to three times higher than in the nation as a whole. The Northeast currently accounts for about one-third of the nation's coastal population (44 million people). Its population density of 654 persons per square mile is more than double that of any other region (NOAA 1998).

Coastal shoreline counties are more racially diverse and more affluent than the nation overall. In 2010, 35 percent of people in these jurisdictions identified themselves as a race or races other than white alone, a higher percentage than the national average of 28 percent. Coastal shoreline counties

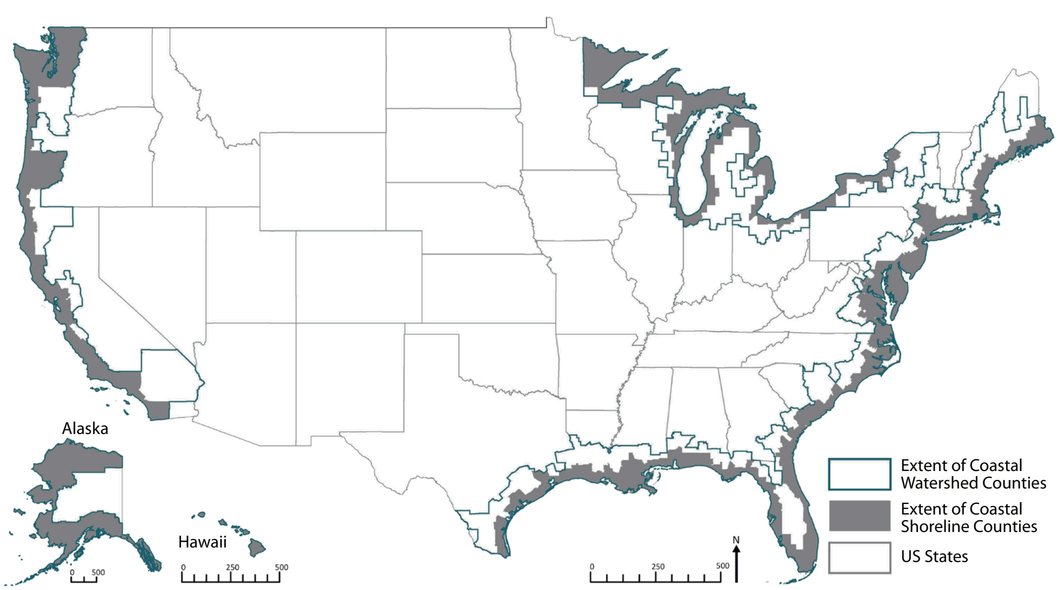



*Figure 1.1. Comparing coastal shoreline and coastal watershed counties (NOAA 2013b)*

## MEASURING POPULATION

For measuring population, the National Oceanic and Atmospheric Administration (NOAA) categorizes jurisdictions as coastal watershed counties or coastal shoreline counties. Coastal watershed counties represent the 769 counties where at least 15 percent of land area intersects the coastal watershed. Human activities and land uses in these counties affect coastal water quality and ecosystems, and therefore these areas include "the US population *that most directly affects* the coast" (NOAA 2013d, 1; italics added). Coastal shoreline counties represent the 452 counties directly bordering an open ocean, estuary, or one of the Great Lakes. These counties feel the impacts of coastal hazards most strongly, and they have local economies dependent on the coast. Therefore they represent the US "population *most directly affected by* the coast" (Ache et al 2013, 2; italics added). In 2010 coastal shoreline counties had a population density of 446 persons per square mile, and the density of coastal watershed counties was 319 persons per square mile—both significantly higher than the national average of 105 persons per square mile. As population densities continue to increase, coastal managers must work both to preserve environmental quality and to protect these populations from coastal hazards (NOAA 2013b).

contain nearly half the US households that earn more than $100,000 annually, while including only 39 percent of the population. The percentage of families living below the poverty line in coastal shoreline counties is 15.4 percent, which is the same as the national average (NOAA 2013b).

The growth in population of coastal areas illustrates the importance of emergency planning and preparedness for areas that are more susceptible to strong and damaging storms like Superstorm Sandy and Hurricane Katrina. Population data enable emergency planners to assess the needs of coastal populations and anticipate the number of people at risk during a given disaster. Census data are also used by the Federal Emergency Management Agency (FEMA) and other agencies to plan for and fund emergency operations and post-disaster recovery efforts.

## THE COASTAL ECONOMY

Coastal states account for more than three-quarters of US domestic economic activity. In 2011, 45 percent of the US gross domestic product (GDP) was generated in counties adjacent to an ocean or Great Lakes coast. This economic activity accounted for 51 million jobs and $2.8 trillion in wages (NOAA 2013c). Several sectors of the US economy are dependent on proximity to the coast (NOAA 2013e), including:

- waterborne cargo, which contributes more than $742 billion to the US GDP and creates employment for more than 13 million people;
- commercial marine fisheries with an average annual value from 2008 to 2010 of about $4 billion and approximately 1 million jobs associated with this industry;
- marine recreational fishing, which generated over $30.5 billion in sales and $12 billion in income in 2000 and supported nearly 350,000 jobs; and
- beach tourism and the leisure and hospitality sector (which includes recreational fishing), as reflected in the fact that coastal states earn 85 percent of all US tourism revenues.

Because of the significant contribution of the coastal economy, planning for these areas is essential.

## HOUSING, TOURISM, AND RECREATION

To say the coast is an attractive place to live would be a great understatement. Between 2000 and 2010, 1,355 building per-

*Figure 1.2. Port of Redwood City in the San Francisco Bay Area, a deep-water port providing berths for cargo and adjacent to wetlands and natural habitats (Army Corps of Engineers)*

mits were issued *per day* in coastal shoreline counties (Crowell et al. 2010). Also a popular place for vacationing, a significant portion of housing along the coast is seasonal, which means many housing units sit vacant for parts of the year. In large urban areas, coastlines are densely developed with hotels, resorts, and condominiums. The tourism sector of the US economy is part of the overall shift to a service economy. Tourism is a common focus of many coastal communities' economic development strategies because it cannot be outsourced. Many communities value this place-based economic activity, although it does significantly change the character of communities, and it puts substantial strain on infrastructure and services.

The more extreme and erratic weather resulting from climate change will alter the quality and length of the seasons. These factors in turn will affect tourism and recreational opportunities. Environmental protection is essential for tourism, as the degradation of natural resources will take away what drew in visitors in the first place. Tourism itself has the potential to damage the natural environment through coastal development and growth and the significant greenhouse gases emitted during vacation travel and activities.

## TRANSPORTATION AND PORTS

The 360 commercial ports in the United States, which include both ocean and Great Lakes' coasts, are areas of intense industrial activity and infrastructure development on coastlines. They are also located in river deltas and estuaries, the most ecologically significant areas within the coastal zone. According to the American Association of Port Authorities, commercial US ports in 2014 created employment opportunities for an estimated 23.1 million Americans. (This figure includes 21.4 million people who were employed in exporter- and importer-related businesses and their support industries throughout the United States.) Business activities related to waterborne commerce contributed approximately $4.6 trillion overall to the US economy; those same businesses paid nearly $321.1 billion in federal, state, and local taxes. Seaport activities alone in 2014 accounted for $41 billion in federal, state, and local tax revenues (AAPA 2015). The landside uses and infrastructure associated with ports involve extensive roadway and rail transportation systems where freight is transferred off of ships and onto trucks and railcars. Warehouses and other port-supportive industries and commercial uses are also present (Figure 1.2).

The value of ports as economic engines in regions and nationwide cannot be underestimated, but in most port regions the price of economic success has come at the expense of the natural coastal environment. Ports are subject to air and water quality protection standards as well as laws to protect open ocean waters; reduce diesel emissions; and safeguard wetlands, habitats, and ecosystems. However, natural coastal zone systems and processes—such as beaches, dunes, and habitat—in the immediate vicinity of ports have been significantly altered or eliminated by coastal and lakeside development and related landside uses.

The Port of Seattle is an example of a government agency that has in recent years focused more on environmental protection concerns in its long-range strategic planning. Its 2012 Century Agenda initiative states several strategic objectives to protect the environment, including: "To be the greenest most energy efficient port in North America" (Port of Seattle 2015). The specific aims are the following:

- Meet all increased energy needs through conservation and renewable sources.
- Meet or exceed agency requirements for stormwater leaving port-owned or -operated facilities.
- Reduce air pollutants and carbon emissions by 50 percent from 2005 levels.
- Prevent urban sprawl by concentrating industrial uses in the existing port area.
- Restore, create, and enhance 40 additional acres of habitat in the Green–Duwamish watershed and Elliott Bay.

Given their locations, ports are likely to be significantly affected by climate change and sea level rise. No broad-based state or federal approach exists for dealing with this issue. A 2013 study for the World Ocean Council included a survey of port officials worldwide to better understand how they perceive climate change will affect port operations (Becker 2013). A majority of the respondents, 81 percent, agreed that climate change is something that they need to address, but only 31 percent indicated that they felt sufficiently informed as to how climate change will affect port operations.

As an indicator of the lack of preparedness for sea-level rise, the study found that just 17 percent of ports had an infrastructure planning timeframe of 25 years or more while 41 percent had only five-year plans. Planners and port cities have an opportunity to create a dialog with port authorities about the projected impact of sea level rise on infrastructure and to start planning immediately for increasingly intense storms that could put port-dependent local economies at risk in the coming decades.

## HUMAN IMPACTS ON COASTAL ZONES

Economic growth and development in coastal zones affects the natural coastal environment in many ways. A growing economy attracts population growth that creates demand for new housing, commercial uses, and infrastructure. If growth is not carefully managed, it can precipitate urban sprawl, increase impervious surfaces, and increase vehicle emissions—all of which can damage the sensitive natural surroundings in coastal zones.

Contaminants such as metals, herbicides, pesticides, and pathogens can threaten public health, impair ecosystem productivity, and potentially alter species' compositions and biodiversity. When coastal ecosystems are degraded by human activity, concurrent damage occurs to what coastal experts refer to as "ecosystem services," which in short are the contributions that a biological community and habitat provide to people's day-to-day lives, such as fishing.

Commercial and recreational fishing and beach tourism are absolutely dependent on ecosystem services. Water-dependent industries, including ports, also need to be able to operate without significant disruption or encroachment from other uses. The challenge for coastal communities that have a mix of intense land uses and sensitive natural areas and systems is to find ways for economic and human activities to thrive without compromising the health and functionality of the environment.

## OVERVIEW OF THIS REPORT

This report focuses on the challenges of and approaches to effective planning in coastal areas. This chapter reviewed some essential facts about coastal populations and economic activity in these areas dependent on proximity to the coast. It also presented the impacts that human and economic activities have on natural systems. Chapter 2 describes the physical elements that make up coastal areas as well as the effects of climate change on coastlines and the planning policy implications of such change. Chapter 3 reviews the federal and state coastal zone management framework that governs how environmental protection and conservation objectives are balanced with human activity. It also explains state coastal zone management programs generally and describes programs in several key states. Chapter 4 continues with a look at the role of local planning in coastal areas and the role of planners in adaptation planning and resilience. Chapter 5 looks specifically at coastal zone management in the Great Lakes areas, including case studies of programs in Michigan and Wisconsin. Chapter 6 presents principles of effective coastal planning and considers the future of coastal zone management.

CHAPTER 2

# THE NATURE OF COASTS AND CLIMATE-CHANGE THREATS

Coastal zone management is a collective effort on the part of planners, environmental scientists, elected officials, and environmental advocates to manage natural and human-made systems in a way that minimizes risks to people, property, and the environment. To do this requires a basic understanding of the natural elements, forces, and processes that make up coastlines.

This chapter describes the many physical features found on coastlines, such as habitats and dunes. There are also complex and dynamic natural processes that are constantly shaping and reshaping the physical elements in the coastal zone. These include wind, waves, erosion, sediment movement, and water temperature. Climate change and the resultant rises in sea levels pose significant hazards to the environmental well-being of coastal areas as well as to the residents and industries located in coastal zones.

## THE PHYSICAL ELEMENTS OF COASTS

The physical geography of a coast is a combination of tectonic plates, beaches, barrier islands, dunes, estuaries, and other elements. The defining physical characteristics of coasts vary around the world. They combine to make any particular coastal area distinct from others. Examples include the haystack rocks off the Oregon coast and the wide white sand beaches of the Gulf Coast of Florida. Physical forces—namely, water, wind, and waves—are constantly shaping and reshaping these physical features. The following sections explain the most common physical elements that are found on US coastlines.

### Coasts and Coastal Landforms

*Coast* is a general term for the juncture of land and water. A beach is a portion of a coast that is made of sand, cobbles, or shells. Beaches vary greatly by geography and location. For example, northern beaches on the Pacific and Atlantic coasts are made of gravel, stone, and pebbles while southern beaches are made of finer-grained sands and shells. Seasons, weather, and, in particular, storms greatly modify beaches and their dune systems. Beach erosion occurs at the greatest rate during winter storms, when wave activity is the most intense. Most of the country's beaches are eroding and moving landward due to sea level rise, but some beaches are accreting (i.e., becoming larger) and others are stable in size.

Geologists group coasts into two main types: trailing-edge and collisional. The Atlantic coast and Gulf Coast of the United States are trailing-edge coasts, defined by a wide continental shelf, with a flat topography, barrier islands, deltas, estuaries, lagoons, inlets, marshes, and beach islands. Trailing-edge coasts are created by deposits of sediment from both landside runoff and the movement of underwater sediment by waves and tides. These forces combine to form a broad continental shelf and coastal landforms like barrier islands, capes, and spits.

Collisional coasts are formed by the convergence of two tectonic plates; the Pacific coast of the United States is in this category. Collisional coasts are characterized by a narrow continental shelf and a coastal mountain range with seismic fault lines and volcanoes. The California coast has two types of seismic boundaries in play. The southern portion, stretching from the Imperial Valley on the Mexico border more than 600 miles north to Cape Mendocino on the Pacific coast, is a "transform boundary" where the tectonic plates are sliding side by side. North of Mendocino, California—through Oregon, Washington, and continuing to the Aleutian Islands of Alaska—is a "convergent plate boundary" where the oceanic plate is colliding with the continental plate and the former is being subducted by the latter. (Subduction is the process by which one tectonic plate moves under another tectonic plate. Regions where this process occurs are known as subduction zones.)

### Dunes

A coastal dune is a pile of windblown sand. The size and height of a dune depends on the amount of sand available. As with beaches, dunes are in a constant state of change. They can grow larger or recede depending on onshore winds, sand quantity, storm events, and human activity. New dunes can form where clumps of vegetation, such as tree trunks or seaweed piles, trap windblown sand particles. The root structure of dune vegetation helps hold sand in place and stabilizes the larger landform.

Dune restoration and construction involves planting native vegetation and installing fencing, which both trap sands. Bulldozers are used to rebuild dunes because it can take years to establish a sizable dune from vegetation and fences. Coastal communities put a high priority on dune conservation and restoration, both for their ecological value and economic placemaking value. The economic value of dunes is attributable to their ability to draw tourists, beachgoers, and naturalists who come to view and enjoy these distinct and often visually stunning coastal landforms. Many community and environmental organizations hold dune planting events to raise awareness and engage the public in hands-on conservation.

Many coastal jurisdictions have enacted ordinances to ensure dunes remain undisturbed by visitors, vehicles, heavy equipment, and construction. Local ordinances to protect dunes typically prohibit development on or within a specified distance of a dune; restrict the removal of native vegetation; and prohibit people from walking, grading, or otherwise disturbing dunes. It is also common for ordinances to require that beach access through a dune system be allowed only by walkover structures.

### Barrier Islands

The linear islands that are common along the shallow continental shelf of the Atlantic coast are called barrier islands. They are formed by the gradual accumulation of sand and sediment over time and, like coastal marshes and estuaries, they absorb the brunt of ocean waves, winds, and storm surges that would otherwise hit the mainland. Natural forces continually change the shape and size of these islands, often in dramatic fashion during a hurricane or nor'easter (a cyclonic storm along the East Coast), when waves can not only wash away beaches but can also fully bisect a barrier island, creating new inlets and smaller islands.

The islands pose one of the biggest challenges for coastal planners and policymakers because they are among the most sought-after locations for beach tourism and second-home development. Many barrier island chains have been in ex-

*Figure 2.1. Assateague Island, previously parallel to Ocean City, Maryland, has migrated westward (Jane Thomas,Integration and Application Network, University of Maryland Center for Environmental Science)*

istence for centuries. Even the most dynamic island chains have been in place for as long as anyone alive can remember. This creates a false sense of permanence on the part of the public and is why intense development has occurred on sites that technically may be a temporary position of the shoreline (Figure 2.1). Once private property rights are established and subdivisions platted and lots sold, the takings clause of the US Constitution can preclude any governmental effort to prohibit development in such areas.

Sea level rise is increasing the likelihood and frequency that barrier islands will be flooded or destroyed. Coastal states are now using adaptation planning to educate the public and shape public policy that is proactive about the effects of climate change, and natural coastal systems generally, on barrier islands. The Coastal Barrier Resources Act (CBRA), enacted in 1982, is one of the oldest federal policies that employed adaptive approaches to addressing long-term changes to the physical characteristics of coastlines. The act limits the federal financial assistance for development-related activities such as spending for roads, wastewater systems, potable water supply, and disaster relief in CBRA-designated areas. The federal government has estimated that limiting development in high-risk coastal barrier island areas saved taxpayers $1.3 billion between 1982 and 2010 (NOAA 2012b). The law also precludes federal flood insurance for new or improved structures on barrier islands. In these ways, the law has purposefully discouraged continued development on barrier islands in favor of an adaptive approach that aims to reduce loss of life and property in the future by allowing the natural processes to occur without major engineering interventions (e.g., seawalls) to alter natural processes.

### Estuaries and Coastal Lagoons

Estuaries are some of the most ecologically productive elements of the coastal environment, rivaling tropical rainforests in their primary productivity (Beatley, Brower, and Schwab 2002). An estuary is a semi-enclosed coastal body of water which has a free connection with the open sea and within which seawater is measurably diluted with fresh water derived from land drainage (Pritchard 1967). Estuarine features vary based on their geological formations and are classified as flooded river valleys; tectonic estuaries, where tectonic forces caused subduction; and bar-built estuaries, which are restricted-mouth estuaries that occur when sandbars or barrier islands are built up by ocean waves and currents along coastal areas fed by one or more rivers or streams. Flooded valleys, such as the Chesapeake Bay estuary, were formed through sea-level rise. Others, like the San Francisco Bay, formed through tectonic processes of subduction and faulting.

Estuaries are also classified by the extent and type of mixing of fresh and salt water; these differences occur due to wave activity, seasonal changes, and tidal effects. Stratified estuaries are those where saltwater and freshwater layers remain mostly separate, with heavier saltwater at the bottom. A partially mixed estuary contains a mix of saltwater and freshwater at all depths; however, the lower layers of water typically remain saltier than the upper layers. A vertically mixed estuary occurs where a low-flow river meets moderate to strong tidal currents carrying saltwater upstream. The strength of the current mixes the salt and freshwater. Ecosystems vary depending on this salinity gradient.

There are more than 100 estuaries in the United States. Many are so large that they border multiple cities, counties, and even states, such as in the Virginia Tidewater region. Estuaries provide habitat for around 75 percent of the country's commercial fish and 90 percent of recreational fish, as well as many other types of aquatic life and wildlife, including migratory birds (NOAA 2008). The nonprofit environmental group Restore America's Estuaries (2015) estimates that commercial and recreational fishing provide 11.5 million jobs and contribute $111 billion to the US economy. Oyster reefs and sea grass meadows (classified as submerged aquatic vegetation) are particularly important estuarine habitats as they provide food for aquatic life and help to oxygenate and stabilize estuarine sediments. Estuaries which suffer from nutrient loadings, especially nitrogen and phosphorous from agricultural runoff, have severely damaged habitats. Sea level rise further threatens estuarine ecosystems, making them more vulnerable to nonnative species. The National Estuarine Research Reserve System of NOAA (2015e) establishes living laboratories to study climate change and resilience, habitat protection, and water quality. The EPA's National Estuary Program (US EPA 2015a) calls for the development of comprehensive conservation and management plans to ensure the long-term quality of water, habitat, and other living resources.

Restoration activities greatly improve the environmental health and economic vitality of estuaries. Land uses that are immediately adjacent to watersheds as well as those that drain into an estuary have significant impacts on the estuarine ecosystem. Land-use strategies to protect the quality of estuaries include reducing impervious surfaces, conserving wetlands and natural habitats, and encouraging farming practices that lessen organic and chemical runoff, such as rotating crops, planting buffer areas with natural vegetation, and encouraging practices and land uses which reduce

*Figure 2.2. In Florida, wetlands protect low-lying development from flooding and storm inundation (National Oceanic and Atmospheric Administration)*

industrial discharge. Clean-up of ports and other industrial lands and restoration of land to its natural state, along with the restoration of submerged aquatic vegetation habitats, can all improve the water quality and overall health of estuaries.

### Rocky Shores and Bluffs

Rocky shores can form either through tectonic activities or after waves and ice wash away all the sand. The Pacific sea bluffs, cliffs, and headlands rose from sudden uplift and faults, while sloped shores in the Gulf and Atlantic resulted from the submergence of the continental shelf over time. Because they are made of loosely consolidated deposits, bluffs face erosion and landslides more so than rocky headlands They are characterized by high, breaking waves, rocky shores, intense erosion, and steep sea cliffs. Many human activities and development in these coastal areas increase incidences of erosion. Despite the precarious environment, diverse plant life—including numerous varieties of wildflowers—and many sea birds survive on coastal cliffs.

### Wetlands

Historically an undervalued resource, many wetlands have been converted to agricultural uses or drained and developed. Fewer than half of the wetlands in the United States remain intact, and of those remaining, many are seriously damaged. The Clean Water Act, which regulates human disturbances of wetlands, defines wetlands as areas that are inundated or saturated by surface water or groundwater at frequencies and durations sufficient to support certain types of vegetation. Marshes, bogs, fens, and swamps are all wetlands. Found next to rivers or lakes, non-tidal marshes are the most plentiful type of wetland in the United States. They are home to thousands of species of plants and animals, and they have mineral-rich soils of clay, sand, and silt. Tidal marshes exist on all ocean coasts but are most prevalent on the East and Gulf Coasts. They are characterized by extremely high biological productivity, even more so than the already very productive non-tidal marshes. There are very few marshes on the Pacific coast.

More recently, knowledge of the benefits of wetlands has become more widespread. High biodiversity, a good source of fish and shellfish, and an ability to sequester carbon are among some of the many natural values of wetlands. Additionally, wetlands both protect coastal development from storms, by mitigating flooding, and protect the water from pollution, by filtering runoff. They also are an important element of climate change adaptation, by serving as a protective barrier between other ecosystem elements (Figure 2.2). One study reported that coastal wetlands sequester carbon at three to five times the rate of mature tropical forests (Murray et al. 2011). A greater understanding of the benefits of wetlands has led to new priorities to restore damaged ones, preserve them, and sometimes construct them as an amenity of communities.

While the days of large-scale projects to drain and fill wetlands have ended, marinas, roads, railroads, seawalls, and other types of development still are able to damage wetlands. Section 404 of the Clean Water Act protects wetlands through a program that regulates the discharge of dredged or fill materials and requires a permit review process for proposed activities (US EPA 2015b). Many states have adopted even stricter policies for protection than these federal measures. Storms, as well as coastal property and infrastructure, also significantly damage natural resources. Hurricanes Katrina and Rita accounted for 135 square miles of wetlands loss in coastal Louisiana from 2005 to 2006, and Hurricanes Gustav and Ike added another 95 square miles of loss in 2008 (Couvillion et al. 2011).

### Habitat

Coastal and marine habitats—for birds, fish, plants, groundcover, seagrasses, and aquatic vegetation—are inextricably linked to and a product of the physical and aquatic features of the coastline. Coastal estuaries and wetlands, where the majority of plant and animal diversity exists, are, by far, the most susceptible to degradation and loss from human activity. These areas also provide the greatest benefits to humans through "ecosystem services," a concept that identifies and measures the contributions that a biological community and its habitat provide to the physical and mental well-being of the human population. These benefits include food, recreation, storm protection, and medicine (NOAA 2015c). For example, coral reef plants and animals are important sources of new medicines being developed to treat cancer, arthritis, human bacterial infections, Alzheimer's disease, heart disease, viruses, and other diseases (NOAA 2015a).

## Currents, Tides, Waves, and Wind

Currents, tides, waves, and wind are all part of a complex set of natural dynamic processes that characterizes the shape, sedimentation, and movement of water that occur in oceans and lakes and along coastlines. Currents are created by a combination of wind, tides, and water temperature. Winds that blow along the shoreline—longshore winds—affect waves and, therefore, currents. Wave height is affected by wind speed, wind duration, and fetch, the distance over water that the wind blows in a single direction.

Tides are caused by the regular and predictable gravitational pull of the moon and sun on the earth and the earth's rotation. Tides vary by time of day and by season. The movement of tides up and down relative to the average sea level is by definition high and low tide. The vertical motion of the tides near the shore causes the water to move horizontally, creating currents. The dynamic nature of the coast is due in large part to tides. Over the course of a month, in addition to the two daily high and low tides, coastlines experience spring tides—where the high tides are highest and low tides are lowest—and neap tides—where the high tides are lowest and low tides are highest—as well as seasonal tidal differences.

The size and shape of waves determine their impact on coastlines. Steep waves (large height, short duration) cause more severe erosion. Water depth plays a role in wave impact on sediment transport, and beaches with steeper profiles experience greater wave energy than shallow, broad beaches. Most coasts bear both constructive waves, which result in a net sediment gain, and destructive waves, which result in sediment loss (as wave action drags sediment off of beaches during high tides and deposits it on the ocean floor). In addition to moving sediment, tides also influence coastal ecology; certain habitats, such as salt marshes, can only exist in intertidal zones. Winds and tides, along with gravity and solar heating, sway the coastal currents, which move sediment from one location to another. The majority of coastal sediment movement is due to current activity.

## Accretion and Erosion

Accretion is the accumulation of beach sediment, frequently occurring in areas receiving a one-directional flow of water, such as deltas. A delta is a triangular-shaped area that is formed by deposition of sediment carried by a river into the area where the river meets a body of water. The more common coastal zone management issue is erosion, which is the shoreline recession or landward retreat of the water's edge. Temporary erosion can occur seasonally where sediment loss during winter storms is replaced naturally as tides and currents change with less volatile wave action in warmer months. Storm surges and waves often cause erosion but can also result in significant sediment overwash deposits. In this case, the water and sediment carried over the crest of a dune or barrier island do not return to the water body after water level fluctuations have returned to normal. Unless it is reversed using heavy equipment, overwash can result in newly formed lagoons that can stay in place indefinitely. The overwash of sand and other sediment in developed areas can easily disrupt public infrastructure if it settles on streets, sidewalks, or other facilities. In such cases, heavy equipment would likely be used to return the sand to the beach to clear the roads and sidewalks. If coastal areas were not developed or used for specific human activities, then much of this erosion would not be a problem. However, coastal lands, as the result of human activities, are now too valuable for communities to allow them to erode (French 1997).

Historically, engineering techniques to combat coastal erosion used hard stabilization structures, such as bulkheads, groins, seawalls, and revetments. These techniques significantly diminish beach quality and mass, and they are now regarded by experts and decision makers as too expensive and too disruptive to coastal environments. A current and more favored technique is beach replenishment, where heavy equipment is used to dredge offshore sands and deposit it on the beach and in dunes. Coastal tourism depends heavily on healthy, generously sized beaches with ample public access. In beach destinations, ongoing investment in beach replenishment is as important as budgeting for transportation, sewer, and stormwater infrastructure. Replenished beaches can also reduce the energy of waves and storm surge as they reach coastline structures. The ecological benefits of replenishment include enhancement of beach and dune habitats, such as fragile sea turtle nesting sites.

Beach replenishment has many of its own drawbacks. Replenishment can increase volume on the upper beach alone, creating a steeper beach, which then leads to increased waves and higher rates of erosion. Replenished beaches wash away much faster than natural beaches. Additionally, dredging can damage sea grasses, fish, and marine life.

Beach replenishment is inherently a short-term fix. It is also often funded by the federal government. The appropriateness of using federal funds for the protection of private beachfront property is increasingly being called into question by lawmakers and voters, some of whom have argued that coastal property owners who benefit from replenishment should be responsible for paying for it (Ludden 2013).

The Gulf Coast experiences an average erosion rate of six feet per year, and the Atlantic coast between two and three feet, as the barrier island systems gradually move landward (Bush et al. 1996; Titus 1998). A 2000 study by the Heinz Center (2000) estimated 350,000 properties in the contiguous United States were within 500 feet of a shoreline. Rising sea levels have and will further change erosion and accretion patterns. Policies are needed to address the legal and economic implications of loss of coastal land area and damage to public and private property.

### Hurricanes and Coastal Storms

In the United States, the East and Gulf Coasts are vulnerable to the storms originating in tropical waters off the west coast of Africa. These storms grow into large heat engines, fueled by the release of latent heat from condensation. Wind speeds greater than 39 miles per hour form tropical storms; when the wind speed of a storm exceeds 74 miles per hour, it is classified as a hurricane. The National Weather Service's National Hurricane Center identifies the hurricane season as running from June to November. Meteorological research points to an increase in the intensity of hurricanes being caused by the increase in ocean surface water temperatures, which is a byproduct of greenhouse gas emissions buildup in the earth's atmosphere (Geophysical Fluid Dynamics Laboratory 2015).

Other types of coastal storms affect coasts at different times of year, such as nor'easters in the winter. Nor'easters are strong areas of low pressure that produce large waves, snow, and rain. These storms move slower than tropical storms, often lingering off the coast for several days. The resulting continual inundation can be even more damaging than that of hurricanes.

Intense coastal storms and hurricanes significantly affect coastal development and environments. Hurricane winds can exceed 200 miles per hour, resulting in flying debris and uprooting of vegetation (Figure 2.3). Increased intensity of storms induced by climate change will increase tidal flooding and coastal storm surge. The runoff associated with heavy storm rain not only causes erosion; a rapid influx of nutrients and sediments that significantly harm aquaculture and water quality can occur as well.

## CLIMATE CHANGE IMPACTS ON COASTLINES

Climate change and sea level rise have elevated the importance of planning in coastal zones as policymakers work to address these emerging hazards in the context of an already complex set of planning issues, including population growth, economic growth, and environmental protection. The current scientific consensus on climate change is that the influence of human beings on the natural environment has increased atmospheric concentrations of greenhouse gases, and changes in land cover are responsible for global warming and environmental changes. A recent review of nearly 12,000 scientific papers found that one-third took a position on the causes of global warming, with 97 percent of these papers endorsing "the consensus position that humans are causing global warming" (Cook et al. 2013, 1). Another analysis of more than 1,300 climate researchers and their publications found that almost all (97 to 98 percent) of "the climate researchers most actively publishing in the field support the tenets of anthropogenic climate change outlined by the Intergovernmental Panel on Climate Change" (Anderegg et al. 2010, 12107).

*Figure 2.3. Debris removal in Seaside Heights, New Jersey, after Superstorm Sandy (Adam DuBrowa, Federal Emergency Management Agency)*

A technical input paper prepared for the 2013 National Climate Assessment on Coastal Impacts, Adaptation, and Vulnerabilities declared with high confidence that "most coastal landforms . . . are highly dynamic and sensitive to even small changes in physical forces and feedbacks such as warming, storms, ocean circulation, waves and currents, flooding, sediment budgets, and sea level rise" (Burkett and Davidson 2012, 10). Among the other key findings of the paper is that increasing human presence in the coastal zone will alter nature's response to the impacts because the cumulative impacts of land use and other human activities will increasingly inhibit physical processes and adaptation by plants and animals. Also, global sea levels rose at a rate of 1.7 millimeters per year during the twentieth century, but the rate has increased to more than 3 millimeters per year in the past 20 years. Scientific studies suggest a greater than 90 percent chance that global mean sea level will rise between 7.9 inches and 6.6 feet by the end of the century.

Some regions, such as Louisiana and the Chesapeake Bay, will experience greater relative rise due to factors such as land subsidence, ocean circulation changes, regional ocean thermostatic effects, and gravitational redistribution of ice-sheet meltwater[1] (Burkett and Davidson 2012). The report predicts that sea-level rise effects will be greatest and most immediate on low-relief, low-elevation parts of the US coast along the Gulf of Mexico, mid-Atlantic states, Hawaii, and island territories, and especially on coasts containing deltas, coastal plains (flat, low-lying areas adjacent to coasts), tidal wetlands, bays, estuaries, and coral reefs. Beaches and wetlands on steep cliff coasts and shores backed with seawalls may be unable to move landward or maintain their landform with sea-level rise. On the other hand, regions undergoing land uplift, such as Alaska and the northwestern Pacific coast, will experience less sea level rise. The variability in the location and time-of-year storm genesis can influence landfalling storm characteristics, and even small changes in the storm genesis can lead to large changes in landfall location and impact. Any sea-level rise is virtually certain to exacerbate storm-related hazards (Burkett and Davidson 2012).

Rising seas, storms, and flooding pose a number of threats to coastal communities. The resulting loss of beach access and population displacement, in addition to property and infrastructure damage, have the potential to devastate the economies and well-being of coastal communities. Both sea-level rise and the increased frequency of extreme weather events pose the risk of injury and loss of life to individuals proximate to coasts as well as increases in various health risks—from increased disease outbreaks to threats to food and water security. Other climate change impacts include changes in the chemical and physical characteristics of marine systems, changes in migration patterns of marine and coastal species, habitat loss, increased algal blooms, increased nonpoint pollution runoff into coastal waters, and saltwater intrusion into groundwater aquifers and other fresh water drinking supplies. Human activities have the potential to exacerbate the impacts of climate change on coastal ecosystems. Table 2.1 provides a summary of the many climate change and human factors that affect coastal areas.

1. With the gravitational redistribution of ice-sheet meltwater, ice sheets melt and gravity redistributes the water in a counterintuitive way: sea levels near the melting sheet tend to lower while gravity redistributes the increased water volume to other areas and coastlines up to 1,200 miles away. Models show that potential sea-level rise in the Gulf Coast is the result of melting of the West Antarctic Ice Sheet.

**TABLE 2.1. IMPACTS OF CLIMATE CHANGE AND HUMAN EXACERBATING FACTORS ON COASTAL ECOSYSTEMS**

| Climate Factor | Direct Impacts | Indirect/Interactive Impacts | Exacerbating Human-Development Impacts | Ecosystem Responses |
|---|---|---|---|---|
| Sea Level | • Inundation<br>• Erosion<br>• Saltwater intrusion | • Altered patterns of flooding<br>• Upstream salinity changes<br>• Soil salinity changes | • Freshwater extraction<br>• Sea walls/coastal armoring | • Wetland drowning and migration<br>• Reduced viability of mangroves<br>• Beach and mudflat loss |
| Extreme Events | • Storm surge<br>• Waves<br>• Wind scour<br>• Erosion<br>• Drought | • Flooding<br>• Altered flushing and residence times | • Sea walls/coastal armoring<br>• Urban development/ impervious surfaces | • Beach and mudflat loss<br>• Habitat destruction<br>• Altered food webs |
| Precipitation | • Soil moisture<br>• Hydrologic changes | • Salinity changes<br>• Altered water residence times<br>• Increased nutrient loading and eutrophication<br>• Reduced stream flows | • Urban development/ impervious surfaces<br>• Altered nutrient runoff concentrations<br>• Altered sediment delivery<br>• Agriculture/ fertilizers and pesticides | • Changes in distribution of fresh and salt water biota<br>• Altered productivity of fisheries species<br>• Increased harmful algal blooms |
| Temperature | • Soil moisture<br>• Salinity changes<br>• Permafrost thawing | • Reduced stream flows<br>• Altered nutrient and toxin concentrations<br>• Eutrophication | • Freshwater extraction<br>• Urban development/heat islands | • Altered metabolism and growth rates<br>• Altered plant and animal distributions<br>• Local extinctions<br>• Increased harmful algal blooms |
| Wave regimes | • Shoreline retreat<br>• Erosion | • Altered patterns of flooding | • Sea walls/coastal armoring | • Beach and mudflat loss<br>• Wetland edge loss |

*Source: Burkett and Davidson 2012*

## DIGITAL COAST

NOAA's Digital Coast program (https://coast.noaa.gov/digitalcoast) provides data, tools, and training to professionals working in coastal communities. Launched in 2008, the site hosts more than 75 terabytes of data in more than 1,000 data sets from NOAA and other sources. Data range from measures of land-cover change and coastal employment to coastal topographic lidar data used for mapping, based on a laser and light sensor technology that generates precise location and spatial information

Digital Coast also provides over 50 tools to visualize data, including the map-based Sea Level Rise Viewer that shows inundation of coastal communities at varying sea-level rise depths and the Coastal County Snapshots tool that generates information about the economic value of coastal jobs, various flooding risks, and wetlands benefits. Training for specific tools and planning is available as well. One of the trainings is a coastal community planning and development workshop, which examines the impacts of current development patterns as well as alternative types of development that will reduce risks and improve the quality of the natural environment. Further, over 100 case studies illustrate the Digital Coast in action, adding more context for the various tools and datasets.

The NOAA Office for Coastal Management is the lead organization for the Digital Coast project, and it partners with a diverse group of stakeholders and organizations. The partners work to ensure the relevance of tools and data, inform the development of new tools, and help with outreach. The American Planning Association joined the partnership in 2010 and surveyed members in coastal communities about their data needs and most pressing issues in order to assess whether Digital Coast resources were meeting those needs. The majority of the respondents reported that they were competent with geospatial technologies and worked for organizations that use these technologies frequently. The biggest challenge they identified was a lack of knowledge about available data and information. The survey findings highlight the importance of the partnership in connecting coastal resource managers, planners, and other practitioners with information and providing the most relevant products and tools. (More information about the survey is available at www.planning.org/research/digitalcoast.)

CHAPTER 3

# FEDERAL AND STATE COASTAL ZONE MANAGEMENT PROGRAMS

There is a wide array of federal, state, and local programs and regulations in place that are addressing every aspect of the natural and human-made activities that occur along coastlines, most notably beginning with the Coastal Zone Management Act (CZMA) of 1972. The purpose of the law is to "preserve, protect, develop, and where possible, to restore or enhance the resources of the Nation's coastal zone for this and future generations" (16 U.S.C. §§ 1451–1465). This chapter examines the CZMA as well as other federal programs, including the National Flood Insurance Program and an array of state programs across the country.

## COASTAL ZONE MANAGEMENT ACT OF 1972

The CZMA established the National Coastal Zone Management Program and tasked the Office of Ocean and Coastal Resource Management of the National Oceanic and Atmospheric Administration (NOAA) with overseeing the program. (Following the NOAA reorganization at the end of 2014, the Office for Coastal Management was established and currently oversees the program.) The federal program delegates authority to states, which receive funding to prepare coastal zone management plans. Each state is given broad discretion to design and implement programs and initiatives that address the state's specific coastal zone issues.

Of the 35 eligible coastal and Great Lakes states and territories, 34 participate in the National Coastal Zone Management Program. Washington was the first state to join, and Illinois the most recent. In 2011 Alaska voluntarily withdrew from the program thereby relinquishing its funding. Elements of each state's coastal management program vary widely based on priorities and issues relevant to the particular geography. Additionally, states are allowed to delineate and map their own regulatory coastal boundaries and to es-

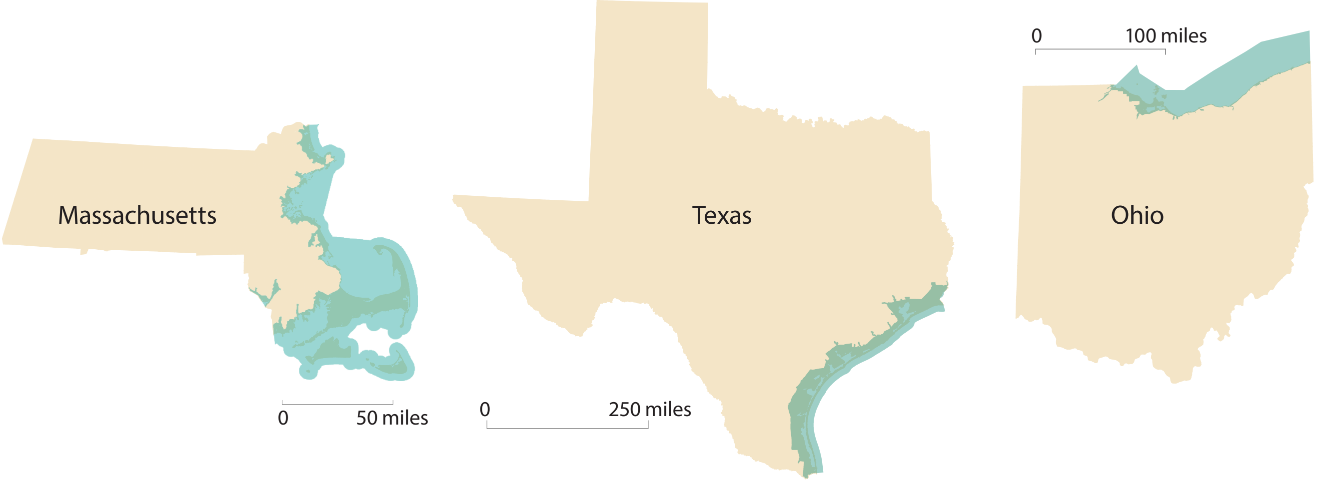



*Figure 3.1. Land and aquatic boundaries for three coastal zone management programs (Data from Massachusetts Office of Coastal Zone Management, Texas General Land Office Coastal Management Program, and Ohio Department of Natural Resources Office of Coastal Zone Management; map created by Elizabeth Felter)*

tablish their coastal zone management programs and specific projects and initiatives based to their own needs (Figure 3.1, p. 21). Each year NOAA evaluates how well states are meeting the federal CZMA goals using five performance standards: (1) government coordination and decision making, (2) public access, (3) coastal habitat, (4) coastal hazards, and (5) coastal-dependent uses and community development.

The Office for Coastal Management also supports states and local and regional agencies with data, technology, and management strategies to meet their coastal zone management goals. Through the Digital Coast website (https://coast.noaa.gov/digitalcoast), the office offers expertise in geospatial technologies and makes its data, trainings, and visualization tools—including GIS extensions and browser-based interactive maps—available to the coastal management community. NOAA administers the federal program funding for coastal zone management programs through two sections of the CZMA:

1. Administrative and coastal resource improvement grants (16 U.S.C. § 1455), which must be matched by state contributions, fund general program costs and the preservation, restoration, and general management of natural resources and coastal infrastructure. Funds are allocated based on a formula considering coastal population and length of coastline in that state, with a cap imposed on states with very long coastal areas or large populations, such as California and Texas.
2. Coastal zone enhancement grants (16 U.S.C. § 1456b) help states develop and implement changes to their coastal programs in nine different "enhancement areas": wetlands, coastal hazards, public access, marine debris, cumulative and secondary impacts of growth, special area management planning, ocean resources, energy and government facility siting, and aquaculture.

In addition to funding, states receive other benefits from participating in the program, such as technical assistance, in the form of tools and training provided by the Office for Coastal Management. The federal consistency provision further encourages participation in the program. This provision affords states discretion over federal agency activities "that have reasonably foreseeable coastal effects" (16 U.S.C. § 1456). Federal coastal activities "must be fully consistent with the enforceable policies of state coastal management programs" (16 U.S.C. § 1456.). The CZMA also created the National Estuarine Research Reserve System to designate specific sites for protection and research. The system currently consists of 28 sites, representing various biogeographic regions around the country, which are funded by NOAA and managed by universities or other state agencies. State coastal management programs collaborate with the program partners and use research data collected through the program.

## NATIONAL FLOOD INSURANCE PROGRAM

The National Coastal Zone Management Program and its state partners regularly collaborate with other federal agencies and programs that are invested in coastal zone management. Planners are likely most familiar with the National Flood Insurance Program (NFIP) (42 U.S.C. §§ 4001-4005), and many coastal communities participate in this voluntary program. Municipalities adopt floodplain management ordinances that meet or exceed federal standards for limiting and protecting development in a Special Flood Hazard Area (defined as the area subject to inundation by the base flood event, which is the flood that has a one-percent chance of being equaled or exceeded in any given year). Once floodplain management measures are in place to reduce future flood risks, property owners and renters can receive federally backed flood insurance. Additionally, in the event of a presidentially declared disaster, communities located in these flood areas must be participating in NFIP in order to receive funds for rebuilding and rehabilitation.

With the addition of the Community Rating System to the program, communities earn points for surpassing federal requirements and then receive further discounted insurance premium rates proportional to points received. Points are earned for actions aligned with the system's goals:

- Reduce flood damage to insurable property.
- Strengthen and support the insurance aspects of the NFIP.
- Encourage a comprehensive approach to floodplain management.

Communities receive points for actions taken in four categories: (1) public information, (2) mapping and regulations, (3) flood damage reduction, and (4) flood preparedness.

The NFIP is undergoing major changes (see "National Flood Insurance Act Reforms") to modernize and digitize flood maps and update flood insurance rates to be more actuarially sound. As updates are implemented at the federal level, local planners will play a key role in updating flood mitigation ordinances and disseminating new maps and information about changes in insurance.

## NATIONAL FLOOD INSURANCE ACT REFORMS

Congress created the National Flood Insurance Program (NFIP) under the National Flood Insurance Act of 1968 because, by mid-century, private insurance companies had largely abandoned the field of flood insurance. In recent years, the NFIP has undergone significant reforms. Most of the reforms have been motivated either by perceived abuses of the program or, more recently, by a desire to place the NFIP on sounder financial footing.

The Flood Insurance Reform Act of 1994 codified the Community Rating System, which incentivized communities to surpass the minimum federal floodplain regulations for a further discount on insurance premiums. This addressed shortcomings of the NFIP detailed in studies of the 1993 Midwest floods, particularly a report by the Interagency Floodplain Management Review Committee (1994) that became known as the Galloway Report.

An evaluation of the NFIP from 2001 to 2006 using a GIS natural-disaster-based modeling program concluded that the program avoided $1 billion in flood damages annually (American Institutes for Research 2006). More recently, however, hurricanes have pushed the program into financial difficulty. Major debts began to accumulate in 2005 after payouts from Hurricanes Katrina, Rita, and Wilma. By 2011 the NFIP debt stood at $17.75 billion (King 2012). Problems with the program had been identified earlier, such as the fact that properties that suffer repetitive loss affect the program significantly. A 2003 study by the US Government Accountability Office found that properties that sustained losses two or more times during a 10-year period accounted for 38 percent of total claims losses but only 2 percent of insured properties (US Government Accountability Office 2003). Caps on flood insurance claims can discourage owners from inhabiting buildings on vulnerable properties and putting themselves at risk. These flood-prone properties are then more likely to be rented out, often at a discount, and attract lower-income tenants who have fewer resources in the event of a disaster. This disproportionately affects vulnerable populations and often results in more federal spending on both disaster aid and flood insurance losses.

To address these concerns, and the growing debt of the program, the Biggert-Waters Flood Insurance Reform Act (Public Law 112-141) was passed in 2012. The act phased out discounts and subsidies, and it incrementally increased insurance premiums over several years to reflect full risk rates. It also called for updating flood insurance rate maps, which would then include many more homes in the floodplain and raise insurance premiums. This reform was met with strong criticism and a grassroots lobbying effort to repeal it, in large part because of backlash over its practical implementation following Hurricane Sandy (which occurred three months after Biggert-Waters was passed). Criticisms of the act included its impacts on the economy and property values and affordability, as rate increases are difficult for low- and fixed-income households. Some property owners alleged that their insurance rates would increase tenfold (Ferraro 2014). The State of Mississippi filed a lawsuit against the federal government for not completing the mandated study on affordability and failing to calculate economic impacts (*Mississippi Insurance Department v. US Department of Homeland Security*). Congress had requested an affordability study from the Federal Emergency Management Agency (FEMA) to further understand financial impacts to property owners and compensation strategies. Hurricane Sandy, however, then struck and the aftermath consumed FEMA resources.

The Homeowners Flood Insurance Affordability Act of 2014 (Public Law 113-89) modified and repealed some of Biggert-Waters. The act limited annual increases in premiums, restored grandfathered rates, allowed property owners who sell their homes to transfer the lower rate to the buyer, designated an advocate for fair treatment of policy holders, and required affordability studies and framework. The National Research Council of the National Academies (2015) has produced the first of two reports on premiums, with a focus on policies, the effects of Biggert-Waters, and options for offering affordable premiums.

Much of Biggert-Waters is still being implemented. FEMA continues the digitization and update of flood insurance rate maps with the assistance of state and local governments and property owners, and preliminary data are available for public review (FEMA 2015). At the end of December 2014, FEMA made a principal repayment of $1 billion but still owes $23 billion to the US Treasury (US Government Accountability Office 2015).

## A BRIEF HISTORY OF COASTAL ZONE MANAGEMENT

In the United States, the public trust has existed since the country's inception, when colonies maintained the lands below the mean high water line for the public purpose. In its earliest form, the public purpose mainly pertained to commerce, fisheries, and navigation (Slade, Kehoe, and Stahl 1997). The later discovery of offshore oil and mineral resources prompted President Truman in 1945 to proclaim US jurisdiction over the outer continental shelf, bringing attention to the idea that the ocean held "something of great value besides fish . . . and that nothing in international law prevented a coastal state from claiming it" (Cuyvers 1984, 148).

While Truman's proclamation made the federal government the authority of offshore waters, the Submerged Lands Act of 1953 (43 U.S.C. § 1301) returned authority to states of the three nautical miles from the mean high water mark (a measurement based on the distance of a canon shot) (Beatley, Brower, and Schwab 2002). Following the most recent Law of the Sea Treaty in 1982, international law now recognizes a twelve-mile territorial sea for the United States, with the three nautical miles closest to the shore under state ownership. However, western Florida, Texas, and Puerto Rico claim nine nautical miles, the maximum allowed by the federal government (NOAA 2015d).

Past the states' boundaries, the United States Exclusive Economic Zone claims jurisdiction over the waters and natural resources up to 200 nautical miles from shore (NOAA 2014). State inland coastal zone boundaries also vary from state to state and are continually being updated. For example, Louisiana recently expanded its boundaries beyond those defined at the start of its coastal zone management program in 1978. The new boundaries incorporate 4,887 additional acres—an over 12 percent increase in total management area—after research concluded that many wetlands under coastal influence were not being adequately protected (NOAA 2012a).

The Marine Resources and Engineering Development Act of 1966 (33 U.S.C. § 1101) established a Commission on Marine Science, Engineering, and Resources—also known as the Stratton Commission. After evaluating the impacts of increasing coastal development and populations, the commission recommended that states continue to be primarily responsible for coastal zone management but that state coastal zone authorities be established to focus on national shoreline goals and objectives. The Stratton Commission report recommended the Coastal Zone Management Act of 1972 (16 U.S.C. §§ 1451–1465), which Congress passed to address growing concerns about the future of coastal regions.

## OTHER FEDERAL PROGRAMS

Other federal programs and agencies that are relevant in state and local coastal management planning include the US Fish and Wildlife Service's Coastal Program (2010), which protects two million acres of coastal wetlands and upland habitats and the National Park Service (2010), which oversees the protection of more than 7,300 miles of shoreline. The Coastal Nonpoint Pollution Control Program is jointly administered by NOAA and the US Environmental Protection Agency (EPA). In addition, the Army Corps of Engineers oversees many of the large-scale infrastructure projects located along coastlines, and the Department of Defense and US Navy both have strong interests in and influence over coastal activities.

The EPA's National Estuary Program, established as part of the 1987 amendments to the Clean Water Act, is a place-based program to protect and restore the water quality and ecological integrity of 28 estuaries located along the Atlantic and Pacific coasts and the Gulf Coast and in Puerto Rico. Each designated estuary is managed by a group of citizens and representatives of local, state, and federal agencies; nonprofit organizations; and the private sector. Each group uses a consensus-building approach and collaborative decision-making process to prepare a comprehensive conservation management plan that is tailored to local environmental conditions and that reflects local community input and priorities.

## STATE COASTAL ZONE MANAGEMENT PROGRAMS

State coastal zone management programs are voluntary federal-state partnerships through which states receive federal funds for program implementation. States develop programs that adhere to basic standards and the following broad national goals:

- Protect and restore significant coastal resources
- Prevent, reduce, or remediate polluted runoff to coastal waters
- Improve public access to the coast
- Minimize the loss of life and property in coastal hazard areas
- Promote sustainable growth in coastal communities
- Provide for priority water-dependent uses
- Improve government coordination and decision making

The CZMA gives states much flexibility in program design in order to address their particular cultural, environmental, and political needs. While coastal management program components vary greatly from state to state, all state coastal agencies collaborate formally and informally with different levels of government and other organizations. To qualify for federal funding, each state much address the following items in its coastal zone management plan:

- Identify the boundaries of the coastal zone subject to the management program
- Define what constitutes permissible land and water uses within the coastal zone (specifically uses that could have a direct and significant impact on coastal waters)
- Identify the state's constitutional, legislative, and judicial authority for its proposed controls over the land uses and water uses
- Include broad guidelines on priorities of uses in particular areas, including those uses of lowest priority
- Describe the organizational structure of the state's coastal zone management program, including the responsibilities and interrelationships of local, regional, state, and interstate agencies in the management process
- Define the term *beach* and describe a planning process for the protection of and access to public beaches and other public coastal areas of environmental, recreational, historical, esthetic, ecological, or cultural value
- Outline a planning process to mitigate impacts of energy facilities in the coastal zone or ones that will affect the zone
- Outline a planning process for assessing the effects of and ways to control or lessen the impact of shoreline erosion and to restore areas adversely affected by such erosion

Table 3.1 (p. 26) provides an overview of state coastal zone management programs.

Planners are involved at every step in the development of coastal zone management programs and, in particular, at the local level where decisions about land use, development intensity, transportation, and conservation are made. The following sections and chapters look at coastal zone management programs and local and regional initiatives across the county. These particular state programs and local initiatives are highlighted because of their success and transferability to other state and local programs. They also all address sea level rise directly, which is one of the most important issues facing planners, policymakers, and citizens in coastal communities today and in the coming decades.

## TABLE 3.1. STATE COASTAL ZONE MANAGEMENT PROGRAM CHARACTERISTICS (2012)

| State/ Territory | Coastal Zone Counties Population | % of State Population in Coastal Zone | Miles of Coastline | Approval Year of Program | Lead Coastal Management Agencies |
|---|---|---|---|---|---|
| Alabama | 604,726 | 12.5 | 607 | 1979 | Department of Conservation and Natural Resources |
| Alaska | 614,259 | 84.0 | 33,904 | — | — |
| American Samoa | 54,719 | 100.0 | 126 | 1980 | American Samoa Department of Commerce |
| California | 28,417,647 | 74.7 | 3,427 | 1978 | California Coastal Commission, San Francisco Bay Conservation and Development Commission, State Coastal Conservancy |
| Connecticut | 2,236,420 | 62.3 | 618 | 1980 | Department of Energy and Environmental Protection |
| Delaware | 917,092 | 100.0 | 381 | 1979 | Department of Natural Resources and Environmental Control |
| Florida | 19,317,568 | 100.0 | 8,436 | 1981 | Department of Environmental Protection |
| Georgia | 651,910 | 6.6 | 2,344 | 1998 | Department of Natural Resources |
| Guam | 160,378 | 100.0 | 110 | 1979 | Guam Bureau of Statistics and Plans |
| Hawaii | 1,392,313 | 100.0 | 1,052 | 1978 | Department of Business, Economic Development and Tourism, Office of Planning |
| Illinois | 5,933,471 | 46.1 | 63 | 2012 | Department of Natural Resources |
| Indiana | 770,546 | 11.8 | 45 | 2002 | Indiana Department of Natural Resources, Division of Nature Preserves |
| Louisiana | 1,884,522 | 41.0 | 7,721 | 1980 | Department of Natural Resources |
| Maine | 993,404 | 74.7 | 5426 | 1978 | Department of Agriculture, Conservation and Forestry |
| Maryland | 3,920,579 | 66.6 | 3,190 | 1978 | Department of Natural Resources |
| Massachusetts | 5,012,707 | 75.4 | 1,519 | 1978 | Executive Office of Environmental Affairs |
| Michigan | 4,851,799 | 49.1 | 3,224 | 1978 | Department of the Environment |
| Minnesota | 251,670 | 4.7 | 189 | 1999 | Department of Natural Resources |
| Mississippi | 379,582 | 12.7 | 359 | 1980 | Department of Marine Resources |
| New Hampshire | 421,939 | 32.0 | 235 | 1982 | Department of Environmental Services |
| New Jersey | 7,984,446 | 90.1 | 1,792 | 1978 | New Jersey Department of Environmental Protection and the New Jersey Meadowlands Commission |
| New York | 16,631,225 | 85.0 | 2,625 | 1982 | Department of State |
| North Carolina | 1,009,491 | 10.4 | 3,375 | 1978 | Department of Environment and Natural Resources, Division of Coastal Management |
| Northern Mariana Islands | 53,883 | 100.0 | 250 | 1980 | Coastal Resources Management Office |
| Ohio | 2,641,005 | 22.9 | 312 | 1997 | Department of Natural Resources |
| Oregon | 1,515,223 | 38.9 | 1,410 | 1977 | Department of Land Conservation and Development |
| Pennsylvania | 3,016,404 | 23.6 | 140 | 1980 | Department of Environmental Protection, Water Planning Office |
| Puerto Rico | 3,674,209 | 100.0 | 700 | 1978 | Departmento de Recursos Naturales y Ambientales |
| Rhode Island | 1,050,292 | 100.0 | 384 | 1978 | Coastal Resources Management Council |
| South Carolina | 1,271,948 | 26.9 | 2,876 | 1979 | Department of Health and Environmental Control |
| Texas | 6,326,058 | 24.3 | 3,359 | 1996 | General Land Office |
| US Virgin Islands | 106,405 | 100.0 | 175 | 1979 | Department of Planning and Natural Resources |
| Virginia | 5,190,204 | 63.4 | 3,315 | 1986 | Department of Environmental Quality, Division of Environmental Enhancement |
| Washington | 4,742,774 | 68.8 | 3,026 | 1976 | Department of Ecology |
| Wisconsin | 2,061,729 | 36.0 | 820 | 1978 | Department of Administration, Bureau of Intergovermental Relations |

*Source: Data from NOAA Office for Coastal Management and US Census; compiled by Elizabeth Felter*

## California

California's Coastal Management Program is designed to comprehensively manage coastal resources using a variety of planning, permitting, public education, and non-regulatory mechanisms. The program is administered by three state agencies: the California Coastal Commission, the San Francisco Bay Conservation and Development Commission, and the California Coastal Conservancy. The three agencies together manage the coast of California, which includes more than 3,400 miles of coastline, inlets, bays, and islands. The commission administers the California Coastal Act of 1976. The act requires the commission to ensure continued public access to the coast; protect sensitive environmental resources, such as rare species, habitats, and wetlands; identify priority coastal-dependent uses; accommodate coastal agriculture uses; and minimize the risks of coastal hazards through planning and permitting of coastal development.

The state delegates responsibility to the 15 counties and 61 cities in the coastal zone to carry out the program mandates through preparation and certification (by the commission every five years) of a local coastal program. This program includes a land-use plan and maps, and it is implemented through local land development regulations, such as zoning codes and coastal permits for projects occurring in the defined coastal boundary. Many of the local coastal programs that have been certified by the commission are adopted as chapters or elements of the city or county's general plan. Local jurisdictions have the option of preparing multiple programs for discrete areas of the coastal zone within their corporate boundary. The commission retains permitting authority for all development in the coastal zone not covered by a local planning program. A case study of San Luis Obispo County (p. 42) illustrates a successful collaboration between citizens, landowners, local officials, the commission, and the state transportation agency to protect a vital roadway from coastal hazards.

## Hawaii

The entire state of Hawaii is within the coastal zone, with preservation of the quality of the natural environment and sustained land and marine resources being particularly important. In 2013 the *Hawai'i Ocean Resources Management Plan*, the guidance document for ocean and coastal zone management, was updated (Hawaii Office of Planning 2013). This updated plan includes performance measurement standards for the first time. The new plan also uses a place-based approach (versus the sector-based approach of the 2006 version) and encourages the collaboration of diverse stakeholders.

In 2011 the Hawaii Office of Planning held workshops, together with NOAA and the Army Corps of Engineers, to

*Figure 3.2. He'eia wetlands restoration on Oahu in Hawaii (Manuel Mejia © The Nature Conservancy)*

develop strategies and policies to address climate change. The materials produced at the workshops led to the state legislature's passing of the Climate Change Adaptation Priority Guidelines of 2012 (H.R.S. §226-109), an amendment to the Hawaii State Planning Act. The Office of Planning is using the resources management plan as an implementation mechanism; all county and state activities must incorporate adaptation priority guidelines into capital improvements, land uses, and other programs. The office is currently in the third phase of the process to designate the He'eia estuary in Kāne'ohe a National Estuarine Research Reserve site. (Figure 3.2, p. 27) The site will be managed by the University of Hawai'i and Hawai'i Institute of Marine Biology. Current activities in Kāneʻohe Bay include sedimentation reduction and restoration of a traditional Hawaiian wetland system that harvests taro and other crops.

## Maryland

Maryland's coastal zone includes more than 3,000 miles of coastline and extends inland to boundaries of the 16 counties that border the Atlantic Ocean, Chesapeake Bay, and the Potomac River. In total, the zone covers two-thirds of the state's land area, and about 70 percent of the state's population lives within it. Maryland's Chesapeake & Coastal Service, a partnership between various agencies, administers the state's coastal zone management program within the state's Department of Natural Resources. Its core goals, which date back to its creation in 1978, are to improve water quality, reduce flooding, and conserve coastal habitats.

Today the CoastSmart Communities initiative is the state's flagship coastal zone management program. The initiative initially undertook three projects in Somerset, Worcester, and Dorchester Counties, some of Maryland's most at-risk coastline areas. Its focus is on helping Maryland cities and counties assess and reduce their vulnerability to coastal hazards, sea-level rise, and climate impacts. CoastSmart staff and their local partners have put together a collection of resources, including the Community Scorecard, the Coastal Communities Initiative competitive grant, Maryland's Coastal Atlas, a model sea-level rise ordinance, and case studies that serve as models for other local governments.

The model ordinance was drafted for use by local governments in Maryland but is transferable to local jurisdictions in other coastal states. It provides a two-part zoning framework for planners to implement adaptive planning measures in coastal areas that are increasingly seeing the effects of sea-level rise. The first is a floodplain conservation district, which aims to protect natural resources and provide for the gradual relocation of development in highly vulnerable areas. The second part is a floodplain accommodation district, designed to allow for continued development while requiring that structures be sited and built to be more resilient. This district may include areas with intense to moderate existing development, some ecologically sensitive resources, and limited viability for hard-shoreline armoring. The model contains zoning provisions for downzoning, increased setbacks, building height and bulk limits, increased freeboard (elevating of a building's lowest floor above predicted flood levels), density limits, and restrictions on rebuilding.

Somerset County enacted its portion of the Chesapeake Bay Critical Area Program in 1988 and implemented county-specific goals for minimizing impacts on water quality, conserving fish and marine plant habitats, and putting into place land-use controls to mitigate the effects of growth and development in the coastal zone. More recently, Somerset County received a grant from CoastSmart Communities to assess the county's vulnerability to climate change and to develop a plan of action, which includes policies and codes that reflect future climate change issues, specifically sea-level rise and coastal storms. The county plans to revise its plans and ordinances to incorporate the recommendations of the vulnerability assessment and action plan.

## North Carolina

In 1981, as part of the Public Beach and Waterfront Access Program, North Carolina acquired public access sites along the coast and, in 1983, in inland areas, including estuary beaches and waterways. The program's enabling legislation (GS 113A-134.1) states that the public interest would be served by providing increased access to coastal waters, public parking facilities, or other related public uses. The program gives local governments matching grants to fund improvements to existing coastal sites, such as the construction of dune crossovers, boardwalks, and parking and sometimes toilets, changing areas, and showers.

A current priority of the program is to identify and acquire unbuildable lots that have the potential to be used as access ways. In fiscal year 1996–97, the program began receiving a percentage of the revenues from the state's Parks and Recreation Trust Fund. Since 1981 over 320 public access sites have been acquired, constructed, or improved using $38 million in grant funds. Additionally, the Surface Waters and Shorelines Act (SL 2013-384, Sec. 160A-203) authorizes cities to enforce local ordinances to protect the public's rights to use state ocean beaches and to regulate placement of personal property on these beaches, both within or adjacent to municipal boundaries.

## Pennsylvania

Pennsylvania has 77 miles of coastline along Lake Erie and 112 miles of coastline along the Delaware estuary. The Lake Erie coastal zone is located in Erie County. It extends inland an average of 1.4 miles and outward to the middle of the lake and to the Canadian border bisecting the lake. The Delaware estuary coastal zone lies within Bucks, Philadelphia, and Delaware Counties. The coastal zone also contains islands, marshes, and shorelands of tributary streams that are tidally influenced. The combined facilities of the Delaware estuary make up the largest freshwater port in the world. Both areas face increasing pressure from development, shoreline erosion, biodiversity losses, and nonpoint source pollution.

Pennsylvania's Coastal Resources Management Program is administered by the Pennsylvania Department of Environmental Protection. The program manages both the Lake Erie shoreline and the Delaware estuary. The Pennsylvania Bluff Recession and Waterfront Access Program (enacted in 1980 and amended in 2009) monitors bluff erosion and establishes setbacks for new building construction in bluff recession hazard areas on Lake Erie. Field staff members from the environmental protection department are in both coastal zones, and they provide technical assistance in interpreting the bluff recession rules and make onsite visits to development projects along the shoreline. The program also provides funding to local planning agencies, including the Erie County Department of Planning and the Delaware Valley Regional Planning Commission, for implementation and coordination program policies and activities. Annual funds are provided to municipalities located in the bluff hazard recession area to administer bluff setback ordinances within the Lake Erie coastal zone. The state also funded an update to a municipal reference document for administering the Bluff Recession and Setback Act. A detailed account of coastal zone management planning in the Neshaminy Creek watershed, part of the Delaware River estuary, is in Chapter 4 (p. 44).

## Virginia

The Virginia Coastal Zone Management Program was started in 1986 with the goal of protecting and restoring the state's coastal resources, habitats, and species. In 1991, the program acquired its first four acres. Since then, the program has set aside a portion of its CZMA Section 306A funds each year to establish a small, continuous stream of funding for the acquisition of coastal and estuarine land with significant ecological and economic value. The initial land acquisition has grown to over 2,350 acres. Nearly 1,200 additional acres have been protected in Virginia through the federal Coastal and Estuarine Land Conservation Program.

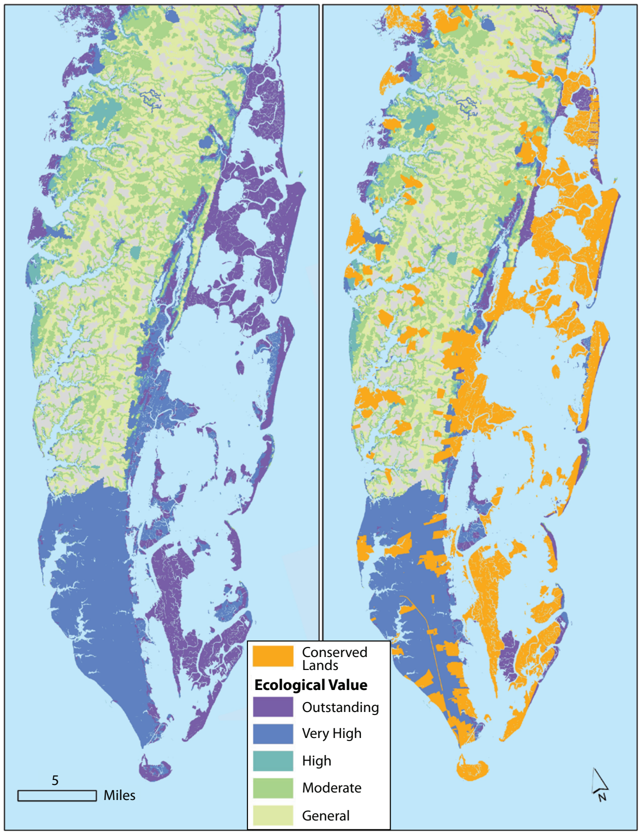



*Figure 3.3. On Virginia's Eastern Shore, conserved lands correspond to lands that rank highly on the Coastal Virginia Ecological Value Assessment scale (Virginia Coastal Zone Management Program)*

Partnerships and leveraged resources play a tremendous role in land acquisition in Virginia. On the Eastern Shore of Virginia, an initial $309,000 in coastal zone management funds for songbird research in the early 1990s led to approximately $35 million from a variety of funding sources for the acquisition of 3,188 acres of critical migratory bird habitat on the southern tip of the shore. The Southern Tip Partnership manages more than 24,000 acres of land in the area that is considered one of the most important migratory bird habitats in the Western and Northern Hemispheres. Selection of the most ecologically valuable lands to acquire and protect in the state has been guided by the Virginia

Ecological Value Assessment, which included data that validated the value of stopover sites for birds earlier identified by scientists and bird banders (Figure 3.3, p. 29).

More recently, Coastal Virginia has begun to benefit from what is hopefully an ongoing trend, private landowners donating sizeable tracts of very valuable waterfront land to regional land conservation authorities. In February 2013, the Middle Peninsula Chesapeake Bay Public Access Authority received 96.81 acres of waterfront property on the Severn River in Gloucester County. Valued at $1.6 million and including thousands of feet of shoreline, much of the property is a pristine coastal ecosystem with emergent tidal wetlands and dense mixed hardwood and pine forests. The authority, a political subdivision created by the Virginia General Assembly for the express purpose of improving water access, has accepted 31 private land donations as of the end of 2014.

Following the authority's lead, the Northern Neck Chesapeake Bay Public Access Authority is positioning itself to manage properties for public benefit. Although no donations of land have been made yet, the office is available to receive donations of and hold easements on land with water access, in addition to working with its member counties to secure funds to provide new public access points to the waters of the Chesapeake Bay and its tributaries. With help from the general assembly and Governor Terence McAuliffe, the Eastern Shore is also now ready to create a public access authority for the region; the 2014 Eastern Shore Water Access Authority Act allows Accomack and Northampton Counties by resolution to declare the need for a public access authority. The Accomack-Northampton Planning District Commission is very interested in pursuing the development of an authority, considering the successes occurring in other regions. The Chesapeake Bay and Atlantic Ocean are vital assets and having such an entity would greatly enhance the ability of localities to provide and ensure public access and use of the water.

## FEDERAL AND STATE PROGRAMS: AN OVERVIEW

The passage of the Coastal Zone Management Act in 1972 provided federal recognition of the importance of coastal zone management. The resulting Coastal Zone Management Program was a partnership between the federal government and coastal and Great Lakes states and territories. Coastal zone management at the federal level has also involved a range of other relevant programs, including the National Flood Insurance Program and the National Estuary Program. As the examples in this chapter have illustrated, each state faces particular challenges in managing its coastal zones, but partnerships and collaborative efforts between state governments, local municipalities, and the public have proven a successful strategy. The following chapters look at coastal zone management programs at different scales and with different geographic boundaries—local programs in communities around the country and programs specific to Great Lakes coastal areas.

CHAPTER 4

# LOCAL COASTAL ZONE MANAGEMENT PROGRAMS

Local planners play a critical role in managing change and responding to challenges that face their jurisdictions. They have experience tackling complex problems of growth and development and are experts in bringing residents and stakeholders together to work positively and productively on planning issues. Planners in coastal communities get involved in coastal zone management through programs and projects that are funded by state coastal zone management programs. These efforts involve other regional and local agencies and nongovernmental entities working together on a variety of initiatives, including erosion and sedimentation control, habitat protection, nonpoint source pollution prevention, and hazard mitigation.

Most coastal communities also participate in the National Flood Insurance Program, which requires mapping of coastal and inland floodplain boundaries and adoption of local ordinances that regulate development in areas identified as floodplains and flood hazard areas. In states where local planning is either mandated or encouraged through statewide legislation (e.g., smart growth or growth management), like Florida and Washington, it has become standard practice for local comprehensive plans, specific plans, policy documents, and development regulations to include implementation directives that aim to fulfill state coastal zone management goals. Local jurisdictions in other states (where planning may be required or voluntary but not subject to state requirements and review) are also increasingly including coastal planning goals and objectives in their comprehensive plans and implementation tools.

## COASTAL AND WATERFRONT PLANNING: AN OVERVIEW

Outside of the context of federal and state regulatory and funding programs, there is a long history in coastal communities of waterfront revitalization planning, coastal environmental protection and restoration efforts, and planning for future growth and development in general. Historically, most urbanized coastal areas in the United States supported a mix and intensity of industrial land uses that changed over time as economic conditions evolved. US coastal cities have been major hubs in the shipping, lumber, fishing, ship-building, and energy industries. The strength of each of these sectors has fluctuated over time. For example, the commercial fishing industry in New England and the mid-Atlantic has probably experienced an equal number of economic highs and lows over time as overfishing, water and air pollution, new or changing government regulations, and competition in the global market have caused perennial uncertainty.

Waterfront manufacturing uses have experienced a steady decline that roughly parallels the overall decline of manufacturing uses in the United States since the 1970s and 1980s. In many waterfront cities, the downward economic spiral was followed by several decades of neglect and deterioration. Industrial sites were classified as Superfund sites or brownfields, which brought attention and resources to cleanup efforts but also stymied interest by investors because of the lengthy and complicated processes required to make the sites developable again.

Many coastal cities, however, began to recognize their former industrial waterfronts as assets they could use to leverage city or regional economic comebacks. This sparked the preparation and implementation of waterfront revitalization plans all over the country. Most of these sought to catalyze tourism development and recreational uses, but many also had goals to protect and maintain the remaining viable waterfront industrial uses, ports, and commercial fishing facilities. Such plans have been developed as standalone special area plans and also adopted as elements or chapters of citywide comprehensive plans.

Baltimore's Inner Harbor is a good example of this story arc. The shipbuilding industry thrived in the harbor in the late eighteenth century. By the mid-nineteenth century, steel production and oyster canning were the dominant industries. After decades of decline, civic leaders launched plans in the 1950s to bring new life and economic activity back to both downtown Baltimore and the harbor. The 1974 Inner Harbor master plan, completed by the Philadelphia-based planning and landscape architecture firm Wallace, McHarg, Roberts & Todd, set the stage for the harbor's transformation from an obsolete industrial district to a waterfront tourist destination with public open space, a brick promenade, and space to accommodate tall ships. Harborplace, a James Rouse-designed waterfront festival marketplace opened in 1977, and the National Aquarium opened in 1981. The public investments spurred private investment of hundreds of millions of dollars in office towers and condominiums in the harbor area.

In 2013, 40 years after the first plan, the city and its public and private partners completed *Baltimore Inner Harbor 2.0* (Waterfront Partnership of Baltimore 2013), a plan to improve the physical infrastructure and programming of the public spaces in the harbor. In keeping with developing planning trends, the new plan expressly addresses the effects of climate change on the harbor. Specifically, it notes the damage rising sea levels have caused on the promenade's electrical system, bricks, and wooden piers. An amphitheater located at the lowest point of the Inner Harbor is affected by frequent flooding, which disrupts the harbor's extremely popular water taxi service. The plan is to raise the grade of the amphitheater and adjacent promenade areas to meet the water level and avoid future flooding. Major investment in restoring the promenade surface and structural support are also planned.

## ADAPTATION AND RESILIENCE PLANNING

Baltimore's plan for the Inner Harbor area includes adaptation planning and planning for resilience, emerging areas of focus for planners. These approaches, described here in the context of coastal zone management and local planning, are also very relevant and transferable to communities that are not adjacent to coasts. Historically, the term *adaptation* has been used to describe the individual actions required to respond to change. The Intergovernmental Panel on Climate Change defines adaptation as an "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC 2007, 869).

Adaptation plans look at all aspects of a community that are both susceptible to the effects of climate change and that are contributors to and causes of it. These aspects include—at the very minimum—population trends, development patterns, infrastructure, greenhouse gas emissions, energy production and consumption, and natural resources. Existing planning and regulatory frameworks are also analyzed to determine what current trends and future projections will affect and be affected by climate change. Adaptation planning often starts with a vulnerability assessment that looks at buildings, infrastructure, and population as well as cultural, economic, historical, and natural resources at risk to the effects of climate change. Adaptation strategies should be dynamic and regularly assessed for effectiveness using the most current climate change research and scientific modeling.

Comprehensive and effective adaptation planning is part of what communities do to build resilience. In coastal areas, NOAA defines resilience as "building the ability of a community to 'bounce back' after hazardous events such as hurricanes, coastal storms, and flooding—rather than simply reacting to impacts" (NOAA 2015f). Another definition of resilience is "the capacity over time of a system, organization, community, or individual to create, alter, and implement multiple adaptive actions" (Rockefeller Foundation 2009, 2). Resiliency planning includes the ability to understand potential impacts and to take appropriate action before, during, and after a particular event to minimize negative effects and maintain the ability to respond to changing conditions.

Resilience strategies involve evaluating and upgrading the lifeline systems infrastructure—communication, power, transit—that are essential immediately following a disaster. Resilience also involves protective infrastructure. Table 4.1 outlines the three general categories of infrastructure: (1) built, (2) natural, and (3) hybrid. Built infrastructure, such as seawalls or breakwaters, has historically been the main means of coastal protection. However, nature-based, or green infrastructure, resilience approaches—such as the replenishment of beaches and dunes—continue to become more widespread. Green infrastructure brings benefits to a community, including carbon sequestration, enhanced and expanded wildlife habitats, improved water quality, recreational opportunities, increased property values, economic development opportunities, and enriched relationships with nature. For example, restoration and construction of wetlands attenuate waves to lessen storm surge and flooding in coastal communities, while also improving habitat and water quality and providing opportunities for recreation.

The nature-based approach requires more holistic thinking and regional action. For example, managing one beach

**TABLE 4.1. COASTAL INFRASTRUCTURE PROTECTION**

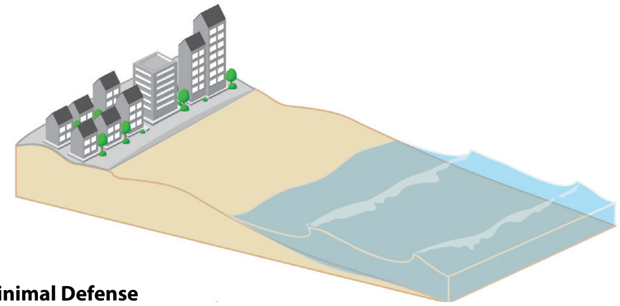
| Infrastructure Type | Examples | Strengths | Weaknesses |
|---|---|---|---|
| Built | seawall, levee, bulkhead | • Significant expertise about how to design, build, and implement these structures<br>• Broad understanding about how structures function and levels of protection they provide<br>• Structures ready for use as soon as they are constructed | • Cannot adapt to changing conditions (e.g., sea-level rise)<br>• Weakens over time and has fixed lifetime<br>• Can have negative effects on coastal habitat and ecosystem services<br>• Can sustain more damage during small storms than natural approaches |
| Natural | salt marsh, mangrove, beach, dune, oyster and coral reefs | • Additional related benefits (e.g., fishery habitat, water quality improvements, carbon sequestration and storage, recreational use)<br>• Can self-recover after a storm or other event<br>• Can sustain less damage after smaller storms than built approaches<br>• Can adapt to sea-level rise<br>• Can be less expensive to construct | • Limited expertise about which strategies to use in which situations<br>• Little data on cost-benefit ratios for projects<br>• Can require significant amount of space, which may not be available<br>• Variable levels of coastal protection depending on the ecosystem, geography, and type of storm event (more research needed)<br>• Can take a long time for establishment of ecosystems that provide necessary level of coastal protection |
| Hybrid | combination of built and natural | • Includes best qualities of built and natural infrastructure protection strategies<br>• Opportunities for innovation in design of coastal protection infrastructure systems | • Limited expertise about which strategies to use in which situations<br>• Little data on performance of systems and best hybrid designs<br>• Little data on cost-benefit ratios for projects<br>• Can have negative effects on species diversity (due to built part of system) |

*Source: Adapted from Sutton-Grier, Wowk, and Bamford 2015*

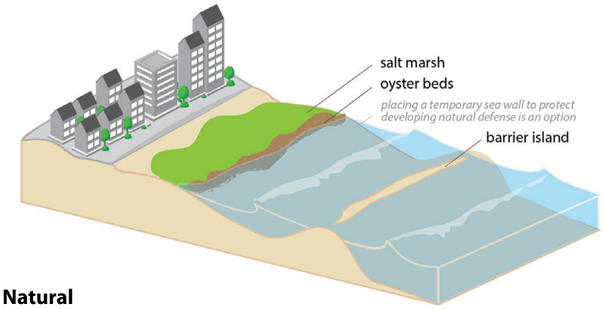
may involve planning for hazard mitigation and storm recovery, accessibility, and regional sediment management. Unlike conventional grey infrastructure, which is easily replicated, green infrastructure designs must be specifically tailored to each location and scaled down to the local level, with more opportunity for public input in the design process. Building strong relationships with stakeholders during green infrastructure project design can lead to their ongoing involvement in the project and its maintenance.

Green and gray infrastructure strategies have their own advantages and disadvantages as outlined in Table 4.1; ultimately, hybrid strategies may provide the most effective outcome (Dow et al. 2013). The integration of strategies allows for a system that balances the range of planning and engineering considerations, including "geophysical setting, desired level of risk reduction, constraints, objectives, costs, reliability, and other factors" (US Army Corps of Engineers 2013, 9). Figure 4.1 (p. 36) shows a hybrid approach that uses built and natural infrastructure brought together to form a cohesive strategy, rather than one that depends only on natural defenses or that employs natural infrastructure to protect existing built infrastructure.

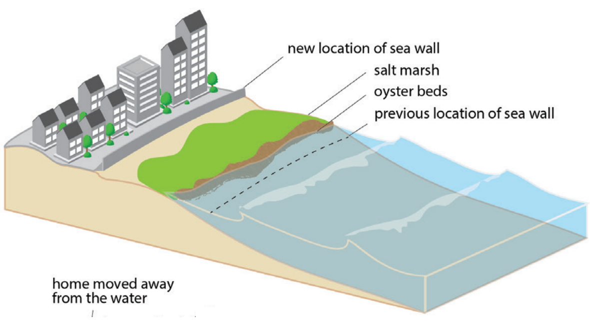
Local planners must also foster social resilience and put mechanisms in place to recover functionality as quickly and fully as possible. Certain populations face greater risks and are more vulnerable to hazards: low-income residents, nonwhites, non-English speakers and immigrants, women (particularly single mothers), children, the elderly, and those



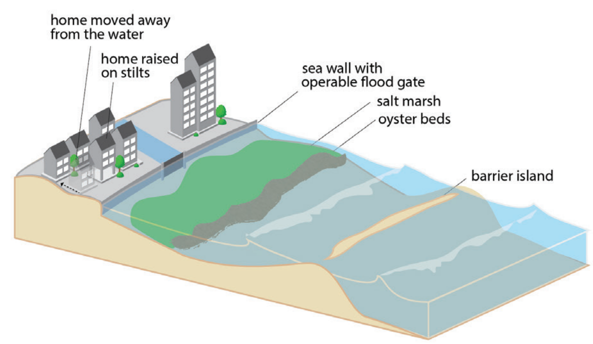
**Minimal Defense**
Many communities have development right along the ocean with only minimal natural defenses from a small strip of beach between them and the ocean.




**Natural**
Natural habitats can provide storm and coastal flooding protection, and a combination of natural habitats can be used to provide more protection (as shown above). Communities could restore or create a barrier island, followed by oyster reefs and a salt marsh. Temporary infrastructure, such as a removable sea wall, can protect natural infrastructure as it gets established.




**Managed Realignment**
Natural infrastructure can be used to protect built infrastructure in order to help the built infrastructure have a longer lifespan and to provide more storm protection benefits. In managed realignment, communities are moving sea walls farther away from the ocean edge and closer to the community and allowing natural infrastructure to provide protection between the ocean edge and the sea wall.




**Hybrid**
In the hybrid approach, specific built infrastructure, such as removable sea walls or openable flood gates (as shown above), are installed simultaneously with restored or created natural infrastructure. Other options include moving houses away from the water and/or raising them on stilts. The natural infrastructure provides key storm protection benefits from small to medium storms. When a large storm is expected, the built infrastructure is used for additional protection.

*Figure 4.1. Examples of coastal defense systems (Sutton-Grier, Wowk, and Bamford 2015)*

with disabilities and chronic health problems (Cutter, Boruff, and Shirley 2003; Heinz Center 2002; Peacock, Hearn, and Gladwin 2000; Peek 2008). Planners have a responsibility to ensure that marginalized populations in their communities are included in planning and communications and that the needs of these people are met.

Social capital is also an important part of developing social resilience. Communities with low social capital have less capacity for adaptation to climate change and for marshalling political will, and they are therefore more vulnerable (Miller and Paolisso 2015). Strong social support systems not only lower fatalities during a disaster but also aid in the emotional and psychological recovery afterwards. Additionally, communities with strong social capital tend to be more accepting of policy interventions (Jones and Clark 2013). Trust in institutions is necessary to develop social capital, and planners can help to build those relationships.

Table 4.2 provides an overview of implementation tools that local governments can use as an adaptation planning response to sea-level rise. Several of the following case studies of local coastal zone management initiatives across the country include examples of adaptation planning and resiliency planning approaches. These case studies help to highlight to diversity of challenges and threats to coastal zones in the United States as well as the range of adaptation and resiliency responses by communities.

## TABLE 4.2. SEA-LEVEL RISE ADAPTIVE LOCAL PLANNING IMPLEMENTATION TOOLS

| ADAPTATION MEASURE | DESCRIPTION | IMPLEMENTATION MEASURES THAT ADDRESS SEA LEVEL RISE (SLR) |
|---|---|---|
| **Planning Tools** | | |
| Comprehensive Plans | Long-range planning tool used to guide future development in a community | Local governments can include SLR data on existing and projected conditions presented in plan, establish goals for community adaptability relative to SLR, address SLR in future land-use policies and scenarios, and incorporate adaptive strategies in plan implementation and land-use decision making framework. |
| Hazard Mitigation Plan | Local or state plan developed for FEMA that identifies and assesses local hazards and outlines strategies to mitigate them (plans establish eligibility for federal mitigation grants) | Mitigation plans can identify a wide range of projects aimed at reducing losses from coastal storms or flooding, such as levees, dune restoration or preservation, coastal setbacks, and land acquisition. |
| Climate Adaptation Plan | Plan to identify specific threats posed by climate change and measures needed to address those threats effectively | Adaptation plans can identify the likely range of climate-induced SLR within the community and strategies, such as retreat or protection, to protect against impacts. |
| Post-Disaster Recovery Plan | Plan developed either prior to or after a disaster for identifying opportunities for improvement using specific post-disaster resources and for responding to likely or real impacts that will affect long-term community recovery | Post-disaster plans can document the real impacts of storm surge related to SLR. The goal is to establish strategies for rebuilding a stronger, safer community that is better protected against SLR during future events. |
| **Regulatory Tools** | | |
| Zoning and Overlay Zones | Major tool for implementation of (or implementing) comprehensive plan goals, specifically for existing and future land use | Zoning ordinance provisions can designate areas that are vulnerable to SLR impacts and classify them according to the adaptation goals (i.e., protection, accommodation, retreat, or preservation). Special zoning provisions can also prohibit or limit expansion or major renovation to existing structures and rebuilding of damaged structures. Applicable regulations in each SLR zone can include variable standards for lots, lot coverage, building height and density (e.g., setbacks, building heights, building densities). Overlay zones superimpose additional regulations on an existing zone based upon special characteristics of that zone (e.g., areas of potential near-term SLR impacts). |
| Floodplain Regulations | National Flood Insurance Program (NFIP) requirement for local governments to enact floodplain regulations that limit development in the 100-year floodplains | Additional restrictions can be imposed on development in floodplains above NFIP minimum standards. Examples include use restrictions in the 100-year floodplain (e.g., limit permitted uses to low-density, large-lot residential, agricultural, or recreational uses) and design requirements in the 500-year floodplain (e.g., requirements that structures be elevated). Typically structures in these areas must be constructed to minimize flood damage (e.g., elevated). |
| Building Codes | Tool to regulate construction to maximize protection from flooding (e.g., elevation and construction techniques and materials) | Building code regulations can be applied to properties in the 500-year floodplain and require that new structures be designed to be more resilient to flood impacts. Building codes can require structures in the 100-year coastal floodplain be further elevated or strengthened to account for increased coastal flooding from SLR over the life of the structure. |

*Source: Adapted from Grannis 2011*

## TABLE 4.2. SEA-LEVEL RISE ADAPTIVE LOCAL PLANNING IMPLEMENTATION TOOLS (CONTINUED)

| ADAPTATION MEASURE | DESCRIPTION | IMPLEMENTATION MEASURES THAT ADDRESS SEA LEVEL RISE (SLR) |
|---|---|---|
| Setbacks/Buffers | Requirements included in the zoning ordinance that development be set back distance from a baseline, typically a shoreline feature (e.g., high water mark, bluff crest, or vegetative line) | Governments can establish or increase mandatory setbacks from the coast based upon projected shoreline position using calculations of increased flood and/or erosion rates; create a tiered setback system for smaller versus larger structures; and require shore-adjacent development to leave portions of property that support natural and beneficial functions (such as wetlands that prevent runoff and flooding) in a natural state. |
| Conditional Development and Exactions | Imposition of special conditions on development permit in SLR-affected areas | Examples of such conditions that could be imposed include prohibitions on hard coastal protection, required removal of inundated structures, mandatory dedication of coastal buffers, and required impact fees for emergency response costs or to mitigate impacts from coastal armoring. |
| Rebuilding Restrictions | Imposition of limits on owner's ability to rebuild structures destroyed by natural hazards, such as flooding | Governments can limit if, when, and how structures are rebuilt by prohibiting reconstruction, requiring that structures be rebuilt using resilient design techniques, or conditioning redevelopment on a landowner's agreement not to armor in the future. |
| Subdivision and Open Space Development | Subdivision ordinances specifying conditions under which land can be subdivided, which may include layout and construction, street lighting, sidewalks, sewage and storm water systems, water supply systems, and dedication of land for schools, parks (open space development—or cluster development—is a type of subdivision) | Governments could encourage concentration of development in upland areas and require dedication of vulnerable areas as open space and flood buffers. Open space development is the grouping of residential properties within a subdivision in order to use the extra land for open-space, recreation, or agriculture activities. |
| Hard-Armoring Permits | Permits that regulate the construction of hard-engineered structures that provide flood and erosion control | It may be necessary to harden the coast where there is considerable existing development or critical infrastructure. However, governments can limit hard armoring along vulnerable coastlines with sensitive ecosystems, require that the armoring be constructed to protect against storm surge combined with increased sea levels, and require mitigation where armoring is permitted. |
| Soft-Armoring Permits | "Soft" coastal protection projects that replenish or mimic natural buffers, such as beach nourishment, living shorelines, or wetlands restoration | Such permitting programs require the use of soft-armoring techniques where feasible in order to lessen environmental impacts of shoreline armoring. |
| Rolling Coastal Management/ Rolling Easement Statutes | Combination of different land-use regulations to ensure that coastal development does not impede the natural inland migration of coastal resources | Rolling coastal management statutes can limit new development in at-risk coastal areas, limit or prohibit the construction of hard-coastal armoring, require removal of structures that come to encroach on public lands due to erosion, and require real estate disclosures. |
| **Spending Tools** | | |
| Capital Improvement Programs | Tool to guide future investments in public infrastructure based upon projections of the community's growth | Capital improvement programs are used to site new infrastructure out of harm's way, discontinue maintenance and repair of infrastructure that is repetitively damaged, or relocate or retrofit existing infrastructure to be more resilient to SLR. |

| ADAPTATION MEASURE | DESCRIPTION | IMPLEMENTATION MEASURES THAT ADDRESS SEA LEVEL RISE (SLR) |
|---|---|---|
| Acquisitions and Buyout Programs | Acquiring of property at risk from flooding or other hazards, with structures typically demolished and the property restored (undeveloped lands are conserved as open space or public parks or for natural resources) | Floodplain buyout programs can acquire properties immediately threatened by SLR and those with high natural resource value, including areas that serve as flood buffers for existing development or that have the potential to serve as corridors for migrating beaches and wetlands. |
| Conservation Easements | Flexible mechanism that allows local government to preserve land in its natural state while allowing land to remain in private ownership | Governments could prioritize acquisition of easements on properties vulnerable to SLR and acquire conservation easements to ensure preservation of lands that could serve as flood buffers, habitat, or migration corridors. |
| Rolling Conservation Easements | Adaptation of conservation easements to provide a rolling boundary that is designed to preserve the ability of the shoreline to migrate inland | Governments use rolling easements to purchase landowner rights in order to construct coastal armoring, compensate owners to remove threatened structures, and encourage new development upland from coast. |

## BILOXI, MISSISSIPPI: COMING BACK AFTER KATRINA

Staff, Institute for Sustainable Communities

The city of Biloxi, Mississippi, is centrally located on the Mississippi coast, approximately halfway between the cities of Mobile, Alabama, and New Orleans, Louisiana. It is home to about 46,000 residents and is the fifth largest city in Mississippi. With 24 miles of coastline and large bayous surrounding it, Biloxi has a rich array of natural resources that have spurred historical and modern-day industries centered on tourism and fisheries.

Biloxi is still rebuilding from the devastation of Hurricane Katrina in 2005. Since the storm, the city has focused on preventing future flooding and stormwater damage by hardening both city-managed and privately owned infrastructure. A key community resilience goal is to improve communication and education about natural hazards for a diverse range of stakeholders.

The city created hazard mitigation and climate change adaptation committees to recommend modifications to existing plans and policies aimed at minimizing future damage from disasters. The committees will broaden their analyses to include climate impacts, such as wildfires and increased heat, and are focusing on ways to share these new insights and collaborate on implementation with a variety of audiences, including policy makers and elected officials, residents, city staff, public sector partners from neighboring jurisdictions, community businesses and private-sector stakeholders, and nongovernmental partners.

### Accomplishments

The city finalized the updated *Hazard Mitigation/Floodplain Management Plan,* and it has been adopted by the city council and approved by FEMA and the Mississippi Emergency Management Agency. FEMA recognized the city for considering the persistent challenge of sea-level rise as part of its all-hazards analysis. The city successfully amended a local zoning code to require one foot of freeboard above sea level for all new construction. This resulted in a reduction of 12 to 15 percent in the overall cost of flood insurance for city residents. Biloxi is one of only a handful of communities in the Gulf Coast that has achieved a Class 5 designation in FEMA's Community Rating System program. The city is now pursuing certification through NOAA's StormReady Communities program, which gauges readiness in six areas: (1) communication, (2) National Weather Service information reception, (3) hydrometeorological monitoring, (4) local warning dissemination, (5) community preparedness, and (6) administration. The city has also adopted and is enforcing a comprehensive stormwater ordinance to reduce the incidence of local flooding.

The City of Biloxi is disseminating flood and natural disaster preparedness information through a 16-page flier mailed annually to all city residents. This pamphlet features familiar preparation guidance together with new information about local climate change impacts. City staff member have been invited to participate in the Harrison County hazard mitigation planning process, which includes the sharing of data about sea-level rise impacts to coastal Mississippi. Nearby municipalities have recently consulted Biloxi municipal staff about incorporating climate change into the planning and policy decision processes and disseminating lessons learned to neighboring jurisdictions.

### Ongoing Challenges

Although the city has made big strides in its hazard mitigation planning and adaptive planning efforts, staff and elected officials see areas for improvement. First, they recognize that the process of educating the public and key stakeholders about climate-related impacts is ongoing and the discussion is broader than just flooding hazards. They are also still working on buy-in from all city agencies for incorporating climate change issues into the planning process. The city still struggles with engaging all relevant groups about the need to protect residents and assets from natural hazards, even on seemingly small matters. An example of this is the city's efforts to convince landscapers that keeping grass clippings out of storm drains is important.

### Bayou Auguste Urban Restoration Project

The wetlands in and around the Biloxi area are the area's defining environmental feature. Their ubiquity makes them an ideal outdoor classroom for the region's school students. In East Biloxi, the Bayou Auguste Restoration Project engages local school children in hands-on environmental education through the restoration of an ecologically important wetland area, Bayou Auguste. The bayou is managed by the Gulf Coast Community Design Studio. This once forgotten natural resource now has the potential to become a focal point of the community and attractive to businesses and tourists. Running west from the Back Bay of Biloxi through a residential neighborhood, the bayou has experienced years of debris pileup and pollution. The bayou has narrowed significantly, and it is often seen as blight on the landscape rather than a valuable natural resource and public amenity.

Bayous are wetland streams in flat, low-lying areas with slow-moving water. Common in the Mississippi River delta, they serve important ecological functions, including purifying water, fostering biodiversity vital to healthy fisheries, and buffering against storm surges and erosion. Unfortunately, many bayous in the Gulf Coast have been drained and developed, or they have become illegal dump sites. This rapid deterioration has led to a significant decrease of wildlife habitat, resulting in fisheries income losses expected to reach $40 billion by 2050.

Recognizing the lost value of the Bayou Auguste and the need to raise awareness in the local community, the Gulf Coast Community Design Studio embarked on an ambitious community-based bayou restoration project that would also provide neighborhood beautification, increased protection from storm surges, and development of an educational asset. From the outset, the organization partnered with local public institutions, including a local elementary school, and engaged the community in a series of design forums and cleanup efforts. Future projects involve construction on a series of park-like amenities, such as expanded wetlands, viewing decks, and walking trails (Figure 4.2).

Early on in the project, the Gulf Coast Community Design Studio partnered with two natural allies: the Biloxi Housing Authority, one of the main property owners in the area, and Nichols Elementary School, which saw the project as a perfect opportunity to expand its curriculum with real-world, hands-on activities. In late 2009, the partners applied for a National Fish and Wildlife Foundation Five Star Restoration Grant, which required five community partners. The City of Biloxi and the Land Trust for Mississippi Coastal Plains were obvious choices, given the organizations' complementary missions. The grant, along with matching funds, totaled approximately $70,000. These funds were used to sponsor community visioning meetings and to hire project staff to manage planning and permitting activities.

The grant also funded an outdoor environmental education after-school program at Nichols Elementary School that addressed ecology, morphology, wildlife biology, and hydrology. In addition, students participated in a stencil art project showcasing wetland species and coining anti-pollution slogans. Students also conducted baseline monitoring activities and collected data on water quality, wildlife counts, and invasive and native species cover; volunteered for invasive species removal projects; and collected and grew native marsh grasses and perennials for the expansion and restoration of the wetlands. In addition, the City of Biloxi committed in-house resources—staff time and machinery from the public works department. This added level of cross-sector collaboration helped the partnership to secure additional funds from the Fish America Foundation and the Gulf of Mexico Foundation's Community-Based Restoration Partnership.

By approaching the Biloxi Housing Authority and the Biloxi Public Schools—two well-established and respected community institutions—early on, the Gulf Coast Community Design Studio was able to count on long-term partnerships and key resources and community perspectives that connect the project to on-the-ground needs and community-level support. The housing authority was able to engage a majority of community members and adjacent property owners, while the schools engaged students in real-world research. These youth have, in turn, become the next generation of advocates for restoring the bayou and decreasing pollution. The project was viewed as a "win-win" solution for all stakeholders with goals in line with those of city officials—to create a nature, park-like setting for this low-income neighborhood while increasing the city's resilience to storm surges.


*Figure 4.2. The Bayou Auguste restoration plan includes public amenities such as a boardwalk, a recreation trail, and viewing decks (Gulf Coast Community Design Studio)*

## SAN LUIS OBISPO COUNTY, CALIFORNIA, AND CALTRANS: PROTECTING CRITICAL COASTAL INFRASTRUCTURE

Michelle Jesperson, California Coastal Commission

Part of the California Coastal Commission's directive is to manage and avoid the risks to public infrastructure posed by coastal hazards. This requires collaboration and coordination with government agencies whose responsibility it is to plan, construct, and maintain public works projects in the coastal zone. In July 2014, the commission approved a coastal development permit authorizing the California Department of Transportation (Caltrans) to relocate a 2.8-mile section of Highway 1 in northern San Luis Obispo County, just north of Hearst Castle and the Piedras Blancas Lighthouse. When the project is completed, the current substantial risks to people and property on this roadway due to coastal hazards will be reduced or eliminated. This is a good example of a project that will achieve several coastal zone management goals: ensuring environmental quality, fostering collaboration among governmental agencies and across disciplines, engaging and educating the public, providing equitable access, and encouraging responsible development and redevelopment.

In the 1990s, Caltrans submitted a coastal development permit application to build a rock revetment to protect the highway from erosion. While the commission approved a temporary permit for the shoreline armoring structure, a condition of the permit required Caltrans to study the feasibility of relocating the highway inland and away from the eroding shoreline. This area of the coast contains many elements that the program is required to protect, including coastal agriculture, public access, and sensitive environmental resources. In addition, much of the area inland of the original highway alignment was private property, complicating Caltrans' ability to relocate the highway. Despite these challenges, Caltrans, the commission, and numerous other public and private stakeholders worked collaboratively for almost two decades to meet the commission's original goals. Ultimately, Caltrans returned to the commission with a coastal development permit application to relocate this vulnerable stretch of highway inland. Pursuant to the requirements of the temporary permit issued in the 1990s, the shoreline armoring will be removed once the highway realignment is complete, and natural shoreline processes will be reestablished along this stretch of coast.

In addition to the benefits that this project offers in reducing risk, Caltrans and the California Coastal Commission ensured that it also protected coastal resources. Paramount to the project's approval is the requirement for a habitat restoration program for offsite restoration and enhancement at Arroyo de la Cruz, a significant coastal wetland that has degraded over time. Approximately 2.8 acres of wetlands will be restored within the abandoned roadbed and adjacent areas that historically supported wetlands. These mitigation actions, along with the other benefits to the project, allowed the commission to approve the project as consistent with the California Coastal Act because, overall, it is protective of the environment.

Caltrans worked extensively and cooperatively throughout the planning process with the commission, other public agencies (including California State Parks), San Luis Obispo County government officials; and other stakeholders, including the public. This allowed Caltrans to develop a project that everyone could support. The long-term planning for the highway also was incorporated into an agreement between the state and the Hearst Corporation, the American Land Conservancy, and the California Rangeland Trust to preserve 128 square miles of coastal prairie rangeland, which includes 18 miles of spectacular coastline along Highway 1.

The realigned highway provides a mostly unobstructed view along the shoreline and will accommodate cyclists along its shoulder. It also, however, reduces the public's ability to access the immediate shoreline due to its relocation inland. Therefore, to continue to provide and enhance shoreline access, Caltrans is required to work with California State Parks to construct, operate, and maintain an off-road section of the California Coastal Trail seaward of the realigned highway. Caltrans is also required to provide parking lots at the northern and southern project boundaries to facilitate use of the trail.

Conditions were included in the permit to ensure that the new section of roadway will not induce inappropriate development. For example, the new road must keep to two lanes. In addition, Caltrans will purchase a deed of scenic conservation easement over 832 acres of agricultural and open space land and scenic easements on either side of the realigned highway. These easements prohibit new development that would be most visible, while allowing the public access trails. Conditions of the permit also require a new access road and retention of an old parking lot from an abandoned motel site that California State Parks plans to convert into a campground. Utility connections to this site were kept but put underground to improve the visual appearance.

Finally, since this project entailed constructing a new roadway in a parallel location inland of the existing highway, it posed potential impacts in terms of adding impervious surface (with resultant runoff and pollutants) and disrupting hydrologic processes, such as seasonal wetlands, groundwater, streams, and drainages flowing to the ocean. As a result, an extensive water quality management plan is being prepared to ensure that the new highway alignment will not cause significant hydrological impacts, polluted runoff will be treated, and drainage patterns will be preserved. Also, as part of the project, the existing culvert crossings that accommodate the three coastal streams in the project area will be replaced by bridges, improving the ecological health of the streams, and the old road alignment and channel crossings will be restored.

## BUCKS COUNTY, PENNSYLVANIA: REDUCING SEDIMENT IN A COASTAL ESTUARY

Alyssum Pohl, National Association of Counties and National States Geographic Information Council

Bucks County is located in the southeastern portion of Pennsylvania and has approximately 625,000 residents. Although there are several riverfront communities, it is an otherwise landlocked county that is part of the Delaware Bay estuary and watershed. The county seat is Doylestown, and the populous southern third of the county lies between Trenton, New Jersey, and Philadelphia. This flat industrial area sits within the Atlantic coastal plain, at about sea level. The area has a long history of large industrial mills and factories producing steel, vulcanized rubber, and plastics; chemical plants; and landfills that receive much out-of-state waste. The central portion of Bucks County is at the urban-rural interface where suburban development abuts farmland and forested areas. The northern portion is much more rural, with bucolic settings attracting tourists. Point sources of pollution, such as industrial and wastewater treatment plant discharges, have historically been the focus of water quality improvements in the county. While these pollution sources are being addressed through mitigation strategies, nonpoint sources of pollution still present a challenge for this area.

### The Challenge

The Neshaminy Creek is a tributary of the Delaware River, which flows to Delaware Bay. The land cover of the 232-square mile Neshaminy Creek watershed includes 24 percent developed, 38 percent agricultural, and 36 percent wooded land. Over 418 miles of streams exist in the watershed, almost half of which have been included in Pennsylvania's list of impaired waters, as defined by the Clean Water Act. This means that even after implementing the required technology-based effluent controls at point and nonpoint sources of pollution, these streams require additional water quality measures through limits on total maximum daily loads (i.e., water pollution caps) to assure future compliance with water quality standards. The daily load analysis showed that more than 75 percent of sediment loading could be attributed to erosion along stream banks, while the remainder was the result of upland erosion and storm runoff, due partly to a 20 percent increase in developed land in the past decade. Problems associated with sediment pollution include clogged storm drains and catch basins, an increased risk of flooding, cloudy water preventing vegetation from growing and animals from seeing food, the increased cost of treating drinking water, impaired fish health, and the altered flow of waterways.

### Interventions

A sediment reduction plan was developed for the Neshaminy Creek watershed (Bucks County Planning Commission 2014) as the first step toward restoring the creek. This plan is a guidance document that assists municipalities in implementing mandatory requirements of the federal Clean Water Act for limiting total maximum daily loads and provides a clear path forward in applying the best practices for creek restoration work. Stakeholders in the process included representatives from county planning commissions, conservation districts, public information departments, police departments, municipal governments, and the Pennsylvania Department of Environmental Protection.

The majority, 86 percent, of the Neshaminy Creek watershed lies within Bucks County, with the remainder in neighboring Montgomery County. The watershed also includes 41 municipalities. Bucks County convened local stakeholders and conducted fieldwork, including stream assessments in key sub-watershed areas, to identify the most challenged areas in the larger watershed. Bucks County maintains responsibility for sharing data collected during the creation of this watershed-wide water quality improvement plan.

The plan stipulates that funding for sediment reduction must be shared across political and property boundaries within the watershed and will help the counties and municipalities implement the plan over a 20- to 30-year period. It also provides specific recommendations for best management practices and the measuring of impacts through ongoing monitoring efforts. Recommended practices include use of riparian buffers, multi-chambered baffle boxes (structures used to remove sediment, particles, and pollutants), vegetated swale and rain gardens for bioretention, the retrofitting of existing dry detention basins, and the construction of wetlands. The plan also recommends several methods for monitoring and measuring total maximum daily loads, including stormwater sampling, pollutant modeling, and photographic documentation. Moving forward, Bucks County will likely continue to function as steward of the watershed plan.

### Outcomes

The willingness of the county to serve as a regional convener and prepare a watershed-wide sediment management plan was a cost-effective alternative to each municipality having to prepare its own plan. The plan provides the 34 municipalities that have "impaired streams" guidance, recommendations, and ways to prioritize areas for implementation. Another benefit is that pursuing additional funding for implementation of the plan is now easier because associated sediment reduction percentages can be calculated using plan recommendations.

Municipalities appreciated the watershed-wide approach, as they had an opportunity to provide feedback, learn about the work of other communities, and share strategies to meet the required sediment load reductions. This example suggests that other jurisdictions wanting to pursue a similar watershed-scale approach should reach out to the stakeholders, municipal environmental advisory councils, and watershed groups, as these groups are typically aware of proposed and existing restoration and retrofit projects in their regions. These groups are also often involved with public outreach efforts and implementation of on-the-ground projects.

## FORT LAUDERDALE AND BROWARD COUNTY, FLORIDA: AN INTEGRATED APPROACH TO ADAPTATION PLANNING

Keren Bolter, Florida Atlantic University

Florida communities are actively addressing coastal flooding in response to increasing risk and exposure as well as a paradigm shift from post-disaster recovery to planning for resilience. A new awareness has stimulated innovative approaches, including increasing partnerships and outreach and employing new risk assessment tools. Adaptation Action Areas are an amendment to the 2011 Community Planning Act (Fla. Stat. 163.3164). They are an optional and flexible plan implementation tool available to Florida cities and counties for addressing sea-level rise adaptation. This new mechanism directs infrastructure away from vulnerable areas, prioritizes funding, and improves resilience to coastal flooding. The distinct risks, assets, and conditions in each community call for localized assessments to develop the most effective adaptation strategies.

### Coastal Challenges in Fort Lauderdale and Broward County

Anchored in the central coastal area of Broward County, Fort Lauderdale is 24 miles north of Miami and about 50 south of West Palm Beach. The Miami-Fort Lauderdale-West Palm Beach metropolitan statistical area is the eighth largest in the United States with a population of almost 6 million in 2014. Broward County draws over 10 million tourists annually, and Fort Lauderdale, with a 2014 population of 176,000, is a hub for recreation, art, music, and entertainment.

Fort Lauderdale includes a significant amount of land at low elevations that is already vulnerable to tidal flooding and storm surge. The sea-level rise affecting Fort Lauderdale is causing higher storm surge, increased flooding, and saltwater intrusion (Figures 4.3a and 4.3b). Saltwater intrusion threatens to contaminate both drinking water and coastal potable well fields. Sea-level rise also causes groundwater lifting because of the landward advancement of a wedge of seawater underlying the Biscayne aquifer. The groundwater is pushed higher toward the land surface and, as water seeps up from belowground and saturates the soil, storage capacity is reduced. This is a distinct threat that cannot be solved by traditional methods of shoreline protection.

In 2012 Hurricane Sandy weakened natural and built coastal armory (i.e., seawalls) in Fort Lauderdale. A month later, high seasonal tides coupled with a strong onshore wind resulted in severe erosion of the remaining beach and the collapse of a 2000-foot section of the Florida A1A roadway. While the city had been well aware of the increasing threat of erosion as due to sea level rises, these two back-to-back events provided a wake-up call for many residents who, perhaps for the first time, were asked to consider how traffic and scenery concerns should be balanced against shoreline protection.

### City, County, and State Activities: A Multilevel Approach

The City of Fort Lauderdale's 2013 community vision plan includes a section called "We Are Ready" that begins with "We are a resilient and safe coastal community" (Fort Lauderdale 2013, 21). This resilience means being prepared for extreme tides, flooding, and storm surge with the following goals: investing in infrastructure, drainage systems, bridges, and roads; protecting assets from inclement weather and high tides; and managing increased water supply demands.

*Figure 4.3a. Las Olas Isles in Fort Lauderdale before a king tide (Paul Krashefski, Broward County)*

The city has been carefully folding resiliency and climate adaptation into a range of other plans, including those related to budgets. In 2014, "environmental benefits" were added as a criterion for the community investment plan's ranking process. The city's budget prioritization methods have shifted towards infrastructure improvements, and the Adaptation Action Areas will allow it to focus more funding on capital improvement projects.

The city also organizes events and outreach to promote goals, including a climate adaptation "open house," an annual survey of residents, stakeholder interviews, town hall meetings with the mayor and city commissioners, and a website (ourvisionftl.com). Next year the city will revise its design standards for infrastructure to integrate climate resiliency and sustainability into planning, designing, and construction.

Broward County has developed an extensive suite of coastal hazard plans and tools, and it integrated the adaptation action area language into its comprehensive plan through the *Climate Change Element*, a document that "provides a framework for integrating the economic, environmental, and social factors of climate change" (Broward County 2013). It states that the county by 2017 will designate adaptation action areas in order to develop policies and enhance the funding potential of adaptation projects. Other components of the county's adaptation strategy include the following:

- The *Enhanced Local Mitigation Strategy* focuses on sea-level rise in the context of risk assessment and economic vulnerability and includes a loss estimation and mapping impacts of different sea-level rise scenarios (Broward County 2012).
- The *Broward County Climate Change Action Plan* and a climate change task force helps the county's 31 municipalities designate Adaptation Action Areas, as needed, in order to prepare and strengthen the community's climate resilience (Broward County 2010).
- Working with the Florida Public Health Institute, Broward County created a regional health impact assessment that examined the health implications of climate change (Florida Institute for Health Innovation, Broward County, and SFRCCC 2014).

Fort Lauderdale, Broward County, and the South Florida Regional Planning Council have been key players in the ongoing efforts of the Southeast Florida Regional Climate Change Compact. The compact—a partnership between Broward, Miami-Dade, Monroe, and Palm Beach Counties—is a regional cooperative framework for setting the adaptation planning agenda in Southeast Florida while also providing a means for state and federal agencies to connect with technical assistance and support. The compact has been successful in changing Florida planning legislation to address changing climate and sea-level rise and prioritize funding for this purpose.

The state, primarily through the Florida Department of Economic Opportunity, sees its role as providing technical assistance, funding, and other support to local governments working with their regions and the state to create opportunities for merging growth and resilience. The Adaptation Action Areas strategy is a way to acknowledge these issues exist and to offer a framework and a common point of reference to address them at the statewide level. The policy is flexible and optional, and communities can tailor the range of tools and strategies for their needs and challenges.


*Figure 4.3b. Las Olas Isles in Fort Lauderdale after a king tide (Paul Krashefski, Broward County)*

## OLYMPIA, WASHINGTON: RESPONDING TO SEA LEVEL RISE

Nicole Faghin, Washington Sea Grant

Olympia is the capital of Washington and sits on Budd Inlet at the southern end of Puget Sound. The downtown is built on fill from dredging Budd Inlet, which began in 1897 and continued until 2007. This area is the retail, entertainment, and cultural center of the city and region, and it is home to numerous public buildings and facilities, including Olympia City Hall, the Port of Olympia, the LOTT Clean Water Alliance, and the Hands On Children's Museum. The public and private improvements in the downtown area represent billions of dollars in investment and are an important part of the city's cultural heritage. The land occupied by the Port of Olympia, located on a peninsula in Budd Inlet, are also fill. Elevations in downtown and the peninsula range from one foot to three feet above high tide, which makes the area vulnerable to the effects of sea level rise (Figure 4.4)

The shoreline of Budd Inlet is zoned into multiple land-use categories, including commercial, public/institutional (e.g., the Port of Olympia), industrial, moderate density single-family residential, multifamily residential, and parks. The largest parcels of undeveloped or underdeveloped property are north of downtown on the shore of Budd Inlet, approximately half of which were light or heavy industrial uses. Other lands are either owned by the City of Olympia's Parks, Arts, and Recreation department or the Port of Olympia. Future development is shifting from industrial uses to mixed-use residential and commercial, predominantly along the eastern portion of the Olympia Peninsula. Redevelopment in downtown is also likely to occur.

*Figure 4.4. Flooding in downtown Olympia, Washington, during a 2012 extreme high tide (Andy Haub, City of Olympia)*

### Sea-Level Rise Challenges

The City of Olympia started to address climate change issues as early as 1990 when the city council appointed a Global Warming Task Force. A 1993 report for the city noted that Olympia was one of the first US cities to look seriously at local impacts of sea-level rise. Projections at that time estimated a sea level rise range of 2 to 5.3 feet by 2100 (Craig 1993). The report identified the areas of Olympia that would be potentially affected by sea-level rise, the types of impacts, and policy considerations for the city going forward. The report also identified the effects of higher flood tides and a higher water table on developed areas, including impacts to the city's sanitary sewer system as well as changes in water quality, potential contamination of surface and groundwater, shoreline erosion, increased landslide hazards, and loss of tidal and estuarine habitat.

From 2008 to 2009, the city engaged in a land-form sea-level rise analysis using lidar remote sensing technology to identify land elevations that were currently or potentially susceptible to tidal changes. These data demonstrated where there might be overland flooding effects as well as backwatering of stormwater pipes in low-lying areas (Figure 4.5). As a result of this analysis, the city determined that near-term priorities should focus on managing marine flows into the downtown via the stormwater pipes. Studies of stormwater system configurations identified key outfalls susceptible to backwatering. Recommendations for regulatory and facility responses to the analysis included raising floor elevations of new buildings and installing tide dates and valves; consolidating stormwater outfalls, thereby re-

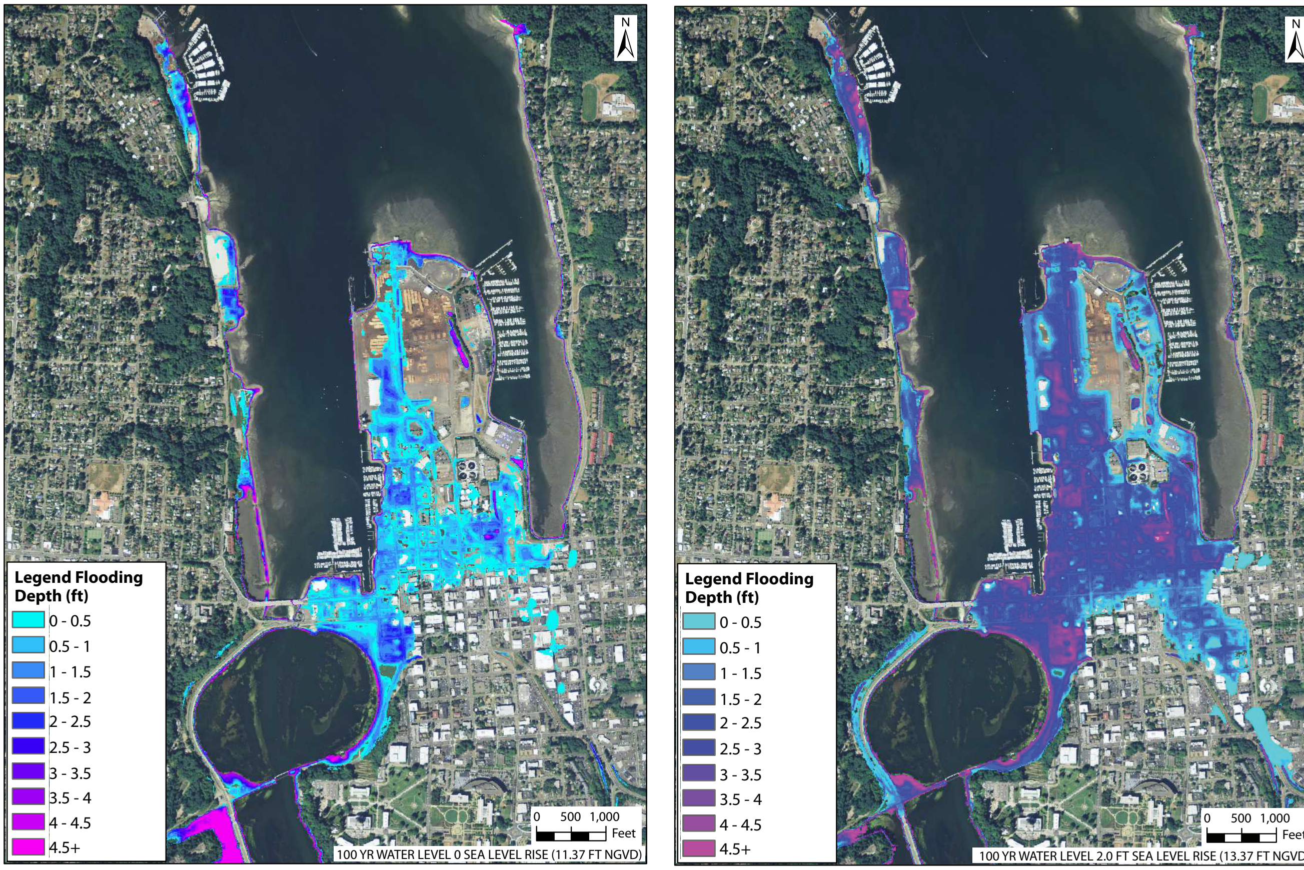



*Figure 4.5. Effects of 100-year flood event in downtown Olympia, Washington, with zero sea-level rise and two feet of sea-level rise (Coast & Harbor Engineering)*

ducing avenues for marine water to flow into downtown; heightening shorelines with redevelopment; and monitoring hot spots and tides.

In 2011 the city commissioned a technical report on the effects of sea-level rise using NOAA's tide data and Olympia-specific floodwater simulations (Olympia 2011). To protect the city's downtown from inundation by the base flood (the flood having a one-percent chance of being equaled or exceeded in any given year), the report recommended interventions, including flood barriers, placement of more valves on outfalls, pipe modifications, and installation of tide gates and pump stations at various outfall locations. An analysis of baseline GIS data, aerial photos, wind data, precipitation runoff volumes, soil and groundwater information, water levels, and land-use details identified vulnerable zones within the project area of the downtown, highlighted the critical facilities affected by potential flooding, and reported where the combined sewer system could receive surface water flowing over low shorelines, even with the existing sea level.

The report also contained varied strategies for the city to reduce flooding risks. These responses included both short-term and long-term strategies that address immediate emergencies and that involve planning ahead to redesign infrastructure to accommodate sea-level rise. For example, the report recommended that in the near term the city should consider temporarily sealing certain catch basins to protect against rare high-water events. Another short-term measure for the port area recommended purchasing a temporary barrier to protect areas subject to inundation and deploying this barrier prior to a high-water event. Long-term recommendations included improving pumping stations and tide gates. By 2012 the City of Olympia had identified a series of engineering response strategies corresponding to various sea-level rise scenarios. Table 4.3 (p. 50) shows the strategies that would be needed at the various increments in sea-level rise.

**TABLE 4.3. PROPOSED RESPONSE STRATEGIES BY INCREMENT OF SEA-LEVEL RISE IN OLYMPIA, WASHINGTON**

| Projected Sea Level Rise (feet) | Proposed Response Strategy |
|---|---|
| < .25 | Implement temporary emergency responses<br>• Seal storm drains at specific locations<br>  • Floodwater flows to the wastewater system<br>  • Floodwater pumped as needed<br>• Sandbag low-lying shorelines<br>Continue with small projects<br>• Consolidate stormwater outfalls<br>• Heighten shorelines |
| > .25 | Adjust different strategies (as emergency response becomes impractical)<br>• Construct priority sea walls to a height of one foot<br>• Install tide gates and small pumps<br>• Upgrade shoreline for utilities and structural stability<br>• Manage Indian Creek/Moxlie Creek flooding |
| > .50 | Increase sea wall construction<br>• Expand and heighten sea walls<br>• Continue installing tide gates and pump stations<br>• Plan construction of large Indian Creek/Moxlie Creek pump station or reroute street drains<br>• Continue consolidating stormwater systems |
| > 1.0 | Implement a downtown-wide protection plan<br>• Plan to protect remainder of peninsula<br>• Construct Indian Creek/Moxlie Creek pump<br>• Increase height of existing sea walls |

*Source: Haub 2012*

## Responding to Sea-Level Rise Threats

One of the City of Olympia's earliest responses to climate change was the use of urban forestry and a tree preservation ordinance. The ordinance's purpose clause describes the ecological importance of preserving trees and other vegetation in an undisturbed and natural condition and also outlines the positive impact of trees and woodland growth on global climate change, as they sequester carbon. Under the provisions of the ordinance, a city-approved tree plan is required for specified activities, and a designated percentage of forest cover must be retained (Schwab 2009).

Low-impact development strategies were initially implemented in the Green Cove Creek watershed, located on the shore of Puget Sound, to improve water quality and address salmon recovery. They also play an important role in addressing climate change. The watershed is protected by regulations requiring narrow streets, small building footprints, and onsite control of stormwater runoff as well as the city's extensive tree regulations (Nature Conservancy 2010). The purpose of low-impact development techniques has expanded, and they are now part of the city's stormwater management response. As climate change brings more erratic and intense storms and rising seas increase flooding risks in Olympia, protective measures such as these will help to mitigate impacts and reduce flooding.

The city has also implemented strategies that various engineering and technical studies have recommended. Another early project is the work completed at Percival Landing, a prominent pedestrian boardwalk shoreline path located on the east side of Budd Bay in downtown Olympia. Constructed in 1978, the wooden timbered boardwalk is one of Olympia's premier attractions and the main public access point to Budd Inlet. In 2004 the Percival Landing boardwalk structure was inspected by marine engineers who found that the wooden creosote pilings, framing, and planks were succumbing to rot and marine organisms.

In 2006 the city council approved a concept plan for Percival Landing (Olympia 2006). The plan outlined a redesign of the park to withstand periods of inundation due to sea-level rise and to restore the environmental, cultural, and historic value of the shoreline. Planned improvements include a new boardwalk, a flexible multiuse space, two interpretive pavilions, and restroom facilities. Additionally, overwater structures will be reduced, and over an acre of shoreline habitat will be restored.

In 2011 the city council directed staff to incorporate sea-level rise policy issues into planning efforts, such as updates to the comprehensive plan and the city's shoreline master program. As city staff began the process of updating these documents, the following key principles provided guidance: protect downtown by understanding the implications of 50 inches of sea rise; incorporate flexibility into public and private infrastructure, through mechanisms such as building elevations, setbacks, and stormwater design; and maintain control of valuable shorelines.

The Shoreline Master Program is the city's strongest regulatory tool to manage development along its shoreline (Olympia 2015), and it launched an update of the program in 2013. The updated plan contains proposed changes to shoreline use and development policies, including the following:

- Continue to develop information about the impacts of sea level rise on the shoreline and other affected properties.
- Develop plans to address the impacts of sea level rise in collaboration with affected property owners, the community, and the Washington State Department of Ecology. The plans should, at a minimum, include flood prevention approaches, shoreline environmental impact considerations, and financing approaches.
- Incorporate measures to address sea-level rise for specific areas of the city's waterfront. Among the regulatory measures adopted with the updated plan is the construction of protective berms or other structures to prevent the inundation of water resulting from sea-level rise.
- Reconcile competing objectives: to improve the natural environment of the shoreline by limiting the amount of hardening and protect the shoreline from rising seas by installing additional hardening of shorelines.

Both the shoreline master plan and comprehensive plan are updated on an eight-year schedule, and the comprehensive plan covers a period of 20 years. Currently, understanding sea-level rise is an important issue, but formulating specific responses has proven more difficult. Disagreements about planning for climate change surfaced during the comprehensive plan update process. For example, one contingent of stakeholders felt that a scenario to abandon downtown should be considered in the planning process, but the city council did not agree. The plan instead includes more general guidance to deal with sea-level rise.

Ultimately, the comprehensive plan helped the city devise the capital facility plan and strategies for infrastructure resiliency. Planning currently is for the near future and for dealing with the immediate impacts of flooding, but more long-term solutions are in development. Following an engineering analysis, the city recognized that the costs of flood protection as a result of sea level rise needed to be included in the budget for the city's capital investment strategy. Specifically, the strategy had to include the costs of flood protection and also account for increased flooding and other effects of future sea-level rise.

City staff is taking a risk management approach, with the potential to expand to climate adaptation in the future. As of late 2015, the city was continuing to research the effects of sea-level rise on downtown, monitoring global climate research, and developing case studies and information relevant to the Pacific Northwest. The city has also allocated a line item in the budget of $75,000 per year for sea-rise-related capital construction.

### Lessons Learned

The planning process in Olympia has clearly shown that the public and the city itself are more likely to take action on something if there is an imminent, easily understandable, and quantifiable threat. In Olympia's case, it was important to begin the conversation with an issue immediately relevant to the community, the Percival Landing pedestrian boardwalk. In addition, detailed research from Vancouver, British Columbia, was useful in educating the public because the two cities share the same coastline and similar geography. The climate change initiative also found an institutional niche within city government, which has helped move it along.

## THE SAN FRANCISCO BAY AREA AND HAYWARD, CALIFORNIA: A REGIONAL APPROACH TO CLIMATE CHANGE IMPACTS

Maggie Wenger, San Francisco Bay Conservation and Development Commission

The San Francisco Bay Conservation and Development Commission conducted the Adapting to Rising Tides (ART) pilot program in partnership with the NOAA Coastal Services Center and with assistance from ICLEI-Local Governments for Sustainability, the Metropolitan Transportation Commission, and the California Department of Transportation (Caltrans). The project was a three-year, collaborative planning effort that addressed two questions:

1. How will climate change impacts of sea-level rise and storm events affect the future of the communities, infrastructure, ecosystems, and economy of the San Francisco Bay Area?
2. What strategies can communities pursue, both locally and regionally, to reduce and manage these risks?

The project area included a portion of the Alameda County shoreline, from the cities of Emeryville to Union City. This sub-region was selected based on local community and stakeholder interests and capacity for participation, the diverse shoreline features, and the presence of regionally significant transportation infrastructure.

The completion of the ART pilot project in 2013 pointed to several geographic areas and issues that needed further assessment, including three focused geographic areas—Hayward, Oakland, and Bay Farm Island—and sector-specific projects focused on community housing, regional passenger rail, and shoreline parks. The Hayward Shoreline Resilience Study involved a collaborative, year-long planning process by a working group made up of local and regional agency staff members. The group developed site-specific vulnerability and risk assessments as well as adaptation responses for individual assets and agencies and the study area as a whole.

### Climate Change Threats and Responses

Hayward is a community of 150,000 in the East Bay of the San Francisco Bay Area. The shoreline of the city is made up primarily of natural areas, including tidal marshes and managed ponds; industrial and commercial land uses; utility infrastructure, such as a wastewater treatment plant; and the eastern approach to the Hayward-San Mateo Bridge that spans the San Francisco Bay.

Hayward has carefully planned and restricted development on its shoreline areas since 1970 through the Hayward Area Shoreline Planning Agency, a joint powers authority between the city, the East Bay Regional Park District, and the Hayward Area Recreation and Park District. The agency has maintained extensive open space for habitat and recreation and studied the effects of sea-level rise since 2010.

The resilience study area covered approximately two square miles of shoreline and included wastewater treatment and discharge, power generation, transportation, recreation, wildlife preservation, and commercial land uses. Staff from three wastewater utilities, both park districts, city planning, the California State Coastal Conservancy, the San Francisco Bay Trail, and the ART program formed a working group that developed four resilience goals to guide the study:

1. Protect the health, safety, and welfare of those who live, work, and recreate in the Hayward shoreline area.
2. Prevent the disruption of key community services by protecting critical infrastructure.
3. Protect the environmental value of the Hayward shoreline area by preserving habitat, water quality, and endangered species.
4. Build organizational and community capacity so stakeholders can work collaboratively to address future conditions.

Mean higher high water could occur during today's 50- or 100-year storm events or as a high tide event near the end of the century. Figure 4.6 shows the areas that would be flooded as the result of 36 inches of sea-level rise. Some assets such as marshes are resilient to short-term flooding but would drown and disappear with permanent inundation. Others, like the wastewater treatment plant, would be severely damaged by even short-duration flooding.

Some vulnerabilities are specific to a particular asset, such as potential erosion of a landfill and subsequent environmental contamination. Other vulnerabilities, like the need for access roads, apply to many assets or the entire focus area. The vulnerability and risk assessment included asset profile sheets as well as focus area vulnerabilities, such as the stringent permitting requirements for marshes and shoreline work, the lack of information sharing between regional transportation agencies and the city about drainage infrastructure, and the need to improve

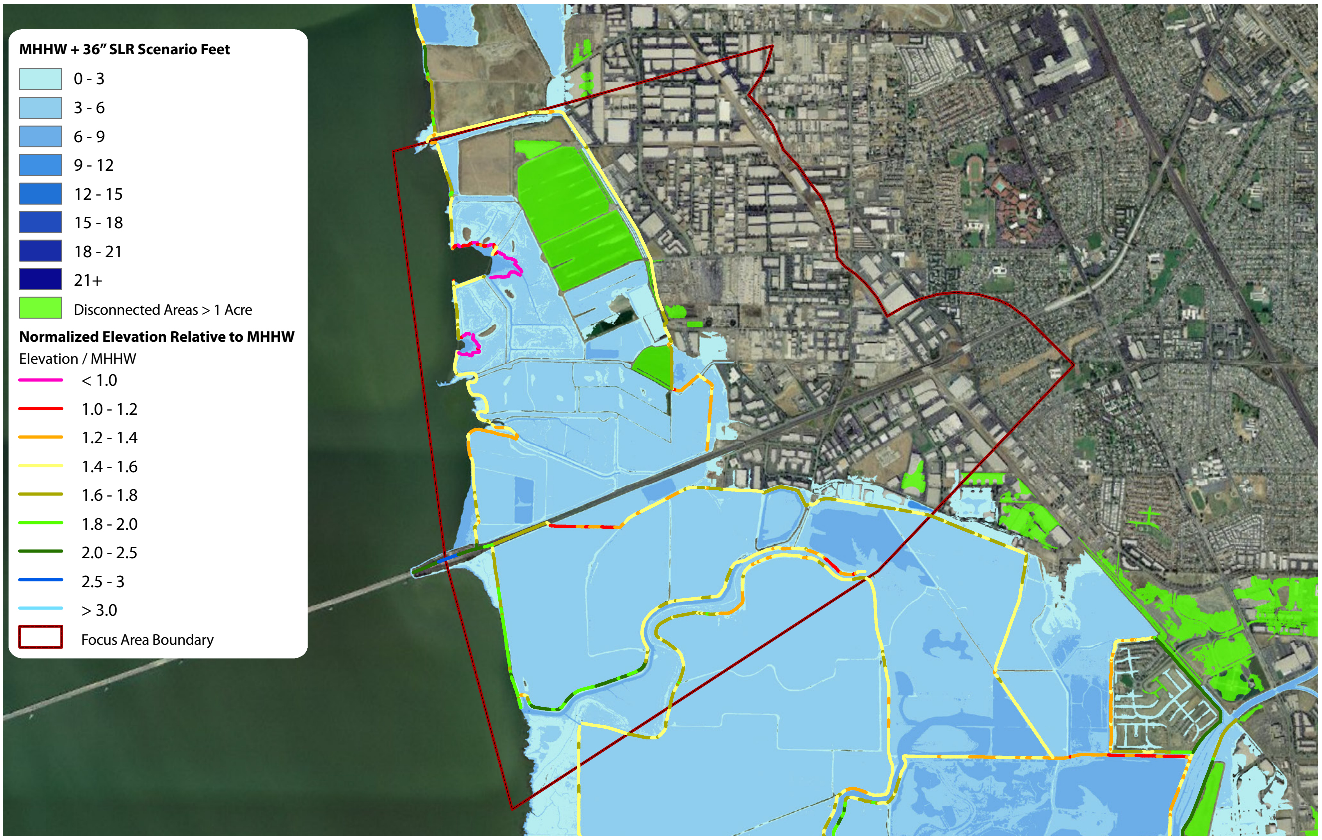



*Figure 4.6. Inundation map of Hayward, California (mean higher high water with 36 inches of sea level rise) (San Francisco Bay Conservation and Development Commission)*

joint wastewater discharge capacity across seven agencies. The study resulted in five key findings:

1. The physical infrastructure that currently protects the shoreline in this area is ad hoc. It comprises historic berms and natural areas and is barely adequate for current storm events. Therefore, it has no capacity to accommodate sea level rise impacts.
2. Disruptions or flood damage in this area would create cascading consequences throughout the San Francisco Bay Area. If the bridge approach is damaged or closed, even temporarily, regional commuter movement will suffer as the Hayward-San Mateo Bridge, which carries 93,000 travelers each day.
3. The current permitting requirements for water quality, shoreline protection, and habitat protection generate added expense in the form of monitoring and mitigation costs, and do not account for unavoidable changes in the environment due to sea-level rise.
4. The Hayward shoreline provides distinct regional environmental education and interpretation opportunities that cannot be easily replaced, due to limited tidal marsh habitat.
5. Because of a patchwork of ownership along the shoreline, any long-term, landscape solution to improve coastal flood protection will require extensive coordination between public and private landowners.

In response to these findings, the working group developed four visions for future of the Hayward shoreline; these scenarios include the retrofitting or relocation of major assets.

**Vision 1: Business as Usual**

This assumes that all property owners do their best to prevent coastal flooding on their properties, without coordinating with their neighbors. In this vision, commercial and industrial areas as well as the wastewater treatment plant and the bridge entrance experience periodic flooding. This flooding would require costly repairs and cause disruptions in the local and regional economy. Without coordinated action, the recreation trails, interpretive center, and marsh habitat in this area will be lost (Figure 4.7).

### Vision 2: Traditional Levee

The shoreline land managers would build a new traditional levee at the edge of current natural areas. This would protect the industrial and commercial development in the area. However, the wastewater treatment plant would lose its overflow ponds and the natural areas would be lost because they would be paved over during level construction. The Bay Trail could be rerouted to the new levee; however, instead of providing a wildlife viewing and natural experience, the trail would follow the border of the industrial park. This option would require coordination between the county flood control agency, the park districts, the city, and Caltrans to ensure that the new levee adequately protects transportation routes and other assets from future water levels.

### Vision 3: Horizontal Levee

A horizontal levee would be constructed across existing overflow ponds to provide a transition zone for tidal marsh habitat. This very shallow levee, with a 100:1 slope instead of a traditional 3:1 slope, would require much more material to construct, but it would protect commercial and industrial development, allow for shallow water discharge of treated wastewater, help tidal marshes persist in this area, and accommodate future environmental education activities. This option would include replacing the approach to the bridge with a causeway to connect habitat restoration efforts north and south of the highway.

*Figure 4.7. Hayward Shoreline Interpretive Center (Ingrid Taylar)*

### Vision 4: No Hard Infrastructure

In this scenario, no levee, seawalls, or other hard shoreline protection would be built or improved. Land uses in the future floodplain—including commercial and industrial areas and the wastewater treatment plant—would be relocated to higher ground. This would require new land-use policies such as the transfer of development rights to relocate private property. Between redevelopment and rebuilding the wastewater treatment plant, this would an expensive approach to implement. Also, businesses and the jobs and the economic activity they provide may leave the city of Hayward permanently.

### Assessing the Visions

For all four visions, the working group went through evaluation criteria that weighed how well each met the study's resilience goals; their financial, technical, and legal feasibility; and the effect of each vision on the sustainability of the Hayward shoreline. The group discussed tradeoffs between the visions as well as how each one could be phased in or combined with elements from others. From this discussion, the working group outlined further assessment necessary to understand the visions and how they would work in the Hayward shoreline area. These include a regional investigation of current and future shoreline interpretation centers; a coordinated, local look at interim possibilities for maintaining and improving existing structural shorelines; and a study of wastewater distribution efficacy on a horizontal levee. East Bay Dischargers Authority, the wastewater discharge agency, obtained a Climate Ready grant from the state to investigate wastewater alternatives. The study will also include the possibility of a horizontal levee.

## Lessons Learned

Throughout the shoreline study process, ART staff has worked to integrate regional sea-level rise vulnerability and risk information, local expertise on assets and community functions, and the best available sea level rise and storm event projections and exposure mapping to fully understand local risks and adaptation options. This study was able to use data and tools developed by NOAA's Digital Coast program, including CanVIS for mockups of future water levels and the Sea Level Rise Viewer for an initial screening of park flooding. Hayward was also a test case for the ART program in using regional information and processes to lead to local adaptation action. The study relied heavily on working group participation, such as field trips so asset managers could hear from one another about perceived flood risk and potential adaptation actions. Moving forward, local agency staff members will implement projects along the shoreline, so increasing their capacity to understand and address sea-level rise impacts is critical. In Hayward and at other ART project sites, staff members have used information from this study and applied it to general plan updates (Hayward 2014) and project design to elements such as segments of the Bay Trail.

As the ART program learns more at the regional and local scales, three core lessons have emerged. First, scale matters, and the implementation of appropriate adaptation responses requires a detailed understanding of the shoreline and land uses. Research, policy development, and planning can all occur at the regional level and support local adaptation, but they cannot supplant the need for local decision making that reflects local values. Second, sea-level rise and storm event impacts will not happen gradually and on a fixed timeline. Planners and managers of all types will need to adopt a threshold mentality that accounts for possible storm events, changes in policy and funding, and political opportunities to implement adaptation. Third, collaborative, comprehensive planning is necessary for successful shoreline adaptation. Agencies and jurisdictions do not have the capacity or authority to address these issues alone. Working together leads to a better understanding of vulnerabilities and possible actions and strengthens relationships critical to future adaptation. The ART program will continue to support local efforts in Hayward, including the efforts of the Hayward Area Recreation and Park District to protect and preserve environmental education as well as local efforts in Marin, San Mateo, and Contra Costa Counties.

## LEWES, DELAWARE: INTEGRATION OF NATURAL HAZARD MITIGATION AND CLIMATE CHANGE ADAPTATION

Wendy Carey, Delaware Sea Grant; Daniella Hirschfeld, The Resiliency Place; and Melissa Stults, Center for Sustainable Systems, University of Michigan

The city of Lewes, located in eastern Sussex County, Delaware, is a thriving community at the mouth of Delaware Bay. Lewes offers the opportunity to experience intimate walkable commercial and historic districts next to beautiful open spaces, including sandy beaches and healthy wetlands. The proximity of Lewes to the bay and the threats from coastal storms and flooding has put natural hazards at the forefront of the city's mitigation efforts.

Lewes was founded in 1631 by the Dutch as the "Swanendael" settlement, and it is often referred to as the "First Town in the First State." Today the city has a population of 2,747 full-time residents and a summer resident population that increases to more than 6,200 people with another 3,000 or more additional single-day visitors on any given summer day. Lewes is bordered by tidal wetlands, tidal creeks and tributaries, sandy beaches, and agricultural land. The city is also transected by a human-made waterway, the Lewes and Rehoboth Canal. The city is made up of residential neighborhoods, a central business district, a beachfront area that extends five miles along the Delaware Bay shoreline, and an active canal front and harbor area in the center of town (Figure 4.8). The topography is generally flat, ranging from sea level along the shores of Delaware Bay to approximately 20 feet above sea level at some of the highest points in the city center area.

### Natural Hazard Threats and Planning

Lewes is a low-lying community with several water features in the area, and the risk of flooding and erosion is very real. The city has been severely affected by a number of major coastal storms and tropical systems that caused significant damage. The Ash Wednesday storm of March 1962, a nor'easter, was the most serious of these storms. It produced a record high tide of 9.5 feet that caused the Lewes and Rehoboth Canal to overflow and resulted in damage to properties along the beach and the canal. Lewes was also affected by relatively major nor'easters in 2008 and 2009, Hurricane Irene in 2011, and Hurricane Sandy in 2012. These coastal storms caused high waves, tides, and storm surge, and they resulted in extensive flooding of low-lying coastal areas, including roads that served as evacuation routes (Figure 4.9).

The city has often been at the forefront of national hazard mitigation efforts. Lewes was an early adopter of the National Flood Insurance Program (NFIP), and it was the first city in Delaware (one of only 200 cities nationwide) selected to participate in FEMA's Project Impact initiative. The project resulted in a flood mitigation plan in 1999 and a hazard vulnerability study in 2000. This work also helped garner support from local officials for an ongoing hazard mitigation program and the appointment of a mitigation planning team. More recently, the city participated in development of the multi-jurisdictional Sussex County multi-hazard mitigation plan, which was adopted in 2010.

Having this specialized planning team has made the city more effective and proactive in addressing its hazard vulnerabilities. The team has improved emergency preparedness procedures and created a controlled burn program to make the city significantly less vulnerable to the threat of wildfires. It meets on a quarterly basis to discuss hazard mitigation projects and climate adaptation

*Figure 4.8. Shore-adjacent development in Lewes, Delaware (Wendy Carey, Delaware Sea Grant)*

planning strategies, plan education and outreach initiatives, and identify strategic opportunities to increase community resiliency.


*Figure 4.9. Storm flooding in Lewes, Delaware (Wendy Carey, Delaware Sea Grant)*

### The Connection to Climate Change Adaptation

While the City of Lewes has historically been well prepared for natural hazards, community residents realized that climate and weather patterns in Lewes are changing and these changes are likely to exacerbate natural hazard impacts. Changes in temperature, rainfall, and sea levels are being observed statewide. Year-to-year and seasonal temperatures in Delaware have increased by 2°F since 1900, and higher summer temperatures have also been recorded (DNREC 2014). While precipitation patterns in Delaware have been highly variable, a slight increase of 2.7 inches in autumn precipitation has occurred over the past century. The tide gauge at Breakwater Harbor in Lewes shows that an increase in the mean sea level equivalent to a change of 1.12 feet in 95 years (1919 to 2014) (NOAA 2013a).

Climate projection models have complemented the analyses of historic trends. Delaware-specific models show that extreme heat and rainfall events are expected to occur more frequently. Annual temperatures are expected to increase another 2.5°F to 4.5°F by 2050, and the number of very hot days (over 95°F) is expected to increase. Heavy rainstorms are expected to become more frequent and more intense, and average precipitation is expected to increase by about 10 percent by 2100 (DNREC 2014).

Climate change will also affect sea levels along the Delaware coast. Scientists estimate that an acceleration of historic rates will cause the level of Delaware's oceans, bays, and tidal rivers to rise between 1.6 feet and 4.9 feet above present levels by 2100 (DNREC 2013). Rising seas will have a number of impacts, including changes in flood patterns in Lewes. Significant flooding is expected to occur more frequently in the future, and floods will affect larger portions of the city and will reach incrementally greater heights at locations that are prone to repeated flooding. Additionally, the combination of sea-level rise and changing precipitation patterns could result in significant effects to regional and local water sources. These model projections for Delaware clearly show that climate change will exacerbate natural hazard impacts in Lewes.

### An Integrated Adaptation and Mitigation Planning Approach

The Delaware Sea Grant, ICLEI, and the City of Lewes worked together to create an integrated climate adaptation and hazard mitigation planning approach using a framework from ICLEI for climate adaptation planning and one from FEMA for natural hazard mitigation planning. A highly participatory process based on local stakeholder input enabled the community to develop its own plan and also involved early input from city staff, city board and commission members, and regional and state partners about current and potential hazard threats.

The workshops helped identify the hazards to which Lewes is the most vulnerable: flood effects to homes, property, infrastructure, and land use as well as impacts to water resources due to precipitation pattern changes, flooding, and saltwater intrusion. Hazard mitigation and climate change adaptations fell into three categories: (1) knowledge-building activities, which include gaining a better understanding of evacuation route vulnerability and creating an education and outreach program; (2) an incentive program to improve the community's participation in the NFIP Community Rating System, which in turn would reduce residents' flood insurance premiums; and (3) planning and regulatory activities. The city adopted the plan in 2011, and it has been in the hands the mitigation planning team, with a focus on implementation, funding, and ongoing communications with the planning commission and partner agencies and organizations (Lewes 2011). Implementation has been a continual process over the last four years, even with the funding and staff limitations faced by a small community such as Lewes. However, even with these challenges, the city has made progress in addressing a number of action plan recommendations.

### Public Education and Outreach

The city has established a public education and outreach program focused on natural hazard and climate impacts, flood risk awareness, flood insurance, and emergency preparedness. The target audiences for this program are residents and visitors, homeowners associations, city staff, and elected and appointed government officials. The program has conducted seminars, workshops, and professional development training sessions. In addition, the city has made emergency preparedness information available online and has distributed printed materials such as newsletters and booklets.

### Planning and Zoning

The city's comprehensive plan update was completed in 2011, and it addresses climate change and natural hazard concerns. The new comprehensive plan, now in the process of being completed, will also address climate change and natural hazards as well as coastal and inland flood hazards, future flood risk, effects of anticipated sea-level rise, and possible strategies for resilient new development and redevelopment (Lewes 2015). One example of the ways in which the plan addresses flooding impacts is the inclusion of two coordinated strategies to deal with coastal flooding, inland flooding, and saltwater intrusion: retrofitting existing development and creating resilient new development. Specific strategies include raising minimum floor elevations to projected flood elevations (rather than to historic elevations); protecting and expanding existing flood storage lands, both open space and undeveloped lands in and near flood-prone and projected inundation areas; and increasing the flood holding capacity of surrounding marshes. In developed areas, in addition to increasing floodwater storage and infiltration by minimizing pervious surfaces, residents are encouraged to install rain and roof gardens and convert lawn areas to natural areas or landscaped beds.

### Leveraging of the Community Rating System

The adopted adaptation action plan was instrumental in helping Lewes obtain a Coastal Management Assistance Grant from Delaware Coastal Programs to improve community resiliency. Like many coastal communities, the city wanted to determine the best way to address increases in flood and storm damage that are expected to result from increased storm surge and rising sea levels. While the NFIP and its Community Rating System have been effective incentives to implement and maintain risk reduction activities, these practices do not account for changing climate conditions and so may not be sufficient. The grant enabled the city to hire a consultant who evaluated the city's current floodplain management program and offered recommendations for specific measures to reduce future flood risk and put the city in a higher category in the rating system.

### Evacuation Route and Critical Infrastructure Assessment

The grant also will also allow the city to assess vulnerabilities in evacuation planning and risks to critical infrastructure. The assessment will include various sea-level rise and flooding scenarios and their effects on evacuation routes and critical facilities. For priority infrastructure, the assessment will include a survey of threshold flood levels for operations. This information will then be used for future hazard and evacuation planning and infrastructure upgrades.

## Lessons Learned

The Lewes, Delaware, experience points to a number of useful lessons for other communities seeking to address their coastal vulnerabilities. Lewes has a tradition of robust civic participation and community cohesiveness. Two groups, the Lewes Mitigation Planning Team and the Lewes Planning Commission, have worked collaboratively for many years on hazard mitigation project and updates to the city's comprehensive plan. These relationships facilitated the creation and adoption of the hazard mitigation and climate adaptation plan. The planning efforts in Lewes also demonstrate that an initial focus on immediate and recognizable threats can be productive. Communities can start by identifying low-cost or no-cost actions that can be implemented to increase resilience in day-to-day operations, with an emphasis on mitigation strategies that complement climate change adaptation efforts.

According to the Lewes plan, the community's strong foundation in hazard mitigation enabled it to fully engage and guide this integration of these two aspects of resilience planning (Lewes 2011). Despite the fact that climate change adaptation and natural hazard mitigation have a clear overlap, local governments must also consider how they are distinct when pursuing integrated approaches. Hazards are extreme events that cause disasters; therefore, hazard mitigation tends to focus on these extreme events.[1] Climate change will exacerbate extreme events causing disasters to be worse. But many of the hazards caused by climate change will come about slowly, and adaptation planning policies take a longer view of climate change effects. Local governments can address the effects of these slow-progressing hazards through interventions such as capital improvements in areas affected by sea level rise, low-impact development policies, and land acquisition.

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1. APA's work on hazard mitigation and pre-disaster planning for post-disaster recovery can guide communities through the steps to ensure communities are prepared for disasters and able to bounce back as quickly as possible after an event. *See* Schwab (2014) for more details.

**Note from the Authors**

This case study of the Lewes hazard mitigation and climate adaptation action plan project is the result of work sponsored by Delaware Sea Grant with funds from the NOAA National Sea Grant College Program, the US Department of Commerce, and the University of Delaware Sustainable Coastal Communities program. The statements, findings, conclusions, and recommendations are those of the authors and do not necessarily reflect the views of Delaware Sea Grant or the US Department of Commerce.

CHAPTER 5

# GREAT LAKES COASTAL ZONE MANAGEMENT PROGRAMS

The federal government recognizes Great Lakes states as coastal zones and allocates funding to them through the Coastal Zone Management Act in the same manner as oceanfront states. Eight states are adjacent to the Great Lakes, all of which participate in the National Coastal Zone Management Program: Illinois, Indiana, Michigan, Minnesota, New York, Ohio, Pennsylvania, and Wisconsin. Great Lakes coastal zone management programs have traditionally focused on erosion control; water quality and nonpoint source pollution; coastal hazards; management of invasive species; habitat protection; economic activity, which includes shipping, commercial fishing, shoreline industry, and energy production; tourism, including recreation fishing, boating, camping, and outdoor activities; wetlands preservation and management; and public access. The states have broad discretion in deciding which of these areas to focus on, both in terms of policy and planning, and in their own grantmaking to local governments and nonprofit groups that implement the initiatives at the local level.

The Great Lakes contain the largest supply of freshwater in the world, holding about 5,400 cubic miles of water, which is equal to 18 percent of the world's total freshwater and about 90 percent of the freshwater in the United States. The lakes provide drinking water to 40 million US and Canadian citizens. Lake Superior is the largest continental lake in the world. Its surrounding region is sparsely populated, not suitable for agriculture, and heavily forested, resulting in very clean water.

Lake Huron is the second largest of the Great Lakes, and it is connected to Lake Michigan by the Straits of Mackinac. Lake Michigan is enclosed entirely within the United States, and it is the largest lake in the world completely contained within one country. Its highly developed southern region contains Chicago and its north shore suburbs, northwest Indiana, and the Milwaukee metropolitan area. Lake Erie, the shallowest of the lakes, has the greatest amount of coastal urbanization, and it receives much agricultural runoff. This combination of factors has made water quality in Lake Erie a perennial challenge. Lake Ontario, the smallest of the lakes by surface area, also experiences some industrial pollution but little from agriculture.

Outflow from the Great Lakes is less than one percent of the total water volume of the five lakes, which means retained pollutants become concentrated over time. The pollutants affect not only water quality but also plant and animal health. Marshes and wetlands preservation are both key to filtering pollution and serving as buffers from flooding and erosion. Water levels in the Great Lakes fluctuate due to climate change, winds and storms, seasonal ice melt, and evaporation. Warmer temperatures increase evaporation, resulting in lower lake levels, which can have significant impacts on ports, harbors and marinas, and shoreline development.

The following three case studies discuss coastal zone management planning issues, efforts, and initiatives at different geographic scales. Four Great Lakes border the state of Michigan, and a statewide project was piloted in five different cities along the coasts of the lakes. In St. Joseph, Michigan, the focus was on developing an overlay district and identifying a setback line for the city's waterfront area. Douglas County, Wisconsin, has two watersheds—one flowing into Lake Superior and a second into the St. Croix River—as well as a number of sub-watersheds and smaller lakes. The county's planning efforts looked to bridge differing perspectives of stakeholders through a watershed-based approach that focused initially on one watershed but will expand to other watershed areas. These examples show the varying and specific environmental and planning challenges communities face in different Great Lakes coastal areas as well as a range of strategies to collect and analyze data, present findings to the public, and engage communities in the planning process.

## MICHIGAN: PLANNING FOR RESILIENT COMMUNITIES INITIATIVE

Claire Karner, Land Information Access Association

Michigan is bordered by four Great Lakes, and it has 3,200 miles of coastline. The state's coastal zone extends 1,000 feet inland from the ordinary high water mark and includes parts of 329 local government units (namely, counties, municipalities, and townships). The coastal zone boundary extends further inland in some locations to encompass important coastal features. The state has been a national leader in coastal zone management, policy implementation, research, education, and training since 1978, when it enacted its coastal zone program. The program has the following current goals and objectives: "promote environmental stewardship based on collaborative community and regional approaches and initiatives, create and enhance public access to the Great Lakes and coastal resources, preserve cultural and historical maritime structures, [and] further the research and knowledge of coastal natural systems to support science-based policies and regulations" (Coastal States Organization 2014).

### Planning for Resilient Communities

In 2013 the state's coastal zone management grant program provided funding to the Land Information and Access Association (LIAA) to help launch the Planning for Resilient Communities project. The initiative was piloted in five coastal cities: East Jordan, Monroe, Luddington, St. Joseph, and South Haven. This integrated effort combined research, public engagement, planning, and local implementation to foster and support local master plans and multijurisdictional planning efforts for community resilience, despite rapid economic changes and increasing climate variability. Part of the community resilience project seeks to understand how coastal communities use shoreline data to inform the planning process and policy decisions.

Researchers from the University of Michigan and Michigan Technological University—two of the project's partners—are investigating ways to improve Great Lakes shoreland area management through local comprehensive plans, regulations, and infrastructure policies. The overarching policy goal is to help coastal communities promote economic vitality while minimizing risks to people and property and improving natural coastal habitats in near-shore areas. This research is also contributing to knowledge about Great Lakes shoreline dynamics, coastal wetlands and other natural habitats, flooding hazards, coastal area policy and law, fiscal impact analysis, and the use of visualization techniques to convey complex shoreline-related concepts. Working with LIAA, the researchers are developing technical methodologies that a typical Great Lakes coastal community could use to incorporate these kinds of assessments into its plans, while studying how localities actually understand and use these analyses.

A major aspect of this research is the development of scenario-based planning tools. These tools will combine climate change uncertainties, captured through a set of "future condition" cases, with a range of potential shoreland area management options that encompass current practice (current zoning), desired practice (incorporating master plan policies not yet adopted), and best practice (incorporating additional and appropriate best practice strategies). For each scenario, the researchers are developing analytical methods to assess potential risks—including lake level fluctuations, storm surge, flooding, and lake temperature variations—along with corresponding potential fiscal, critical facilities, and environmental impacts. In addition to contributing to the academic literature, researchers and LIAA staff will develop training materials about the planning methods created for other coastal localities.

In each project community, LIAA seeks to foster interjurisdictional coordination by engaging cities and villages as well as their adjacent townships. This stems from the belief that land-use planning and regulation and all forms of community development must become more comprehensive, systematic, and inclusive to properly address communities' needs for climate change mitigation and adaptation. Local governments in Michigan that have elected to create a planning commission are required to prepare a master plan (i.e., comprehensive plan) pursuant to the Michigan Planning Enabling Act (P.A. 33 of 2008). From LIAA's perspective, the adaptation and resilience planning frameworks will be most effective if they are integrating into the already established master planning processes of communities. Adaption and resilience planning that is undertaken this way helps establish it as standard that infuses all aspects of planning, rather than just a standalone goal.

### Data Collection and Document Review

At the beginning of the planning process for a community, LIAA gathers quantitative and qualitative information to highlight the relevance of resilience planning and to inform the scenario planning. Local newspaper archives are tapped for details of historic weather events. Climate data, including daily high and low temperatures and precipitation records, are obtained from the NOAA Midwestern Regional Climate Center. Additional climate data and regional projections are solicited from the Great Lakes Integrated Sciences + Assessments project. The University of Michigan research team reviews wave information studies from the US Army Corps of Engineers to model shoreland dynamics. It uses data on wind speed, wind direction, and wave patterns on the Great Lakes to model sediment transport and identify potential impacts of erosion and inundation to shoreland communities.

In the initial project phases, the project team also conducts a thorough review of existing local plans. Master plans and others plans (e.g., hazard mitigation, emergency management, infrastructure, and social services plans) help to provide a complete view of the community. In some cases, local news can also provide important context for the issues that will arise during the planning process. The information gathered helps to inform a vulnerability assessment, which is designed to identify, quantify, and locate populations at risk of certain anticipated hazards, such as extreme temperatures, severe storms, wildfires, flooding, shoreline inundation and erosion, and wind. A population's vulnerability is gauged in terms of its potential exposure to and sensitivity to the hazard. Sensitivity to natural hazards is based on a number of demographic characteristics, including age, general health, and socioeconomics. With technical assistance and expertise from the University of Michigan research team, LIAA creates spatial GIS analyses for populations most at risk at the census block level to conduct vulnerability assessments. These populations include those that are 65 years and over, 5 years and under, nonwhite, living in poverty, and lacking high school educations as well as households with people living alone.

Flooding and heat are the most common climate hazards identified in Michigan's coastal communities, though their impacts vary widely from place to place. To map flooding hazards in project communities, FEMA flood insurance rate maps (50- and 100-year flood zones), soil surveys, and historic data are integrated with the risk of storm surge, wave and wind action, and high lake levels into the overall flooding hazard analysis. Areas of the community most at risk for extreme heat events are mapped through digitization of the tree canopy cover and aerial photography showing the percentage of impervious surfaces—including building footprints—in the community.

## Public Engagement

Public engagement is a critical component of the Planning for Resilient Communities project. The public engagement effort begins with stakeholder interviews in each community. Representatives from the local hospital and schools, police and fire departments, and the aging commission as well as social service providers, emergency managers, public health officials (environmental health and emergency preparedness), and the drain commissioner are usually among the first contacts. These stakeholders provide suggestions for additional contacts, culminating in a day-long leadership summit of approximately 150 elected officials, planning commissioners, business people, and community leaders. The summit includes a variety of educational presentations on climate science, the intersection of climate change and public health, local economies and economic resilience, shoreline dynamics, emergency management and response, and green stormwater management.

The summit also serves as a networking and recruitment tool in the development of topically focused community actions teams. Following the leadership summit, these smaller groups of citizens, elected officials, planning commissioners, and local government staff will work together to address specific topics, including agriculture and food, access and transportation, neighborhoods and infrastructure, human and social networks, energy and the economy, and the environment and natural resources. Each community action team develops topic-specific recommendations for actions that can be incorporated into the master plans of jurisdictions. Every process involves a series of meetings (typically three) where the teams facilitate in-depth discussions and provide community-specific recommendations. The open process achieves consensus-driven results and fosters broader support for the resulting plans.

Each project site has distinct qualities, and a community may identify the need for additional project components or activities. For the Monroe community, LIAA created an extensive resource atlas that combined information gathered for the project with maps, graphics, photos, and contextual details to make the project more tangible and to communicate to a wide audience the direction the community was taking. In a few of the communities, LIAA is conducting three-day multijurisdictional planning charrettes—intensive community-driven meetings—focused on economic and transportation corridors.

## Resilient Monroe and Replicable Models

The inaugural project site was Monroe, Michigan, and it is the first community to complete the project. The planning effort resulted in the implementation of a number of resilience actions. The City of Monroe partnered with the Monroe Community Foundation and received funding to forge cooperative arrangements for maintenance of public land acquired for the *River Raisin Heritage Corridor East Master Plan* initiative, as much of this land will serve as temporary flood storage. The city also applied for a grant from Partners for Places to create an Office of Neighborhood Sustainability that will form neighborhood associations and implement low-impact design and other resilience actions.

The University of Michigan research team is working to create an easily replicable process for evaluating the dynamic nature of shoreland areas. The team and LIAA together are creating educational materials to guide future coastal communities through the entire Planning for Resilient Communities planning process. This information will help facilitate wider adoption of the techniques and tools used and inform communities considering such a process about the type of work and activities necessary.

### Lessons Learned

LIAA and the project team have noted several challenges, identified critical factors for success, and found opportunities to improve the reach of the project in the future. Recruitment of project communities has required more labor and time than anticipated. The timing of the project in a community ideally should coincide with existing plans to update the master plan. Even when that timing is right, local staff and officials need to be willing to commit to a very intense process—something that not every participant is eager, or even able, to do. An additional challenge emerges in the attempt to engage communities in a collaborative process that spans a more regional area and not just the boundary lines of a single city, town, village, township, or county.

In addition to local units of government, the planning process may involve working more closely with nonprofit and social services groups to help empower them to be agents of change in their own communities. Many groups are working on various aspects of climate resilience, though they may not explicitly refer to this work as such. Yet they often are not involved in the municipal planning process. LIAA hopes to help more of these groups integrate resilience into their work and to get those groups more involved in the community planning process. This added collaboration not only brings good ideas to the planning table but also sustains long-term implementation and community education efforts.

The Planning for Resilient Communities project showed that community education is an essential component of the planning process and results in policy and practice recommendations with more traction. A community planning process that seeks to engage its citizenry will also encounter a range of viewpoints and approaches to planning for resiliency. By providing the community with the tools and data upfront, the process sets the stage for effective dialogue about complex issues and encourages the creation of realistic strategies for the future.

The planning process is also challenging because many communities have significant local concerns that outweigh a seemingly unpredictable threat like climate change. However, planning for resilience can help create a strong local economy, encourage smart infrastructure investments, preserve natural resources, and increase energy efficiency. From this perspective, increasing a community's capacity for resilience can also improve it in other significant ways not directly related to climate change.

## ST. JOSEPH, MICHIGAN: LAKEFRONT OVERLAY ZONE

Bridget Faust, Association of State Floodplain Managers

St. Joseph, Michigan, is located on the southeastern shore of Lake Michigan, approximately 50 miles west of Kalamazoo and 95 miles east of Chicago. Although the city itself only is 4.8 square miles in area, it has a considerable amount of waterfront within its jurisdiction, including the St. Joseph Harbor, St. Joseph River, and several miles of Lake Michigan shoreline. St. Joseph is an example of sound science, in conjunction with public participation, being effectively used to improve public awareness of coastal hazards. This ultimately generated support for a zoning ordinance that will preserve public trust lands and protect both public safety and private property along the shore into perpetuity. Specifically, the City of St. Joseph addressed encroachment by private development on the shoreline. This was sparked by an application by a landowner for a permit to install hard infrastructure to ward off coastal erosion on the landowner's lakefront property. The eventual outcome was the adoption of an overlay district.

Just north of the St. Joseph River is a residential area where the homes are built at shoreline level. Decreasing lake levels over time had created more presumably developable land that was in high demand by homebuilders. Over time, as lake levels dipped below average and the demand for lakefront property increased, these lots were divided and homes were built closer and closer to the shoreline (Figure 5.1). In 2009 a new lakefront home was built very close to the lake at a time when lake levels were at a record low. The development application was in compliance with all federal, state, and local regulations. Just two years after the home was completed, the city received an application from that same homeowner for a permit to build a large seawall to protect the property from erosion caused by waves. This was the first such request from a homeowner in the neighborhood. The shoreline in question had more typically been accreting; however, at least one storm brought sustained northwesterly fetch winds (i.e., winds that had traveled more than 150 miles across Lake Michigan), which had put the neighborhood at risk for extreme storm surges (St. Joseph 2012).


*Figure 5.1. The area north of the St. Joseph River reveals multiple lines of development, moving steadily closer to shore (Association of State Floodplain Managers and US Army Corps of Engineers)*

Adjacent property owners and the surrounding community raised objections based on concerns that the proposed seawall would aggravate erosion along the beach and limit public access to the shoreline. Extreme erosion and damage to lakefront property due to lake level fluctuations were not new challenges for the city; these are an ongoing and recurring problem caused by shifts in what is perceived as a "normal" lake level. This case prompted the city to find a long-term solution to a historical problem.

### Challenges, Issues, and Concerns

Soon after the city received the homeowner's permit application for the seawall, it placed a temporary hold on all coastal construction in the area. To evaluate the options available, the city contracted a local engineering firm to do a complete a coastal engineering study on the area and provide recommendations. The consultant was tasked with finding solutions that took a number of issues, described in the following sections, into consideration.

#### Public Perception of Long-Term Cyclical Change

Long-term cyclical changes in water levels influence the severity of the hazards associated with living along the shore (St. Joseph 2012). Property owners' awareness of these hazards tends to come and go with the appearance, heightening in times of high waters or after severe events and diminishing as water levels abate and weather patterns return to what is considered normal (Morphey 2013). Any policy solution to prevent further encroachment on the shoreline and further property damage would have to take into account both the cyclical changes in water levels and hazards as well as the variability in the public's awareness about the risks associated with shoreline development.

### Preserving the Public Trust Lands

The public trust doctrine originates in ancient Roman law and English common law and has been developed through case law in the United States. The doctrine maintains that states are obligated to protect the public's access to certain state-owned resources for their use and enjoyment, a responsibility that states cannot abdicate. The doctrine applies to navigable waters, like oceans and the Great Lakes, as well as freshwater rivers, lakes, streams, and ponds. In accordance with the precedent set by the Michigan Supreme Court, the State of Michigan has a duty to protect the public's access, recreational use, and enjoyment of all lands at or below the ordinary high water mark along Lake Michigan's shore (Norton, Meadows, and Meadows 2011).

As a result, public trust lands can seemingly grow as water levels lower and shrink as they rise. This definition was perceived as an immediate threat and a major concern for much of the general public in St. Joseph. Homeowners in the area had witnessed firsthand as a house that had once been set back a reasonable distance from shore was now so close that the public trust beach had all but disappeared in front of it. Recognizing that this scenario would likely become more common if no action was taken, the public maintained that whatever solution was implemented must preserve their interest in these lands. In order to ensure that the solution implemented would effectively protect future development from extreme events and other long-term changes to the shoreline, various concerns were taken into account.

*Water level fluctuations.* NOAA has consistently monitored and recorded the water levels of the Great Lakes and has historical data going back to 1860. The Great Lakes undergo seasonal, short-term, and long-term water level fluctuations to various degrees. Lake Michigan has experienced sustained below-average water levels since 1999. However, if previous trends are indicative of the future, these levels are expected to return to average or above-average levels (St. Joseph 2012).

*Coastal storms.* Coastal storms frequently pass through the Great Lakes region, in some cases with hurricane-force winds. These storms can cause hazardous storm surge and waves. The St. Joseph shoreline is often battered by a strong northwest wind fetch that pushes waves together across 150 miles of the lake's surface. The fetch can cause storm surges of greater than three feet and near-shore waves in excess of 10 feet (St. Joseph 2012). Strong winds can also generate a seiche, which is the sudden occurrence of a large wave or series of waves caused by air pressure changes and strong downbursts of wind that move rapidly across the lake.

*Erosion.* Coastal erosion along the Great Lakes is a product of storm waves, instability in slope soils, surface water runoff, and other natural factors. Coastal erosion can also be aggravated by the construction of shoreline protection structures, such as bulkheads and seawalls (St. Joseph 2012). When shoreline protection structures are constructed parallel to the water's edge, they reflect and amplify the energy from impacting waves. This reflected energy can force sand at the base of the structure to be lifted into the water column and carried away, and thus increase the rate of erosion. These structures also have the potential to interrupt the regular movement of sediments by creating a physical boundary behind which sediment is ultimately retained. In the long term, the construction of these structures can also have significant impacts on long-shore transport regimes, causing unnatural erosion and deposition on down shore properties and sand starvation of downdrift beaches.

### A Zoning Solution

The consulting engineers recommended that the City of St. Joseph consider enacting an overlay zoning district along the coastal zone that would take into account each of the previously mentioned coastal hazards, lake level fluctuations, and a safety factor of two additional feet in elevation. The city agreed to pursue this strategy, recognizing that the ordinance would serve as an enforceable standard and can be amended in the long term.

### Public Involvement

Planners are well versed in the importance of and the approaches used to engage the public in local planning and land use decisions. Environmental scientists and engineers do not typically include the same level of public engagement in their technical decision-making activities. In the city of St. Joseph, members of the community were engaged and involved from the very beginning, including in the selection of the firm to conduct the engineering study. Their interest was driven by the desire to maintain the


**2,650′ North to 4,575′ North**

*Figure 5.2. Section of Edgewater Beach setback distance diagram showing parcel lines (yellow) and building lines (black) (Edgewater Resources, LLC)*

status of public trust of the lakebed along the shore and to protect private development in every respect (Matusak 2012). Ultimately, the city staff, experts, and citizens worked together to define the problem and approach the fact-finding process. This cooperation helped in the completion of a study that was grounded in sound science and that could be trusted as a legitimate and authoritative source of information by both the city commission and general public (Ozawa 1996).

### Public Education Follow-Up

The need for public engagement frequently arises when a subset of the general public voices concerns about a political issue. Before making any decisions related to the issue in question, steps must be taken to engage the broader public in order to ensure that outcomes reflect the interest of the entire community and not merely the concerned group that first raised the issue. After the completion of the original engineering study, the City of St. Joseph accomplished this through the use of educational meetings.

The process the city developed was designed to disseminate study findings and generate discussion around the proposed setback line. Over the course of five regularly scheduled city and planning commission meetings, the consulting engineers led discussions and answered questions about the short- and long-term cycles of Lake Michigan water levels, coastal hazards, the potential impacts of shoreline protection structures, and the process used to determine the placement of the proposed setback line (Morphey 2013). These meetings allowed interested citizens and city staff to come together, ultimately alleviating the uncertainty about the situation being considered. As a result, the study served as a facilitator of sorts for further discussion between the public and the city commission (Ozawa 1996).

To promote the public's understanding of the data being used to support policy decisions, most notably a proposed setback line for shoreline development, the engineering firm used maps, diagrams, and easily understandable terms to explain complex coastal processes. This particular information-sharing approach was effective in demonstrating for the St. Joseph community how the new setback could protect public trust lands along the beach and prevent private property owners from developing in areas potentially at risk. This process fostered a collaborative environment in which a mutual understanding of the necessity of the proposed setback line developed between city staff, project partners, and the general public (Morphey 2013).

### Outcomes of Interventions

Ultimately the public engagement process facilitated the passage of the Edgewater Beach Overlay District in 2012, which is now part of the city's zoning ordinance. This overlay zone applied a fixed setback line to the shoreline north of the St. Joseph River, lakeward of which no new permanent structures could be built (Figure 5.2). The setback was designed to maintain public access along the beach and to prevent losses to private properties by ensuring that the coastal hazards associated with severe storms on Lake Michigan during high water level periods would not reach them (St. Joseph 2012).

Critical considerations for coastal managers when implementing similar coastal zoning ordinances are the terms under which variances are granted and the timeline within which the ordinance needs to be reviewed and updated. Although these factors will vary from community to community, both will significantly affect the effectiveness of the ordinance in question. To ensure that new setback lines continue to fulfill their purpose, it is essential that their locations be reviewed on a regular interval—for example, for a fixed number of years or a set change in water level. With the passage of the ordinance in St. Joseph, it was recommended that the setback be reviewed a minimum of every 10 years, or after a four-foot change in lake level has been observed (St. Joseph 2012). If such considerations are made and such setback lines are revised in an orderly and regular manner, they can be guaranteed to continue to fit the specific needs of the community well into the future.

## DOUGLAS COUNTY, WISCONSIN: WETLANDS CONSERVATION PLANNING

Alyssum Pohl, National Association of Counties and National States Geographic Information Council

Located in the northwest corner of Wisconsin, Douglas County is a primarily rural county with a population of about 44,000. The Fond du Lac Indian Reservation is located just over the state boundary in Minnesota. Tribal members have rights to harvest natural resources in the trust lands of the county, and tribal considerations therefore are part of county planning efforts.

The county has two major watersheds: one that flows north into Lake Superior and another that flows south into the St. Croix River, a tributary of the Mississippi River. The low-lying Lake Superior basin in Douglas County has six large sub-watersheds, and the region has many lakes. The many watersheds, in combination with the red-clay soil that does not readily absorb precipitation or additional inundation, make the region prone to flooding and sedimentation of waterways due to rapid runoff.

As a result of frequent requests to fill wetlands for development projects, many new wetland mitigation sites—wetland enhancement, restoration, creation, or preservation projects—have been developed. These sites help to minimize the negative effects of flooding in this low-lying region with clay soils.

In the past, wetland mitigation was done in a haphazard fashion depending on available properties. Also, most of the county is made up of farmland or existing wetland, and this presents another potential obstacle in planning because farmers want to maintain their agricultural land and many stakeholders do not understand why more wetlands would be helpful to the region.

### The Project

To overcome the fragmented approach to mitigation and the perennial disconnect between key stakeholder groups, Douglas County decided in 2013 to pursue a more holistic watershed-wide wetlands conservation planning process and strategy to reduce flooding and storm damage in the county. It designed a process that takes future land-use plans into consideration and identifies the best locations for wetland mitigation, based on local input. The year-long pilot project to develop the first plan focused on a single watershed. A FEMA map depicting flood damage from a bad storm event was a way to engage local decision makers. Geospatial analysts also used the US Fish and Wildlife Service's national wetland inventory, the Wisconsin wetland inventory, and a data layer of land functions to create a clearer representation of Douglas County's landscape.

Stakeholders were brought together several times to view these data visualizations, learn about wetland functions, and address concerns through a collaborative brainstorming method called *situation mapping*, which covered a range of subjects such as addressing tax-based considerations and gaps in knowledge for those involved in the process. Participants included farmers, county board and city council members, a representative from Enbridge Energy Partners, the US Army Corps of Engineers, and public-sector staff from the state and county departments of natural resources and the county land conservation department. Christine Ostern, a Douglas County land conservationist, guided the process, and the stakeholders succeeded in completing the watershed wetland mitigation plan in 2014. The county's next goal is to complete similar mitigation plans for the remaining watersheds in Douglas County and to share the data publicly in 2016.

### Project Outcomes

Douglas County's watershed-based approach resulted in a number of outcomes. Because the highest priority in Douglas County is to reduce the volume of runoff, the county wants to both conserve and use as models the highest functioning areas for surface water detention. Project leaders are working to develop a prioritization scheme for existing wetlands—first for conservation and enhancement, and then for restoration. This process of watershed-based planning will be the foundation for continued work in Douglas County's other watershed communities.

Douglas County found the project's success was largely attributable to the stakeholder involvement process, which brought people with divergent points of view together on a regular basis to review and discuss geospatial data and wetlands inventory maps. This information supported consensus-based decisions about wetlands conservation, preservation, and mitigation. The project facilitators also recognized the importance of explaining not just the findings but also the technology used to develop these findings. The robust stakeholder involvement process serves as an excellent model for other rural areas with flooding problems that are negatively affecting the larger bodies of water protected under coastal zone management programs.

CHAPTER 6

# CONCLUSION: PRINCIPLES OF EFFECTIVE PLANNING IN COASTAL ZONESS

This report has provided an overview of factors and issues related to coastal zone management and also, through a number of case studies, considered the many short-term and long-term threats faced by planners in coastal areas. The case studies also described coastal zone management happening at different levels (state, regional, and local), the array of strategies and approaches, and the similarities and differences in challenges and responses. The following sections are themes drawn from the experiences of the case study states and communities, and in many ways they represent a synthesis between natural systems and built environments. They also provide a set of strategic principles that coastal communities can use to guide the development of coastal zone management goals and present and future planning efforts.

## ENSURING ENVIRONMENTAL QUALITY

Healthy natural systems are essential in coastal zone management. Historically, coastal zone management primarily focused on balancing economic activities with environmental quality and preservation. This balancing act becomes more difficult as coastal areas are faced with increased population demands—both from permanent residents and tourists—as well as climate change impacts and increased disaster events. Climate change furthers the stress on the natural environment, making its protection and restoration even more important. In addition to conservation, healthy coastal communities encourage the restoration of damaged coastal environments and habitats.

Ensuring high environmental quality leads to a variety of positive effects. Land conservation and protection of natural environments from overdevelopment will help to expand access to the coast and preserve recreational opportunities for future generations. Additionally, savings in disaster assistance quickly offset conservation costs. The coasts are also home to many endangered species and fragile ecosystems with very high levels of biodiversity, and avoiding development that results in fragmented habitats is essential. The Endangered Species Act has aided habitat protection and has resulted in programs that not only protect individual species but larger ecosystems across multiple species as well.

Effective conservation and protection often require land acquisition. In addition to nonprofit organizations, such as the Nature Conservancy, governments a play critical role in land acquisition through programs such as the State of Florida's Florida Forever program. Through land donation programs, the Virginia Coastal Zone Management Program has acquired ecologically sensitive lands and lands particularly vulnerable to sea-level rise.

An important component of environmental quality is climate change mitigation. In planning for adaptation, it is important to incorporate mitigation so future impacts are not worse than those already projected. A level of emissions has been reached where some climate change is inevitable, and future outcomes will continue to worsen if mitigation measures are not implemented. Smart growth and sustainable design elements are important strategies of environmentally responsible communities everywhere, and they should be a part of coastal communities. In addition to limiting emissions through land-use controls, ecosystem protection and restoration can support climate change mitigation. Conservation of coastal lands not only prevents more risky, sprawling development but also serves as a carbon sink.

## REDUCING RISKS

Breaking the damage-rebuild-damage cycle will result in safer, healthier communities and save money at various levels of government. From 1980 to 2014, the United States endured 178 weather and climate disasters with damages exceeding $1 billion and the total cost has been more than $1 trillion (in 2015 dollars) (NOAA 2015b). The impacts have caused widespread damage in communities and also have been a financial burden to governments and those communities. More frequent and intense hazards will require more recovery resources, and money spent on recovery is diverted away from other facets of a community; from federal, state, local, and tribal governments; and from individuals. Linking disaster risk reduction with climate adaptation and planning early in the development process takes a more proactive approach—for example, prioritizing community facilities that are critical in the event of a disaster, such as emergency response centers and shelters, by locating them in the most resilient places.

The design of individual buildings, particularly critical facilities, is also important in reducing risk. Hospitals can be severely affected by the aftermath of a major storm. In New Orleans, following Hurricane Katrina in 2005, many hospitals lost power to vital equipment, and temperatures reached over 100 degrees, leading to patients breaking windows with furniture in order to get ventilation (Gray and Herbert 2006). Spaulding Rehabilitation Hospital, located directly on the Boston Harbor, opened in April 2013 with storm resilience as a major design element. To ensure that the building remains operational in the event of a flood, all critical electrical and mechanical gear is located on the top floor, patient beds start on the fourth floor, and emergency services floors are elevated above the 100-year floodplain predicted for 2085 (accounting for projected sea-level rise). The building is also LEED-Gold certified.

Strategies to protect coastal property include those which work to buttress against natural forces, such as "hard" structural and "soft" shoreline reinforcement, and those which work to avoid hazard exposure in the first place, through mechanisms such as development restrictions (e.g., setbacks, building codes, and elevation requirements). Limiting growth and using smart growth principles in development also can reduce the amount of the population susceptible to risk. In addition, evacuation infrastructure—such as roads, bridges, warning systems, and shelters—are essential for communities in risk-prone areas, and more communities will need to put plans in place for these services as climate change risks increase.

Communication and education are also essential for disaster preparedness. Numerous studies have shown that communities with strong social networks have fewer fatalities when natural disasters strike (*see* Aldrich 2012). New technologies can help better connect communities and help with disaster response. For example, during Hurricane Sandy, New Yorkers using Airbnb—an online platform through which people rent spare rooms or entire apartments—posted their apartments for free on the site, for use by those displaced by the storm (Newcombe 2015).

Risk reduction does not only pertain to weather events but also to protection from everyday erosion. Coastal development can exacerbate erosion as can jetties, sea walls, and revetments—the very structures intended to protect coastal properties in the first place. Some states, such as Maine, have outlawed the use of hard structural reinforcements along the coast. The State of Washington released a 2014 guide about natural shoreline stabilization to help coastal communities in planning and implementing reinforcements (Gianoi 2014).

## DEVELOPING AND REDEVELOPING RESPONSIBLY

Sustainable patterns of development are essential to healthy communities in all locations, and they are absolutely crucial in coastal environments, which are denser than other parts of the country. Restricting development can have benefits beyond preventing property damage: preventing development makes the land available for open-space land uses. Similarly, land conservation can have the positive externality of compact development. Many areas critical to conservation are also the most problematic to develop, such as wetlands and floodplains. In addition to conserving natural lands, preserving water-dependent uses is essential to the health of coastal communities. Fisheries are a vital part of the coastal economy, but commercial fishing cannot be outsourced. While some industry can be relocated, other types are best suited for the coast and should be preserved.

Siting of new infrastructure significantly influences the location of future development. The emphasis should be on improving and maintaining existing infrastructure where possible, especially roadways. In coastal areas, new development should be encouraged in areas that are not subject to the added risk of coastal hazards. New development should also not compromise the safety of or increase risks for other development or conservation areas nearby. In some coastal areas, managed retreat is the best option for residents' safety and environmental quality. Buyout programs—on Staten Island after Hurricane Sandy, for example—provide relocation money to residents who live in particularly vulnerable areas. Development should also efficiently use resources and reduce energy, water consumption, and waste in the construction and operation of buildings.

## ENSURING EQUITABLE ACCESS

Coastal environments vary greatly in their accessibility, as do the access needs of different populations and communities. Aging populations, for example, require more careful planning around access to recreational opportunities. Developers, homeowners, and resorts may obstruct beach access, and many municipalities, and even states, include a requirement of public beach access for a new building approval. Many beaches are adjacent to high-end resorts and expensive homes and providing access to those areas to a diverse group of users is important. Similarly, coastal lodging costs continue to increase, leaving few accommodation options for low- and moderate-income people. To combat this, the City of Santa Monica, California, enacted an ordinance in 1990 that assessed fees on projects that result in a loss of affordable lodging. This funding can then be used for other renovation or new lodging projects (Beatley, Brower, and Schwab 2002).

## MANAGING STORMWATER AND WATERSHEDS EFFECTIVELY

Excessive impervious surfaces can cause down-gradient flooding, reduce groundwater recharge, and increase pollutant loads to coastal zone waterways. Reduced recharge not only depletes aquifers but also damages wetland and other downstream environments. Sometimes activities—agricultural, industrial, even residential—hundreds of miles upriver can profoundly affect coastal water quality. It is for this reason that the coastal zone management boundaries of many states include the entire coastal watershed. Flood control tactics include land conservation, aquatic buffers, and habitat restoration, among others.

Traditional stormwater management systems collect wastewater from one watershed, treat it, and then discharge it—sometimes to another watershed. Green infrastructure has become a common, less expensive, and, many experts would argue, better approach to stormwater management. In short, green infrastructure uses vegetation, soils, and natural processes to manage water and create healthier urban environments. At the scale of a city or county, green infrastructure refers to the network of natural areas, parks, and resources (such as the urban tree canopy) that provides benefits, including habitat, flood protection, and cleaner air and water. At the scale of a neighborhood or site, green infrastructure refers to stormwater management systems that mimic nature by soaking up and storing water.

## ENGAGING AND EDUCATING STAKEHOLDERS

As in all areas of planning, stakeholder engagement is essential in coastal zone management. From visioning through implementation, a diverse group of stakeholders must be involved in all the steps of the planning process. Science informs good decision making, and scientific research—on climate change, habitats, water quality—must be effectively communicated to the public. Similarly, the local and historical knowledge of residents and business owners must be communicated back to scientists to ensure effective planning. Communicating with the public on issues such as climate change and sea-level rise are particularly challenging and critical.

## COLLABORATING ACROSS DISCIPLINES, SECTORS, AND LEVELS OF GOVERNMENT

The diverse array of activities involved in coastal planning requires extensive collaboration across different sectors. Economic drivers such as tourism, fisheries, and port companies rely on each other as often as they compete. Also, healthy and safe communities depend on strong economic and environmental systems. Federal, state, and local governments all have a hand in coastal zone management. Much implementation occurs at the local level, with strong support and technical assistance from state agencies. NOAA administers coastal zone management grants and in turn provides technical assistance to the state programs.

An example of successful collaboration is the New Hampshire Coastal Adaptation Workgroup. It is made up of 21 regional, state, municipal, nonprofit, academic, and consulting organizations. The workgroup leverages resources and expertise on adaptation and preparedness activities in the coastal watershed. It collaborates on projects and provides coordinated information and technical assistance to communities to help them prepare for extreme weather events and climate change impacts. The group also hosts workshops to connect communities with information and resources and to give participants an opportunity to share stories and insights about climate-planning-related activities.

## APPENDIX A: EXCERPT FROM THE COASTAL ZONE MANAGEMENT ACT OF 1972

### 16 U.S.C. § 1452. CONGRESSIONAL DECLARATION OF POLICY (SECTION 303)

The Congress finds and declares that it is the national policy—

1. to preserve, protect, develop, and where possible, to restore or enhance, the resources of the Nation's coastal zone for this and succeeding generations;
2. to encourage and assist the states to exercise effectively their responsibilities in the coastal zone through the development and implementation of management programs to achieve wise use of the land and water resources of the coastal zone, giving full consideration to ecological, cultural, historic, and esthetic values as well as the needs for compatible economic development, which programs should at least provide for—
   - A. the protection of natural resources, including wetlands, floodplains, estuaries, beaches, dunes, barrier islands, coral reefs, and fish and wildlife and their habitat, within the coastal zone,
   - B. the management of coastal development to minimize the loss of life and property caused by improper development in flood-prone, storm surge, geological hazard, and erosion-prone areas and in areas likely to be affected by or vulnerable to sea level rise, land subsidence, and saltwater intrusion, and by the destruction of natural protective features such as beaches, dunes, wetlands, and barrier islands,
   - C. the management of coastal development to improve, safeguard, and restore the quality of coastal waters, and to protect natural resources and existing uses of those waters,
   - D. priority consideration being given to coastal-dependent uses and orderly processes for siting major facilities related to national defense, energy, fisheries development, recreation, ports and transportation, and the location, to the maximum extent practicable, of new commercial and industrial developments in or adjacent to areas where such development already exists,
   - E. public access to the coasts for recreation purposes,
   - F. assistance in the redevelopment of deteriorating urban waterfronts and ports, and sensitive preservation and restoration of historic, cultural, and esthetic coastal features,
   - G. the coordination and simplification of procedures in order to ensure expedited governmental decision-making for the management of coastal resources,
   - H. continued consultation and coordination with, and the giving of adequate consideration to the views of, affected Federal agencies,
   - I. the giving of timely and effective notification of, and opportunities for public and local government participation in, coastal management decision making,
   - J. assistance to support comprehensive planning, conservation, and management for living marine resources, including planning for the siting of pollution control and aquaculture facilities within the coastal zone, and improved coordination between State and Federal coastal zone management agencies and State and wildlife agencies, and
   - K. the study and development, in any case in which the Secretary considers it to be appropriate, of plans for addressing the adverse effects upon the coastal zone of land subsidence and of sea level rise; and
3. to encourage the preparation of special area management plans which provide for increased specificity in protecting significant natural resources, reasonable coastal-dependent economic growth, improved protection of life and property in hazardous areas, including those areas likely to be affected by land subsidence, sea level rise, or fluctuating water levels of the Great Lakes, and improved predictability in governmental decision making;
4. to encourage the participation and cooperation of the public, state and local governments, and interstate and other regional agencies, as well as of the Federal agencies

having programs affecting the coastal zone, in carrying out the purposes of this chapter;

5. to encourage coordination and cooperation with and among the appropriate Federal, State, and local agencies, and international organizations where appropriate, in collection, analysis, synthesis, and dissemination of coastal management information, research results, and technical assistance, to support State and Federal regulation of land use practices affecting the coastal and ocean resources of the United States; and
6. to respond to changing circumstances affecting the coastal environment and coastal resource management by encouraging States to consider such issues as ocean uses potentially affecting the coastal zone.

## GLOSSARY

**accretion** The gradual and imperceptible accumulation of land by natural causes, as out of the sea or a river. This may be the result from a deposit of alluvion upon the shore, or by a recession of the water from the shore. Accretion is the act, while alluvion is the deposit itself.

**backwater** A part of a river in which there is little or no current. It refers either to a branch of a main river which lies alongside it and then rejoins it or to a body of water in a main river which is backed up by an obstruction such as the tide or a dam.

**baffle box** Concrete or fiberglass structures containing a series of sediment-settling chambers separated by baffles. The primary function of a baffle box is to remove sediment, suspended particles, and associated pollutants from storm water.

**bar-built estuary** This occurs when sandbars or barrier islands are built up by ocean waves and currents along coastal areas fed by one or more rivers or streams. Also known as restricted-mouth estuaries.

**barrier island** A detached portion of a barrier beach between two inlets.

**base flood** The flood having a one percent chance of being equaled or exceeded in any given year. This is the regulatory standard also referred to as the "100-year flood." The base flood is the national standard used by the National Flood Insurance Program and all federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development. Base Flood Elevations are typically shown on Flood Insurance Rate Maps.

**bayou** A body of water typically found in a flat, low-lying area, either an extremely slow-moving stream or river (often with a poorly defined shoreline) or a marshy lake or wetland.

**beach** The zone of unconsolidated material that extends landward from the low water line to the place where there is marked changes in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). A beach includes foreshore and backshore.

**bioretention basins** Bioretention is the process in which contaminants and sedimentation are removed from stormwater runoff. Bioretention basins are landscaped depressions or shallow basins used to slow and treat on-site stormwater runoff. Stormwater is directed to the basin and then percolates through the system where it is treated by a number of physical, chemical, and biological processes. The slowed, cleaned water is allowed to infiltrate native soils or directed to nearby stormwater drains or receiving waters.

**bog** A wet, spongy, poorly drained area which is usually rich in very specialized plants, contains a high percentage of organic remnants and residues, and frequently is associated with a spring, seepage area, or other subsurface water source. A bog sometimes represents the final stage of the natural processes of eutrophication by which lakes and other bodies of water are very slowly transformed into land areas.

**bulkhead** (1) A structure separating land and water areas, primarily designed to resist earth pressures. (2) A structure or partition to retain or prevent sliding of the land. A secondary purpose is to protect the upland against damage from wave action.

**cape** A relatively extensive land area jutting seaward from a continent or large island which prominently marks a change in, or interrupts notably, the coastal trend; a prominent feature.

**coast** A general region of indefinite width that extends from the sea inland to the first major change in terrain features.

**coastal plain** The plain composed of horizontal or gently sloping strata of clastic material fronting the coast and generally representing a strip of recently emerged sea bottom that has emerged from the sea in recent geologic times. Also formed by aggradation.

**delta** (1) An alluvial deposit, usually triangular, at the mouth of a river or other stream. It is normally built up only where there is no tidal or current action capable of removing the sediment as fast as it is deposited, and hence the delta builds forward from the coastline. (2) A tidal delta is a similar deposit at the mouth of a tidal inlet, put there by tidal currents. (3) A wave delta is a deposit made by large waves which run over the top of a spit or barrier beach and down the landward side.

**dune** (1) Accumulations of windblown sand on the backshore, usually in the form of small hills or ridges, stabilized by vegetation or control structures. (2) A type of bed form indicating significant sediment transport over a sandy seabed.

**estuary** An embayment of the coast in which fresh river water entering at its head mixes with the relatively saline ocean water. When tidal action is the dominant mixing agent, it is usually termed a tidal estuary. This also refers to the lower reaches and mouth of a river emptying directly into the sea where tidal mixing takes place. The latter is sometimes called a river estuary.

**freeboard** The additional height of a structure above design high water level to prevent overflow. Also, at a given time, the vertical distance between the water level and the top of the structure.

**gravitational redistribution** As ice sheets melt, the earth's gravity redistributes the water in a manner that results in lower sea levels near the melting ice sheet and higher sea levels on other coastlines that can be as far as 1,200 miles away from the melting ice sheet.

**groin** (1) A shore-protection structure (built usually to trap littoral drift or retard erosion of the shore). It is narrow in width (measured parallel to the shore), and its length may vary from tens to hundreds of meters (extending from a point landward of the shoreline out into the water). Groins may be classified as permeable (with openings through them) or impermeable (a solid or nearly solid structure). (2) A barrier-type structure extending from the backshore or stream bank into a water body for the purpose of the protection of a shoreline and adjacent upland by influencing the movement of water and/or deposition of materials.

**headland** A point of land usually high and often with a sheer drop that extends out into a body of water. It is a type of promontory. A headland of considerable size often is called a cape. Headlands are characterized by high, breaking waves, rocky shores, intense erosion, and steep sea cliffs.

**inlet** (1) A narrow strip of water running into the land or between islands. (2) An arm of the sea (or other body of water) that is long compared to its width and that may extend a considerable distance inland.

**lagoon** A shallow body of water, such as a pond or lake, separated from a larger body of water by barrier islands or reefs.

**lidar** A remote sensing method (which stands for *light detection and ranging)* that uses light in the form of a pulsed laser to measure ranges (variable distances) to Earth. These light pulses—combined with other data recorded by the airborne system—generate precise, three-dimensional information about the shape of Earth and its surface characteristics.

**marsh** (1) A tract of soft, wet land, usually vegetated by reeds, grasses, and occasionally small shrubs. (2) Soft, wet area periodically or continuously flooded to a shallow depth, usually characterized by a particular subclass of grasses, cattails, and other low plants.

**mean higher high water (MHHW)** A tidal datum. The average of the higher high water height of each tidal day observed over the National Tidal Datum Epoch. For stations with shorter series, simultaneous observational comparisons are made with a control tide station in order to derive the equivalent datum of the National Tidal Datum Epoch.

**nor'easter** A macro-scale storm along the upper East Coast of the United States and Atlantic Canada. It gets its name from the direction the wind is coming in from the storm.

**outfall** (1) The vent of a river or drain. (2) A structure extending into a body of water for the purpose of discharging sewage, storm runoff, or cooling water.

**overwash** Flow of water and sediment over the crest of the beach that does not directly return to the water body (such as an ocean, sea, bay, or lake) where it originated after water level fluctuations return to normal. There are two kinds of overwash: (1) overwash by runup and (2) overwash by inundation. In the fields of coastal geology and geomorphology, "overwash" refers to a landward flux of sediment due to overtopping of a dune system. Washover is the sediment deposited inland of a beach by overwash.

**revetment** (1) A facing of stone, concrete, or other material to protect an embankment, a scarp, or other shore structure, against erosion by wave action or currents. (2) A retaining wall.

**rocky shore** An intertidal area of seacoasts where solid rock predominates. Rocky shores are biologically rich environments and are a useful "natural laboratory" for studying intertidal ecology and other biological processes

**seawall** (1) A structure built along a portion of a coast primarily to prevent erosion and other damage by wave action. It retains earth against its shoreward face. (2) A structure separating land and water areas primarily to prevent erosion and other damage by wave action. Generally more massive and capable of resisting greater wave forces than a bulkhead.

**seiche** A standing wave oscillating in a body of water. Seiches are typically caused when strong winds and rapid changes in atmospheric pressure push water from one end of a body of water to the other. When the wind stops, the water rebounds to the other side of the enclosed area. The water then continues to oscillate back and forth for hours or even days. In a similar fashion, earthquakes, tsunamis, or severe storm fronts may also cause seiches along ocean shelves and ocean harbors.

**Special Flood Hazard Area** The area that will be inundated by the flood event having a one-percent chance of being equaled or exceeded in any given year, as identified by FEMA.

**spit** (1) A long narrow accumulation of sand or shingle, lying generally in line with the coast, with one end attached to the land the other projecting into the sea or across the mouth of an estuary. (2) An accretion shoreform which extends seaward from and parallel to the shoreline.

**subduction** The process that takes place at convergent boundaries by which one tectonic plate moves under another tectonic plate and sinks into the mantle as the plates converge. Regions where this process occurs are known as subduction zones.

**subduction zone** An elongate region in which the sea floor slides beneath a continent or island arc.

**swale** A low tract of land, especially one that is moist or marshy. The term can refer to a natural landscape feature or a human-created one. Artificial swales are often designed to manage water runoff, filter pollutants, and increase rainwater infiltration.

**swamp** A wetland that is forested. Many swamps occur along large rivers where they are critically dependent upon natural water level fluctuations. Other swamps occur on the shores of large lakes. The two main types of swamps are "true" or swamp forests and "transitional" or shrub swamps.

**tectonic plate** A massive, irregularly shaped slab of solid rock, generally composed of both continental and oceanic lithosphere.

**wetland** Land whose saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities that live in the soil and on its surface.

*Sources: FEMA, LakeSuperiorStreams, National Ocean Service, NOAA Shoreline Website, Southwest Washington Coastal Erosion Study, US Environmental Protection Agency, US Geological Survey, Wikipedia*

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## ACKNOWLEDGMENTS

The authors would like to thank the following individuals and organizations for their contributions to this report: **Keren Bolter**, Florida Atlantic University; **Wendy Carey**, Delaware Sea Grant; **Nicole Faghin**, Washington Sea Grant; **Bridget Faust**, Association of State Floodplain Managers; **Daniella Hirschfeld**, The Resiliency Place; **Michelle Jesperson**, California Coastal Commission; **Claire Karner**, Land Information Access Association; **Lindsey Kraatz**, National Oceanic and Atmospheric Administration; **Alyssum Pohl**, National Association of Counties and National States Geographic Information Council; **James C. Schwab**, American Planning Association; **Melissa Stults**, Center for Sustainable Systems, University of Michigan; **Maggie Wenger**, San Francisco Bay Conservation and Development Commission; Coastal States Organization; Digital Coast Partnership, National Oceanic and Atmospheric Administration; Institute for Sustainable Communities; and Office for Coastal Management, National Oceanic and Atmospheric Administration.

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54800>
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