FUTURE CLIMATE-DRIVEN RISKS—AND THEIR SOLUTIONS—ON MASSACHUSETTS' SOUTH COAST

trustees t ON THE COAST

STATE OF THE COAST

A beach day at Old Silver Beach. Fresh scallops right off a New Bedford fishing boat. A kayak trip around Woods Hole. A sunset stroll next to Buzzards Bay. These are the things that make the South Coast so beloved—and so worth protecting.

But the region faces multiple threats due to sea level rise and climate change. Low-lying areas like Wareham, Bourne, Marion, and Mattapoisett are extremely vulnerable to storm surge. Area marshlands are disappearing much faster than other areas of the state. Water quality issues have decimated the scallop industry and are also impacting eelgrass, shellfish, and fish. And all the while, both flooding and erosion threaten native animal species as well as the health and livelihoods of local communities.

The accelerating effects of climate change are undeniable — and so too is our responsibility and ability to act.

As the oldest and largest conservation and preservation group in the state, protecting the coast isn't just a priority; it's part of our DNA. We strive to be a champion for these irreplaceable landscapes so that future generations can continue to enjoy our coastal communities. We've spent years developing innovative solutions to build resilience on a changing coast, from rebuilding dunes on barrier beaches to developing innovative ditch remediation methods to naturally restore our salt marshes. And we're constantly working to expand these solutions to communities across the state and to work together with fellow advocates.

Our latest report features 14 South Shore communities, including New Bedford and Fall River, two of the largest coastal cities in the state. We highlight potential climate change impacts on the region's places and communities, talk about current actions undertaken by area organizations and municipalities, and propose future strategies and enhanced or new collaborations.

We know that climate change is having a profound impact on our vulnerable coastal areas. We also know that we cannot wait to act to slow the effects. Now is the time to work together to save our local habitats, nature, infrastructure, and economy while modeling more sustainable practices in our own work. Together we can engage in effective solutions and partner to preserve these places of work, community, and beauty for generations to come.

John Judge

Trustees President & CEO

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Cover photo courtesy: Keith Joseph Piwowarski

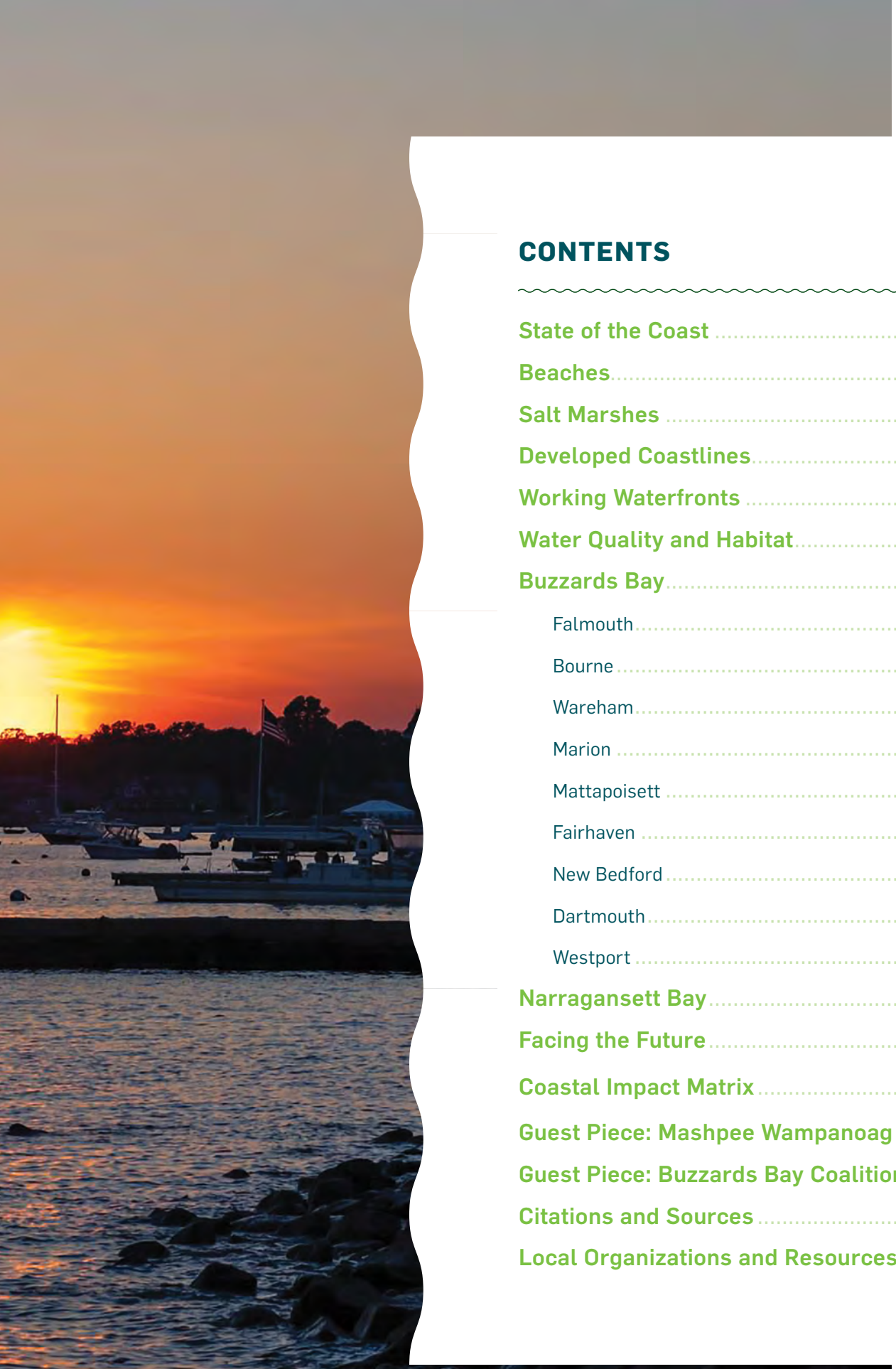

Photo courtesy: Keith Joseph Piwowarski

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State of the Coast

Now in its third year, The Trustees' annual State of the Coast report pulls together the latest climate change projections to tell the story of what is expected to happen along our Massachusetts coastline. This year we focus on the South Coast and the 14 towns that border Buzzards Bay and Narragansett Bay. Over the next 30 years, this region is projected to experience increased flooding in low lying communities, loss of salt marsh, impacts to water quality, and erosion of shorelines. In producing this report, The Trustees collaborated with towns and partner organizations to develop recommendations for collaboration and action that will lead to resilient communities and natural resources.

This report highlights the projected impacts of rising seas and increasing storm surge on the ecology of Buzzards Bay and Narragansett Bay, as well as quantifies the significant threats to community infrastructure projected in the coming years. Communities along this stretch of coast suffered devastating effects from the 1991 storm surge of Hurricane Bob, one of the costliest storms in New England history [CIT. 1]. Today, they continue to face the intensifying and accelerating results of flooding from sea level rise, stronger storms, and wave energy.

The impacts of sea level rise and increased flooding events vary across this region. This is in part due to the glacially formed coastline, consisting of a patchwork of protruding headlands and associated embayments, intermixed with pocket and barrier beaches [CIT. 2]. Exposed to the open ocean, the towns of Westport and Dartmouth experience more erosion from storms and wave energy. Further up Buzzards Bay, towns are more protected from waves but experience a funnel effect as water can surge up the Bay and intensify flooding at the northern end, impacting low-lying roads and buildings in Wareham and neighboring towns.

In addition to infrastructure, projections show vast losses of coastal salt marshes, erosion of beaches with little room to migrate inland, and water quality jeopardized by rising floodwaters, higher water temperatures, and stormwater runoff. These ecosystems provide habitat to shellfish, fish, and birds that call these bays home but also offer critical protection to our coastal communities by buffering flood waters and wave energy. When natural landscapes deteriorate, so does the resilience of our coastlines.

WHY NOW?

Over the next 30 years, sea levels along the South Coast are projected to rise over two feet [CIT. 3], and storms are expected to be more frequent and intense, if global carbon emissions remain high [CIT. 4]. While this report focuses primarily on these pressures from the ocean, the impacts of climate change may also result in drier summers and more frequent droughts, diminishing snowfall and higher precipitation in winter and spring, and increased inland flooding.

The Trustees 2022 State of the Coast report is focused on the South Coast region and the 14 towns that border Buzzards Bay and Narragansett Bay.

It is urgent that we work together to address the climate change pressures that we are already witnessing in our communities and ecosystems. Consider:

- **BOTH DAILY TIDAL FLOODING AND STORM EVENTS** are projected to inundate low-lying roads and buildings that are not adapted to flooding. In Wareham, due to its location and low-lying infrastructure, more than a quarter of all buildings in town could be inundated by a 10-year storm as soon as 2050 [CIT. 5].
- **DAILY TIDAL FLOODING ALONE** is projected to impact over 25 miles of roadway and over 1,400 buildings across the region as soon as 2050. A 10-year storm could impact over 15,000 structures and over 250 miles of roadway by 2050 [CIT. 5].
- **RISING SEAS** are projected to drown out salt marsh earlier than other regions of the state with a 23% loss of marsh as soon as 2050 [CIT. 6].
- **EXISTING DEVELOPMENT** threatens the ability of coastal beaches and salt marshes to migrate inland with sea level rise, putting them at risk of loss.
- **THE HURRICANE BARRIER,** built in 1966 to protect the Port of New Bedford from storms, is projected to close more frequently in the future due to high tides alone. Closing the barrier at the same water level as is done currently would mean 1–2 closures a day as soon as 2050. For comparison, the barrier closed a total of 26 times in 2019 [CIT. 7].
- **RISING WATER TEMPERATURES AND INCREASED STORMWATER RUNOFF** may further impact water quality. Excess nutrients have contributed to the loss of 43% of Buzzards Bay eelgrass beds over the last 30 years [CIT. 8], resulting in major declines in populations of bay scallops and other shellfish [CIT. 9].

"We have relied on the gifts nature provides for thousands of years. Now the abundant gifts are in jeopardy and may not be there for future generations. The ocean nurtures us like a mother nurtures her child. We all appreciate her many gifts, therefore we must all commit to being accountable stewards for those [generations] yet to come."

DAVID WEEDEN,
MASHPEE WAMPANOAG TRIBAL COUNCIL

It may feel like the challenges facing us are too enormous to confront. But by thinking across town boundaries and sharing strategies, solutions, and outcomes of pilot projects, we can start to move the needle. The work of nonprofit organizations together with towns, agencies, and landowners to reduce nutrient inputs to the bay over the last 20 years is already a success story and model to follow. The need for broader regional collaboration such as this along the South Coast to prepare for and mitigate the coastal effects of a changing climate is clear, as is the urgent need for greater resources to make that happen.

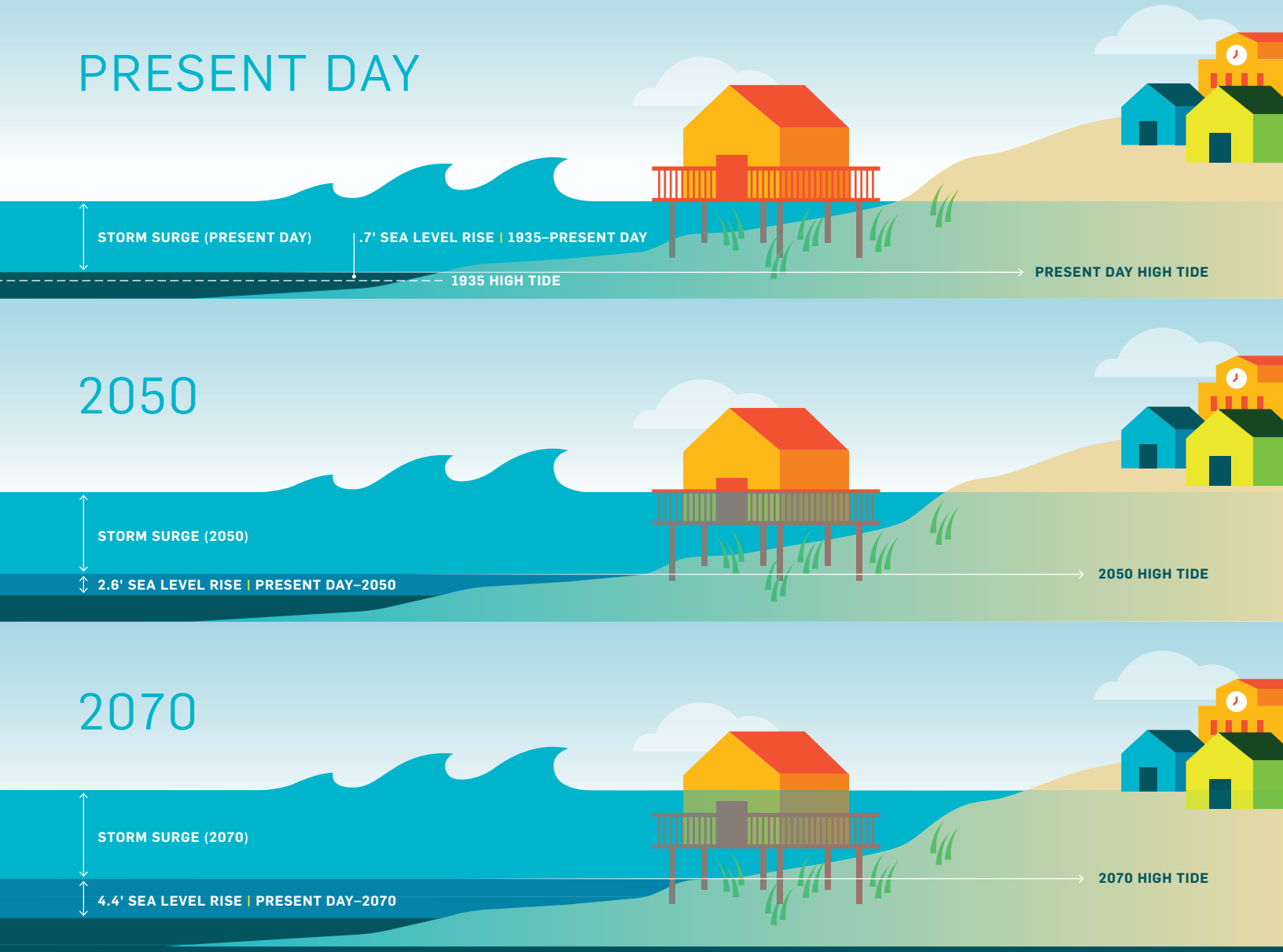
WHY US?

As the largest private coastal landowner and first land conservation nonprofit in Massachusetts, The Trustees has witnessed firsthand the widespread effects of climate change up and down the coast, from the compromised salt marshes and habitats of Old Town Hill in Newbury to the shifting dunes and barrier beaches of the Coskata-Coatue Wildlife Refuge on Nantucket. We are in a unique position to share a long-term perspective that speaks to our mission, values, and philosophy—and underscores the urgent need for new coastal strategies and regulatory reforms.

For us, protecting the coast is not only a priority—it's part of who we are. We strive to be a champion for these iconic landscapes of extraordinary ecological and recreational value—all vulnerable to change. In partnership with local stakeholders, now is the time for bold, coordinated adaptations to climate change.

WHAT DATA DID WE USE?

The Trustees and the Woods Hole Group, Inc. utilized results from the Massachusetts Coast Flood Risk Model (MC-FRM) [CIT. 5, 11] to investigate future scenarios of tidal and storm-based flooding extents and threats to infrastructure (roads and buildings) as soon as 2030, 2050 and 2070. MC-FRM includes sea level rise (SLR) associated with the "high" projections as recommended by the Massachusetts Office of Coastal Zone Management (CZM) and the University of Massachusetts and developed specifically for the Commonwealth of Massachusetts by DeConto and Kopp (2017) [CIT. 3]. This "high" scenario of SLR provides an estimate that is extremely unlikely to be exceeded with continued high global emissions and projects 1.3 ft, 2.6 ft and 4.4 ft of rise above a 2008 baseline year as soon as 2030, 2050 and 2070, respectively [CIT. 3]. By using these sea level rise projections, the findings presented herein are consistent with the Commonwealth's climate change planning tools used by state agencies [CIT. 12].



Impacts of rising seas on both high tide water levels (mean higher high water; darker blues) and water levels during storms (lighter blue; 100-year storm event) are shown for Woods Hole at "present day" (2008), and out to 2050 and 2070 [CIT. 3]. Between 1935 and the present day scenario, seas have risen at the Woods Hole tide gauge by 9 inches (0.7 ft) [CIT. 10]. Under a "high" emissions scenario recommended by the MA Office of Coastal Zone Management for modeling coastal flooding, daily high tides are projected to increase by 2.6 ft and 4.4 ft as soon as 2050 and 2070 respectively [CIT. 3]. With sea level rise and storms projected to get more intense and flooding more frequent, the 100-year storm event in 2050 (similar in extent to a worst-case Category 2 hurricane in this area [CIT. 11]), is projected to be 3.1 feet (2050) and 5.2 ft (2070) higher than current 100-year storm events [CIT. 5].

Projected impacts to tidal marshes and coastal habitats were derived from the Sea Level Affecting Marshes Model (SLAMM) results developed for CZM by Woods Hole Group [CIT. 6]. The SLAMM results were developed using the latest sea level rise projections available at the time of that study [CIT. 13]. The "high" scenario used for this report is a little lower than the more recent projections of DeConto and Kopp (2017).

Sea level rise projections released by the National Oceanic and Atmospheric Administration in 2022 (NOAA) [CIT. 14] are lower than the "high" projections used to model coastal flooding in this report. For example, the value for sea level rise by 2050 under the "high" scenario used by Woods Hole Group for this report (using an 83% confidence interval or 17% chance of underpredicting) is 0.5 feet higher than the NOAA projection. Through consultation with NOAA and CZM, we decided to continue using the same MC-FRM and SLAMM results since they provide greater certainty of identifying impacts that need to be addressed—important when expending significant resources on adaptation and resilience projects.

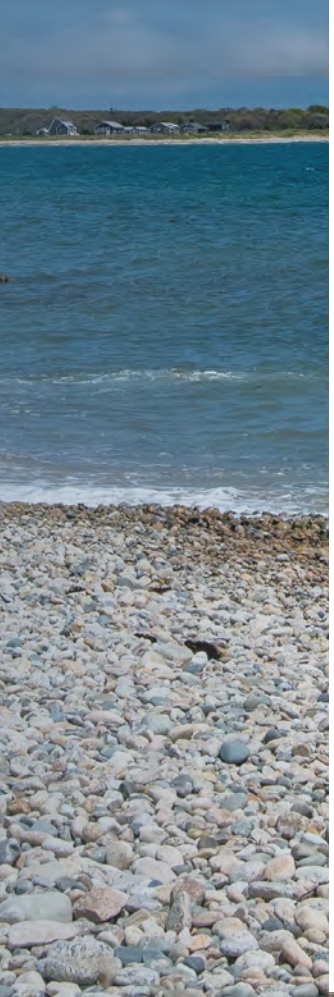
Beaches

With over 250 miles of beaches and rocky shores, the coastlines of Buzzards Bay and Narragansett Bay are unlike any other area in Massachusetts. Rocky headlands jut out between the bays' rivers and streams, and a sweeping arm of land stretches from Falmouth to the Elizabeth Islands—a glacial deposit that creates Buzzards Bay and provides partial protection from ocean waves.

In this region, the shorelines support recreation, commerce, fishing, scientific research, and extraordinary natural habitat. Beaches along the bays and islands provide habitat to migratory shorebirds and waterfowl including breeding habitat for the federally endangered roseate tern. Climate change, bringing rising seas, higher water temperatures, and more frequent and intense storms, may have undeniable impacts on this dynamic environment.

Compared to other regions of the state, such as the islands (Martha's Vineyard and Nantucket) and portions of the North Shore, erosion rates for the shorelines are relatively low. The exceptions are the beaches of Westport and Dartmouth at the mouth of Buzzards Bay, as they are more exposed to direct wave impacts from the ocean. At East Beach in Westport, for example, the shoreline has eroded over 150 feet in the last 120 years [CIT. 15], threatening over 30 homes and forcing several homeowners to relocate.

Photo courtesy: Keith Joseph Piwowarski



Approximately 23% of the shoreline is available for public access (26% in Buzzards Bay and 11% in Narragansett Bay) [CIT. 16]. Rising seas threaten a loss of these beaches as well as access to them where development leaves no room for the beach or the parking area to migrate inland.

The challenge of how to ensure the resilience of beaches and shorelines in this developed region is a difficult one. Much of the shoreline (72 miles or 35%) is hardened [CIT. 17]. Almost 1,800 bulkheads, seawalls, revetments, groins, and jetties have been installed by federal and state agencies, local communities, and private landowners to deter erosion and capture sand [CIT. 18]. These shoreline modifications disrupt the natural process of sediment transport and habitat migration, which allow beaches to adapt.

LOOKING AHEAD

Environmental organizations and municipalities can work together to ensure the future of our beaches and coastal habitats. These natural areas not only protect us from wave energy during storms and provide critical habitat for wildlife, they are the places we recreate, relax, run businesses, and harvest our food.

Let's discuss ways to:

CONSERVE COASTAL LANDS Acquiring and preserving coastal land for open space increases public access, reduces property and infrastructure damage, and improves the functioning of natural processes. Of the coastal habitat along the shoreline, only 23% is protected in Buzzards Bay and 10% along Narragansett Bay (study area only) [CIT. 19].

RESTORE BEACHES AND DUNES In more erosive areas, short-term efforts to protect beaches could include beach or dune nourishment and restoration. For example, beach nourishment has been performed at East Beach in Westport and Little Harbor Beach in Wareham. As these projects can be costly and short-term, weighing infrastructure relocation and retreat from high-risk areas should also be considered.

REDESIGN OR REMOVE HARD BARRIERS The Office of Coastal Zone Management's StormSmart Coasts program recommends the latest design practices for seawalls and revetments to reduce impacts, minimize maintenance costs, and improve longevity [CIT. 20]. In addition, the program also recommends using plantings and natural materials as a method to help control erosion and stabilize soil and sediments. Proactive management of erosion with living shorelines can allow natural sediment accumulation processes to return, restoring habitat and protecting properties.

Salt Marshes

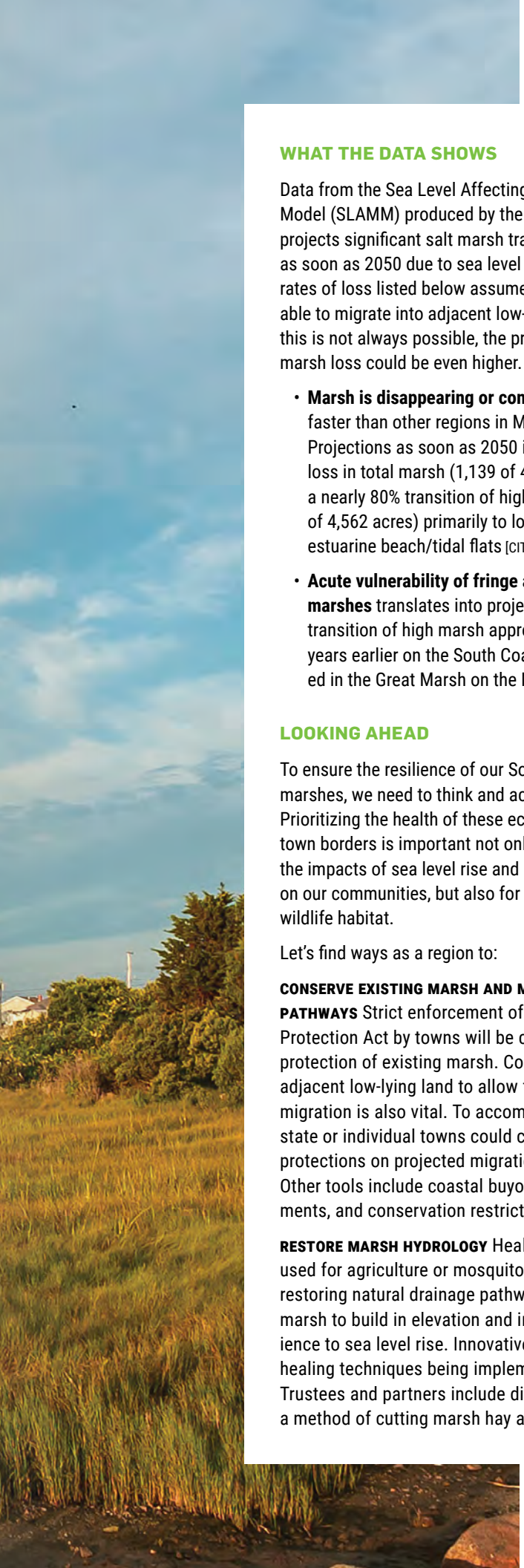
Salt marshes are one of the most productive ecosystems on the planet, and this region's marshes are no exception. These wide expanses of natural open space provide more than a beautiful view, they are home to a diversity of wildlife, filter pollutants before they reach our bays, and provide storm protection to our coastal communities by buffering storm surge and absorbing excess rainwater. These landscapes, if healthy, also show incredible promise for slowing the effects of climate change by sequestering vast amounts of carbon—more than 10 times the amount sequestered by forests [CIT. 21].

But salt marshes are at risk due to rising seas. We must work together to ensure our marshes are resilient into the future.

Of the more than 250 miles of shoreline along Buzzards Bay and Narragansett Bay, approximately one third has salt marsh, totaling 4,900 acres [CIT. 6]. Marsh on the South Coast exists as narrow "fringe" areas along the edge of bay shorelines, as larger landscapes behind barrier beaches, and on islands. The marsh consists of both "low marsh," areas that flood daily at a high tide, and "high marsh," areas known for fine grasses and that flood only a few times each month. Most of the state's existing marsh is high marsh and is critical for flood protection and habitat for at-risk species such as the salt marsh sparrow.

The survival of salt marshes depends upon their ability to flood and drain regularly, accumulate sediment over time, and migrate inland with sea level rise—natural processes that have been compromised by human alterations such as ditching for agricultural drainage and mosquito control, and roads and community infrastructure. Migration of marshes is also naturally constrained by topography, often being trapped against steep landforms or, as is the case with island marshes, simply having limited space to migrate.

South Coast salt marshes are especially vulnerable to rising sea levels. With a mean tidal range of 3.6 feet in New Bedford and 1.8 feet in Woods Hole (well below Boston at 9.5 feet which is representative of most areas north of Cape Cod) [CIT. 22], the fringe marsh that has developed in this area is much narrower than marsh in other places in the state such as the Great Marsh on the North Shore. As such, we see alarming projections for marsh loss as soon as 2050. We must act quickly to heal the hydrology of these degraded marshes and create pathways for them to migrate, or we may lose them.



WHAT THE DATA SHOWS

Data from the Sea Level Affecting Marshes Model (SLAMM) produced by the Commonwealth projects significant salt marsh transition and loss as soon as 2050 due to sea level rise [CIT. 6]. The rates of loss listed below assume marshes will be able to migrate into adjacent low-lying areas. Since this is not always possible, the projections for marsh loss could be even higher.

- **Marsh is disappearing or converting** much faster than other regions in Massachusetts. Projections as soon as 2050 indicate a 23% loss in total marsh (1,139 of 4,918 acres) and a nearly 80% transition of high marsh (3,537 of 4,562 acres) primarily to low marsh and estuarine beach/tidal flats [CIT. 6].
- **Acute vulnerability of fringe and island marshes** translates into projected large-scale transition of high marsh approximately 20 years earlier on the South Coast than is expected in the Great Marsh on the North Shore [CIT. 6].

LOOKING AHEAD

To ensure the resilience of our South Coast salt marshes, we need to think and act regionally. Prioritizing the health of these ecosystems across town borders is important not only for buffering the impacts of sea level rise and storm surge on our communities, but also for saving critical wildlife habitat.

Let's find ways as a region to:

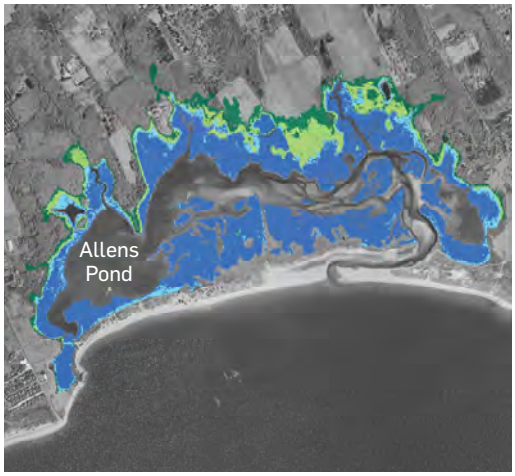
CONSERVE EXISTING MARSH AND MIGRATION PATHWAYS Strict enforcement of the Wetlands Protection Act by towns will be critical for the protection of existing marsh. Conservation of adjacent low-lying land to allow for salt marsh migration is also vital. To accomplish this, the state or individual towns could consider enacting protections on projected migration pathways. Other tools include coastal buyouts, rolling easements, and conservation restrictions.

RESTORE MARSH HYDROLOGY Healing ditches once used for agriculture or mosquito control and restoring natural drainage pathways will allow the marsh to build in elevation and increase resilience to sea level rise. Innovative nature-based healing techniques being implemented by The Trustees and partners include ditch remediation, a method of cutting marsh hay and securing it into ditches to trap sediment over time, and a technique called runneling that restores natural drainage pathways.

IMPLEMENT INNOVATIVE APPROACHES TO RAISE MARSH ELEVATION While using the restoration techniques mentioned above will help salt marshes build in elevation, it is unlikely that natural accretion rates will be able to keep pace with sea level rise in the long-term [CIT. 24]. Innovative techniques can help the marsh build elevation faster including thin layer deposition and mud motors—both of which involve adding dredged sediment to the marsh. These techniques are being tested nearby in Rhode Island and neither are allowed under current regulations in Massachusetts.

MODERNIZE THE PERMITTING PROCESS Cross-agency coordination, streamlining of restoration projects, and openness to new and innovative approaches to resilience will help partners implement these actions more effectively before salt marshes are lost.

POTENTIAL MARSH MIGRATION: PRESENT–2070



Allens Pond salt marsh, Dartmouth. At over 200 acres, Allens Pond is one of the largest salt marshes in Buzzards Bay. Significant loss of the existing marsh (dark blue) will only be minimally offset by inland marsh migration (green) [CIT. 6]. Led by Mass Audubon, several local partners are implementing a project to restore this marsh in hopes it will grow in elevation [CIT. 23]. Due to sea level rise and the clogging of historic ditches, mega-pools have formed on the marsh and are drowning out salt marsh grasses. Runneling allows these grasses to re-establish and increases marsh resilience.

- Projected marsh loss as soon as 2050
- Current marsh remaining
- Projected marsh migration as soon as 2050
- Projected marsh migration as soon as 2070

Developed Coastlines

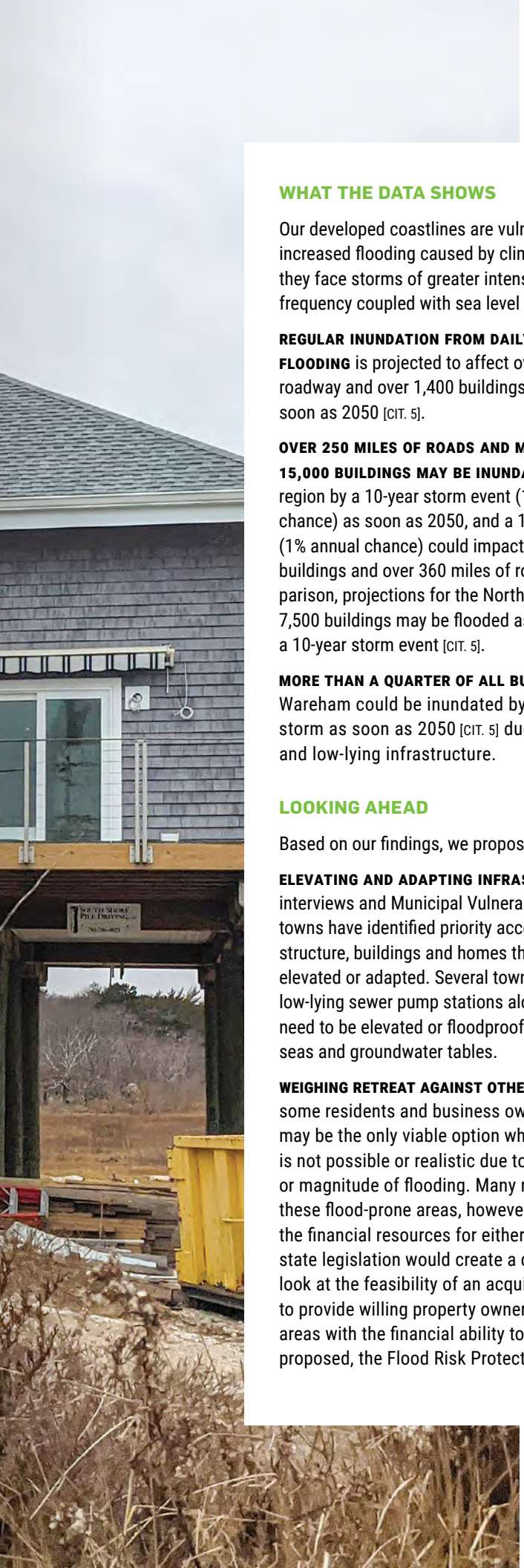
The Massachusetts coast is a beloved place for many. Drawn to the shoreline, we've built cities, towns, and neighborhoods along a waterfront that supports local economies and enhances our lived experience. Yet coastal towns are now on the front lines of the increasing risks of climate change, including impacts from coastal storms, flooding, erosion, and sea level rise.

On the South Coast, there are 14 towns ringing Buzzards Bay and portions of Narragansett Bay which benefit from the ocean's natural resources. Two Designated Port Areas and world-renowned research institutions contribute greatly to the economy of the region that nearly half a million people call home.

Into the future, coastal storms are projected to be more frequent and severe [CIT. 4]. As soon as 2050, more than 8% of buildings in this region (over 15,000) are projected to flood in a 10-year storm event [CIT. 5]. Particularly vulnerable are the towns of Wareham, Bourne, Marion, and Mattapoisett because of their position at the terminal end of Buzzards Bay. As storms enter the bay, a "funnel" effect forces more water up through the Bay and into low-lying neighborhoods and town centers.

The location and orientation of Buzzards Bay has meant it has been disproportionately hard hit by hurricanes relative to the rest of the state. Hurricanes cause both erosion and increased flooding as waves surge onto the landscape. Hurricane Bob in 1991, for example, caused 10 to 15 feet of storm surge in Bourne and Wareham resulting in immense damage to homes and infrastructure [CIT. 1].

All the towns in this region have completed Municipal Vulnerability Preparedness plans identifying community vulnerabilities and needed projects, and some have gone a step further to complete more detailed Climate Vulnerability Assessments. Citing lack of staff capacity and funding constraints, however, most towns have not moved beyond planning. A complicating factor is the separation between private and public sectors, each responsible for different utilities and services while facing the same future of risk. We need to address these constraints regionally, working across sector and town boundaries to act strategically to adapt our roads, buildings, and infrastructure as well as to think about where we choose to move out of harm's way.



WHAT THE DATA SHOWS

Our developed coastlines are vulnerable to increased flooding caused by climate change as they face storms of greater intensity and frequency coupled with sea level rise. Consider:

REGULAR INUNDATION FROM DAILY TIDAL FLOODING is projected to affect over 25 miles of roadway and over 1,400 buildings in this region as soon as 2050 [CIT. 5].

OVER 250 MILES OF ROADS AND MORE THAN 15,000 BUILDINGS MAY BE INUNDATED in this region by a 10-year storm event (10% annual chance) as soon as 2050, and a 100-year storm (1% annual chance) could impact over 21,000 buildings and over 360 miles of roads. By comparison, projections for the North Shore show that 7,500 buildings may be flooded as soon as 2050 in a 10-year storm event [CIT. 5].

MORE THAN A QUARTER OF ALL BUILDINGS in Wareham could be inundated by a 10-year storm as soon as 2050 [CIT. 5] due to its location and low-lying infrastructure.

LOOKING AHEAD

Based on our findings, we propose:

ELEVATING AND ADAPTING INFRASTRUCTURE In interviews and Municipal Vulnerability Plans, towns have identified priority access roads, infrastructure, buildings and homes that will need to be elevated or adapted. Several towns also mentioned low-lying sewer pump stations along the coast that need to be elevated or floodproofed due to rising seas and groundwater tables.

WEIGHING RETREAT AGAINST OTHER OPTIONS For some residents and business owners, retreat may be the only viable option when adaptation is not possible or realistic due to the frequency or magnitude of flooding. Many residents in these flood-prone areas, however, may not have the financial resources for either. New proposed state legislation would create a commission to look at the feasibility of an acquisition program to provide willing property owners in flood risk areas with the financial ability to relocate. As proposed, the Flood Risk Protection Program would result in vulnerable properties becoming (on a voluntary basis) permanently conserved as natural areas, better able to buffer storm impacts and protect surrounding areas (See "Facing the Future" on pg. 30).

BUILDING CAPACITY TO IMPLEMENT RESILIENCE PROJECTS Stepping back from each town's individual lens to take a regional approach to prioritizing resilience work will be critical. The Southeastern Regional Planning and Economic Development District (SRPEDD) is in the initial stage of developing a Regional Resilience Plan that looks at environmental, economic, and social vulnerabilities across the region. But beyond planning work, it is critical we address the capacity needs of the towns to implement resilience work on-the-ground.

PRIORITIZING PROJECTS EQUITABLY In addition to considering the severity of flooding impacts to communities when prioritizing work, it will be critical to also consider the financial ability of neighborhoods to adapt or retreat. We must strive to develop an equitable approach to allocation of public resources.

ENVIRONMENTAL JUSTICE ALONG THE COAST

Environmental Justice (EJ) is "the principle that all people have a right to be protected from environmental hazards and to live in and enjoy a clean and healthful environment regardless of race, color, national origin, or income" as defined by the Commonwealth of Massachusetts. EJ communities are identified by thresholds for household income, minority population percentages, or languages spoken. Several EJ communities along the South Coast are projected to experience increased flooding and may not have the resources to relocate or adapt. In addition, climate change impacts to the maritime economies of New Bedford and Fall River could disproportionately impact the livelihoods of the surrounding neighborhoods, many of which are EJ communities comprised of low-income and minority residents. The Port of New Bedford, for example, supports approximately $1.8 billion in total personal wages annually [CIT. 25]. The needs of these communities should be a focus when prioritizing resources to assist with adaptation and relocation.

Working Waterfronts

Much of this region is intrinsically linked to the sea, with a legacy of whaling, shipping, and fishing that goes back thousands of years. Today, a Blue Economy that relies on fishing remains central to this part of the state (see table) and has grown to include ocean science, tourism, and a nascent wind power industry. One of the more visible examples of this are the working ports that support commercial centers in nearly all the towns, including two Designated Port Areas in New Bedford (includes Fairhaven) and Fall River that are critical to the state's economy.

> "The Blue Economy is the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs, while preserving the health of the marine and coastal ecosystem."
>
> **WORLD BANK**

The economic prosperity of the Port of New Bedford has national implications, as it has been the largest fishing port by revenue for the last 20 years, creating over 39,000 jobs and generating $11 billion in economic value each year from port activity [CIT. 25]. Fall River is an active cargo port second only to Boston in the state, with containerized cargo being delivered to destinations including Cape Verde, the Azores, and Brazil [CIT. 26].

After violent hurricanes devastated the region in 1938, 1944 and 1954, a hurricane barrier was built at the mouth of the New Bedford harbor in 1966—which to this day remains the largest manmade stone structure in the Eastern US. The US Army Corps of Engineers operates the gates, which are designed to keep the water level in the harbor below a certain level (5.4 ft above mean lower low water), protecting the port from the impacts of large storms [CIT. 28]. More recently, however, the water level has been reaching this threshold at extreme high tides. In 2019, for example, the barrier closed 26 times [CIT. 7].

Given sea level rise projections, maintaining this same water level threshold behind the barrier could mean one to two closures a day as soon as 2050. Port Authority staff have stated it would simply not be possible to operate the port with this many closures and that a new management strategy would need to be developed [CIT. 37]. This would likely involve allowing more flooding to occur in low lying areas along the Fairhaven waterfront while also adapting high priority infrastructure and implementing strategic retreat.

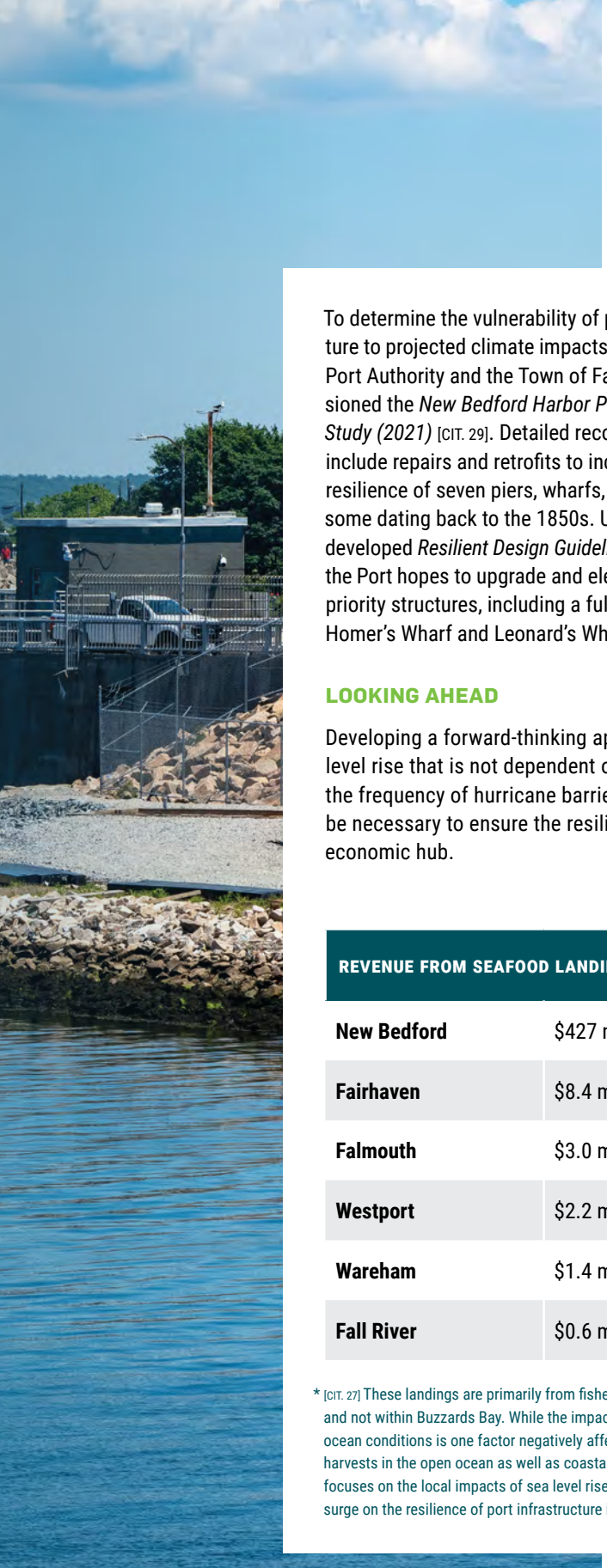


Photo courtesy: Keith Joseph Piwowarski

To determine the vulnerability of port infrastructure to projected climate impacts, the New Bedford Port Authority and the Town of Fairhaven commissioned the *New Bedford Harbor Port Assessment Study (2021)* [CIT. 29]. Detailed recommendations include repairs and retrofits to increase the resilience of seven piers, wharfs, and terminals, some dating back to the 1850s. Using new locally developed *Resilient Design Guidelines (2020)* [CIT. 30], the Port hopes to upgrade and elevate several high priority structures, including a full replacement of Homer's Wharf and Leonard's Wharf.

LOOKING AHEAD

Developing a forward-thinking approach to sea level rise that is not dependent on increasing the frequency of hurricane barrier closures will be necessary to ensure the resilience of this economic hub.

REVENUE FROM SEAFOOD LANDINGS (2018)*	
New Bedford	$427 million
Fairhaven	$8.4 million
Falmouth	$3.0 million
Westport	$2.2 million
Wareham	$1.4 million
Fall River	$0.6 million

* [CIT. 27] These landings are primarily from fisheries in the open ocean and not within Buzzards Bay. While the impact of climate change on ocean conditions is one factor negatively affecting fish and shellfish harvests in the open ocean as well as coastal areas, this report focuses on the local impacts of sea level rise and increased storm surge on the resilience of port infrastructure into the future.

This approach could prioritize:

UPGRADING AGING PORT INFRASTRUCTURE USING NEW DESIGN GUIDELINES *The Resilient Design Guidelines* for New Bedford Harbor [CIT. 30] recommend a hierarchical approach of either ***avoidance*** (taking steps to eliminate a risk), ***protection*** (taking steps to minimize the vulnerability of an asset), or ***recovery*** (designing for quick recovery from predicted hazards). *The New Bedford Harbor Port Assessment (2021)* identifies several priority upgrades to port infrastructure, with funding needed to advance projects [CIT. 29].

HARNESSING THE POWER OF WIND The offshore wind industry is investing heavily in this region and Fall River (operations base), Somerset (grid connection site and cable manufacturing facility), and New Bedford (construction staging) will play major roles in this new element of the Blue Economy. Through innovative designs of coastal infrastructure, the opportunity exists for this industry to be a model for resilient development, reducing our dependence on fossil fuels, decreasing carbon emissions, and potentially slowing the effects of climate change.

> "Over the past several years, the Army Corps of Engineers has mitigated flooding due to storm surge and sea level rise at king tides by closing the hurricane barrier at an increasing frequency. This is not a sustainable practice for flooding…"
>
> **NEW BEDFORD HARBOR PORT ASSESSMENT SUMMARY [CIT. 29]**

Water Quality and Habitat

Historically, Buzzards Bay and Narragansett Bay and the rivers and estuaries feeding them were home to abundant populations of wildlife including bay scallops, quahogs, soft shell clams, and oysters, as well as several fish species such as striped bass, bluefish, and river herring. Human actions and land use, however, have led to water pollution and habitat degradation that have decimated the bay scallop population and had severe impacts on eelgrass, shellfish, and fish populations. Climate change also plays a role with warming ocean temperatures and increased stormwater runoff contributing to habitat declines.

In 1998, the Environmental Protection Agency designated Buzzards and Narragansett Bays as "estuaries of national significance" that are threatened by pollution and land development [CIT. 31]. The Buzzards Bay Coalition, formed in 1987 with the goal of restoring the health of the bay, runs a robust volunteer program to monitor water quality at over 250 points. They classify half of the bay's harbors, coves, ponds, and rivers as degraded by pollution, namely excess nutrients [CIT. 32]. The good news is that through the successful efforts of multiple watershed partners, water quality is beginning to improve.

Currently, nitrogen pollution is the number one cause of habitat degradation in Buzzards Bay as identified by the Coalition. Nitrogen causes algal blooms to flourish which both depletes the water of oxygen and shades out the eelgrass beds growing below. Thirty years ago, the bay was home to over 11,000 acres of eelgrass beds that supported young fish, blue crabs, bay scallops, and other wildlife [CIT. 8]. Approximately 43% of these eelgrass beds have disappeared in the years since [CIT. 8], causing a subsequent decline in the wildlife that depends on them (e.g. 90% decline in bay scallop harvest in the last 30 years) [CIT. 9]. If water quality continues to improve, there is hope that nature can rebound. Acreage of eelgrass beds, for example, has increased by approximately 850 acres since 2017 [CIT. 8].

Excess nitrogen in Buzzards Bay comes primarily from three sources: septic systems, inadequate wastewater treatment, and stormwater laden with fertilizers and other pollutants [CIT. 32]. As the climate changes, higher intensity rainfall events and warmer water temperatures in the bay are projected to increase the impact of these pollutants. Nature is less resilient when it is stressed. We need to act now to clean up this waterbody, allowing eelgrass and wildlife to rebuild so they can better adapt to a changing future.

WHAT THE DATA SHOWS

Water quality and wildlife habitat are linked. Data in this region shows that impairments from nutrients correspond to declines in wildlife populations. Consider:

- **There are 38 harbors, coves and tidal rivers flowing into Buzzards Bay that fall below established water quality standards** for excess nutrients as identified by the Commonwealth [CIT. 33].
- **Eelgrass beds in Buzzards Bay have suffered a 43% decline in just 30 years.** These beds, which provide nursery and foraging habitat for many species, numbered 11,040 acres in the 1980s and fell to 6,275 by 2021 [CIT. 8].
- **The bay scallop population in Buzzards Bay has suffered a near collapse** correlated with the loss of eelgrass beds. The harvest of scallops has gone from nearly 70,000 bushels in 1985 to just 1,770 bushels on average over the last five years — a more than 90% decline in the harvest in just 30 years [CIT. 9].

LOOKING AHEAD

A healthy ecosystem can be more resilient to climate changes. Let's work together to:

IMPROVE SEPTIC SYSTEMS Conventional septic systems do not remove much nitrogen and can result in ground and surface water contamination. Encouraging better maintenance of septic systems and installation of new innovative system designs can reduce contamination. In West Falmouth, the Buzzards Bay Coalition partnered to install 30 nitrogen-reducing systems that are removing over 70% of the nitrogen that would have otherwise ended up in the bay [CIT. 34].

EXPAND AND IMPROVE WASTEWATER TREATMENT Connecting more homes to the sewer system would reduce nitrogen pollution to our waterways. One solution proposed by several regional partners is the expansion of the Wareham Water Pollution Control Facility, allowing it to meet the current and future needs of Marion, Wareham, Bourne, South Plymouth, and the MA Maritime Academy. Doing this could reduce nitrogen pollution by an estimated 100,000 lbs/year — the equivalent of 3,450 septic systems [CIT. 35].

In some cases, our wastewater treatment plants can do better. Wareham, Falmouth, and Marion have upgraded their plants to remove up to 90% of nitrogen from their discharges.

REDUCE STORMWATER POLLUTION Replacing pavement and other impervious surfaces and implementing green stormwater infrastructure practices such as raingardens, permeable pavement, and green roofs allow the soil to filter runoff before it reaches our rivers and bays. Stopping these pollutants at the source is also critical. Best practices can be used with fertilizer and manure applications on both residential and agricultural lands (including cranberry bogs) to reduce or eliminate polluted runoff.

PROTECT AND EXPAND NATURAL AREAS Forests and marshes along our coast and waterways act as buffers that filter out pollutants and absorb nitrogen. Maintaining these as protected areas is critical for improving water quality, buffering storms, and providing wildlife habitat.

> "Reducing nitrogen pollution to Buzzards Bay is the most powerful tool we have to counter the effects of climate change and make our coastal waters more resilient. And, unlike cutting global CO_2, the means for reducing nitrogen are largely within our control."
>
> **MARK RASMUSSEN**
> **PRESIDENT, BUZZARDS BAY COALITION**

Buzzards Bay

Officially recognized as "an estuary of national significance" under the National Estuary Program, Buzzards Bay is an iconic and beloved place. Home also to the historic Port of New Bedford—the nation's largest fishing port by revenue—the bay is an important economic driver to the region as well as a destination for recreating, where residents and thousands of summer visitors each year flock to fish, boat, and enjoy area beaches and scenic views.

Nine towns fringe the 28-mile-long bay, with Falmouth on the easternmost point and, moving westward, Bourne, Wareham, Marion, Mattapoisett, Fairhaven, New Bedford, Dartmouth, and Westport. Of these, two are officially part of Cape Cod, in addition to being partially in the Bay watershed—Falmouth and Bourne—with neighboring Wareham considered the unofficial "Gateway" to the Cape. The Elizabeth Islands and the Town of Gosnold, covered in a previous State of the Coast report (2021), form the eastern boundary of Buzzards Bay.

As soon as 2050, this region is projected to experience a variety of climate change impacts to both natural and developed areas along its 200 miles of coastline. At particular risk are its 4,750 acres of salt marsh, an ecologically rich landscape that also helps to buffer storm surge and absorb excess rainwater. In just 30 years, 1,150 acres of marsh in this region (24% of the Bay's total) may be lost to sea level rise, with almost 3,500 acres of high marsh (79% of total) transitioning primarily to low marsh and tidal flats in the same timeframe [CIT. 6]. When salt marsh transitions, or is lost altogether, an important buffering habitat is gone. With flooding impacts already expected to be significant for several towns in this region as soon as 2050, it lends additional urgency to conserving and adapting the region's marsh or allowing pathways for migration.

Flooding impacts are expected to vary by town—with some residential areas on higher ground, or in New Bedford's case, protected by a hurricane barrier constructed in the mid-60s for $18.6 million. For towns at the head of the bay, a "funnel effect" is at play, with storm surge concentrating as it moves up the bay and putting these areas at more risk of flooding impacts. For towns exposed to open ocean—Westport and Dartmouth—infrastructure damage, flooding, and more erosion is projected from storms and wave energy. Overall, as soon as 2050 more than 13,000 structures around the bay could be flooded in a 10-year storm, with 52% of those structures in just two towns at the head of the bay—Wareham and Bourne [CIT. 5].

At the outset of this year's report process, calls with conservation agents, town administrators, conservation agents, engineers, and others were conducted to understand the main challenges and areas where adaptation is needed. With each town having already completed Municipal Vulnerability Preparedness planning, common threads emerged including the need for funding and the lack of staff capacity to address adaptation needs. With many of the desired projects involving flood-prone downtown areas, vulnerable low-lying wastewater infrastructure, and at-risk coastal roads, a regional strategy could be a vital tactic for this region to collectively address threats and adapt for impacts—impacts that will not stop at town borders.

Falmouth

The Town of Falmouth on Cape Cod has 26 miles of shoreline facing Buzzards Bay [CIT. 17]. The population of 31,104 triples in the summer months due to a robust tourism industry. Falmouth includes the village of Woods Hole, home to several research institutions and ferry service to the islands.

In the next 30 years, Falmouth is projected to experience a variety of impacts to both natural areas and developed areas along its coast (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding is projected to impact 219 buildings (2.7% of town buildings) [CIT. 5]. A 10-year flood is projected to impact 1,386 buildings (17%), and a 100-year flood may impact 2,012 buildings (25%). Vulnerable neighborhoods include Chapoquoit, New Silver Beach, and Woods Hole. Also at risk in low-lying areas are utilities, sewer pump stations, and the scientific facilities along the Woods Hole waterfront [CIT. 5].

ROADS Daily tidal flooding may impact four miles of roads (2.2% of town roads) [CIT. 5]. A 10-year flood is projected to inundate 24.5 miles (13%), while a 100-year flood may inundate 34 miles (19%) [CIT. 5]. Vulnerable roads include causeways such as Chapoquoit Road and the Woods Hole Water and Albatross Streets, as well as residential roads such as Millfield and Gardiner.

SALT MARSHES Sixty two percent (136 of 221 acres) of critical high marsh habitat may be lost by flooding or conversion to low marsh. Overall, about 17% of total marsh (43 of 257 acres) may be completely lost [CIT. 6]. Vulnerable areas include Great Sippewissett Marsh, the oldest studied salt marsh in the country, which has limited room to migrate.

BEACHES 20 miles of shoreline are classified as beach [CIT. 17] and 3.1 miles of the coastline are publicly accessible (12%) [CIT. 16]. Falmouth is expected to experience increased erosion of its beaches, with high-risk areas including Wood Neck and Chapoquoit Beaches.

"Retreat is a real conversation the town is going to have to have, and it's not an easy decision when you're talking about people's homes."

JENNIFER LINCOLN, FALMOUTH CONSERVATION ADMINISTRATOR [CIT. 37]

THE TOWN IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Partnering to protect and restore Great Sippewissett Marsh.
- Developing a retreat plan for coastal roadways.
- Relocation of critical municipal and other facilities out of vulnerable areas.

2050 STORM AND TIDAL FLOODING [CIT. 5]

- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline

Bourne

The Town of Bourne, with 20,691 residents, is home to the Cape Cod Canal and 37 miles of Buzzards Bay-fronting shoreline [CIT. 17]. Its population swells to 40,000 in the summer.

In the next 30 years, Bourne is projected to experience a variety of climate impacts to both natural and developed areas along its coast (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding is projected to impact 156 buildings [CIT. 5]. A 10-year flood may impact more than 2,655 buildings (25% of town buildings), and a 100-year flood may impact more than 3,619 buildings (35%) [CIT. 5]. An estimated 40% of Bourne's single-family homes lie within vulnerable flood zones. Historic buildings and public parks, including the Museums at Aptucxet and Buzzards Bay Recreation Area, are at risk of increased flooding.

ROADS Daily tides may flood 2.5 miles of roads. A 10-year flood is projected to inundate 44 miles (14% of town roads), while a 100-year flood may inundate 60 miles (19%) [CIT. 5]. Particularly concerning are the impacts to causeways and other low-lying roads that provide critical—and often sole—access to neighborhoods, including Wings Neck, Mashnee Island, Scraggy Neck, Circuit Avenue, and others.

SALT MARSHES Seventy five percent (209 of 277 acres) of critical high marsh habitat may be lost by flooding or conversion to low marsh. Overall, about 28% of total marsh (86 of 308 acres) may be completely lost [CIT. 6]. Of particular concern is the salt marsh die-off and degradation at Monks Park, Dolphin Cove, and Gray Gables Beach.

BEACHES An extensive 23.8 miles of coastline are classified as beach [CIT. 17], and 9.2 miles of the coastline are publicly accessible (25%) [CIT. 16]. Peninsulas and islands such as Bassetts Island provide protective benefits but are projected to be vulnerable to erosion and flooding.

"Sea level rise in the downtown is definitely going to be an issue. Foundations that were dug 100 years ago are seeing water."

TIMOTHY LYDON, BOURNE TOWN ENGINEER [CIT. 37]

THE TOWN IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Planning for low-lying, flood-prone roads.
- Improved stormwater and wastewater management including participation in regional solutions for improved water quality.
- Restoration of salt marshes and barrier beaches.
- Adaptation projects to increase resilience of historic resources, municipal infrastructure, and public recreational areas.

2050 STORM AND TIDAL FLOODING [CIT. 5]

- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline

Wareham

The Town of Wareham, with 22,694 residents, has 27 miles of bayfront shoreline [CIT. 17] including the Weweantic and Wareham River estuaries, Onset Bay, and the Stony Point Dike. At the head of Buzzards Bay, several of its low-lying neighborhoods face significant storm flooding risk as water funnels up the bay.

In the next 30 years, Wareham is projected to experience a variety of impacts (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding is projected to impact approximately 250 buildings [CIT. 5]. A 10-year flood may impact 4,326 buildings (27% of town buildings), while a 100-year flood may impact 6,365 buildings (39%) [CIT. 5]. Flooding is projected to affect the downtown village, state-designated Environmental Justice areas (see pg. 13), municipal offices, wastewater pump stations, and historic assets such as the Tremont Nail Factory.

ROADS Daily tidal flooding may impact 3.2 miles of roads [CIT. 5]. A 10-year flood is projected to inundate 61 miles (18% of town roads), while a 100-year flood could inundate 95 miles (28%) [CIT. 5]. Several roadways critical for emergency services are vulnerable, such as Route 6, Onset Avenue and Sandwich Road as well as roads in the Main Street/ Narrows area.

SALT MARSHES Sixty nine percent (573 of 830 acres) of high marsh may be lost by flooding or conversion to low marsh. Overall, about 10% of total salt marsh (89 of 869 acres) may be completely lost to sea level rise [CIT. 6]. Low-lying areas such as the Leonard C. Lopes Memorial Park are projected to transition to salt marsh.

BEACHES Seventeen miles of shoreline are classified as beach [CIT. 17], and 7.5 miles of the coastline are publicly accessible (28%) [CIT. 16]. Vulnerable areas include Swift's Beach on the Wareham River and coastline along the many peninsulas that extend into Buzzards Bay.

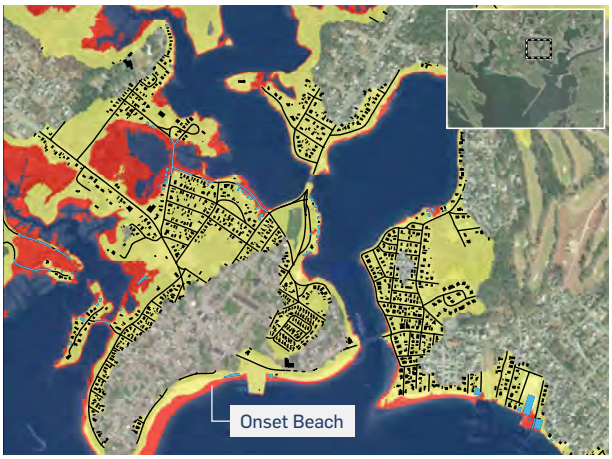
"We're trying to get economic development going, but along with that comes the responsibility for climate change, sea level rise, and what we do about the coastline."

KENNETH BUCKLAND, DIRECTOR OF PLANNING AND COMMUNITY DEVELOPMENT [CIT. 37]

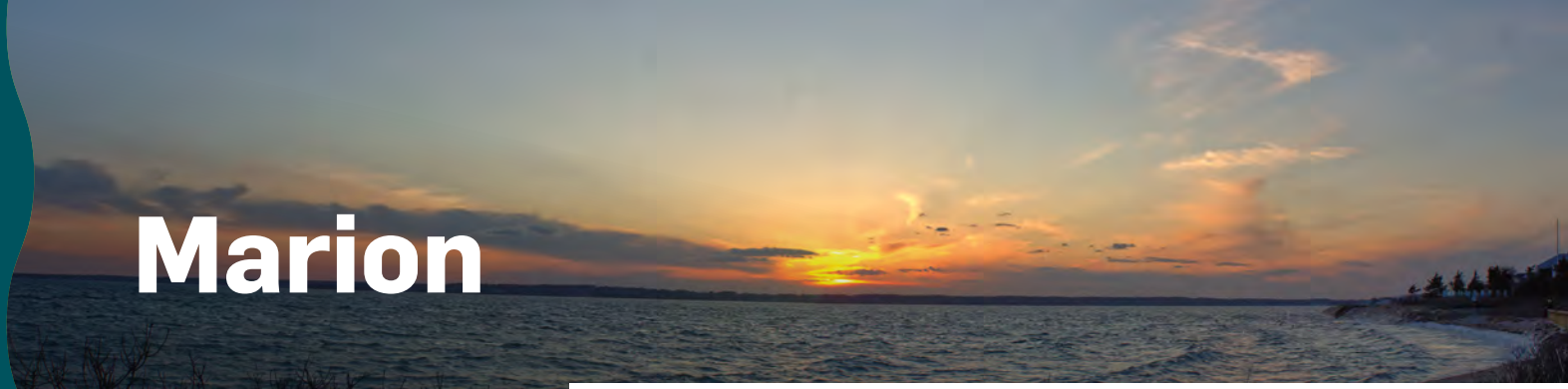
THE TOWN IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Resiliency strategies for low-lying roads, especially critical access routes and municipal facilities such as pump stations.
- Adaptation of recreational areas for public shorefront access and to allow for salt marsh migration.
- Planning for adaptation or retreat in vulnerable areas.

2050 STORM AND TIDAL FLOODING [CIT. 5]



- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline



Marion

The Town of Marion has a modest population of just over 5,000 people and boasts a beautiful 24-mile shoreline [CIT. 17] featuring Sippican Harbor, Aucoot Cove, Wings Cove, and the Weweantic River.

In the next 30 years, Marion is projected to experience a variety of impacts to both natural areas and developed areas along its coast (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding is projected to impact 45 buildings [CIT. 5]. A 10-year flood may impact more than 890 buildings (24% of town buildings), and a 100-year flood may impact more than 1,464 buildings (40% [CIT. 5]). The densely developed downtown, including wastewater treatment pump stations, is vulnerable to flooding. Private septic systems are also at risk of failure due to the rising water table. Additional areas of concern include the Harbormaster Building and Town Landing, the Sippican School, and Tabor Academy.

ROADS Daily tides may flood 0.5 miles of roads [CIT. 5]. A 10-year flood is projected to inundate 16 miles (19% of town roads), while a 100-year flood may inundate 26 miles (31%) [CIT. 5]. At risk roads include Front Street (the main access route into town), Route 6, and the Aucoot Cove area.

SALT MARSHES Seventy two percent (254 of 353 acres) of critical high marsh habitat may be lost by flooding or conversion to low marsh. Overall, about 21% of total marsh (86 of 405 acres) may be completely lost [CIT. 6]. In particular, marshes in the southwest part of Sippican Harbor are disappearing.

BEACHES 9.4 miles of shoreline are classified as beach [CIT. 17], and 4 miles of the coastline are publicly accessible (17%) [CIT. 16]. Areas experiencing beach erosion may include Silvershell Beach, northeast Aucoot Cove, Stewarts Island, and isolated areas within Sedge Cove and Wings Cove. Erosion impacts in areas around Great Hill Point and Warren Point may also increase.

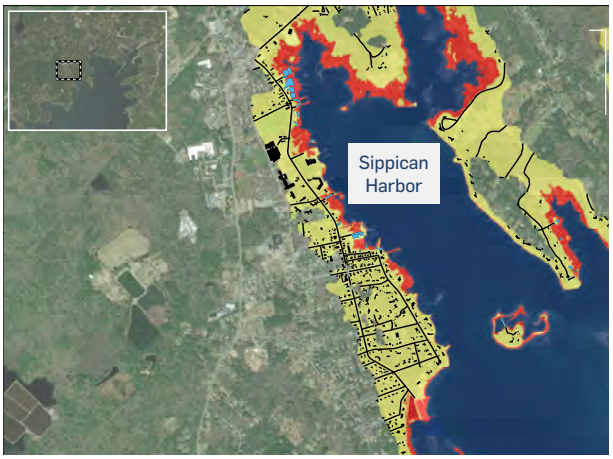
"[People] kicked the can down the road, and the end of the road is in sight."

JAMES MCGRAIL, TOWN ADMINISTRATOR [CIT. 37]

THE TOWN IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Adaptation measures for the Front Street pump station and the Creek Road pump station (which serve about 50% of the town by area).
- Construction of a new harbormaster building and Maritime Center.
- Updating the town's Open Space Plan.

2050 STORM AND TIDAL FLOODING [CIT. 5]



- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline

Mattapoisett

Photo courtesy: Keith Joseph Piwowarski

The Town of Mattapoisett is home to 6,374 people and has 23 miles of shoreline [CIT. 17] that extend along the Nasketucket Bay State Reservation, Mattapoisett Harbor, Aucoot Cove, and the Mattapoisett River.

In the next 30 years, Mattapoisett is projected to experience a variety of climate impacts to both natural and developed areas along its coast (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding is projected to impact 111 buildings [CIT. 5]. A 10-year flood may impact 1,142 buildings (24% of town buildings), and a 100-year flood may impact 1,576 buildings (33%) [CIT. 5]. About 36% of the town's land area is in FEMA flood zones. Areas of concern include the town hall, library, Center School, Ned's Point Lighthouse, and water supply wells.

ROADS Daily tidal flooding may impact three miles of roads [CIT. 5]. A 10-year flood is projected to inundate 20 miles (18% of town roads), while a 100-year flood may inundate 26 miles (24%) [CIT. 5]. Areas of concern include Mattapoisett Neck Road, Molly's Cove Road, Holly Woods Road, Angelica Avenue, Brant Island Road, and Aucoot Road.

SALT MARSHES Eighty one percent (295 of 366 acres) of critical high marsh habitat may be lost by flooding or conversion to low marsh. Overall, about 17% of total marsh (67 of 385 acres) may be completely lost [CIT. 6]. Preserving salt marsh areas, such as Mattapoisett Land Trust's Munn Preserve at Brandt Island Cove, will be an important strategy for future resiliency.

BEACHES Mattapoisett has 10.6 miles of shoreline classified as beach [CIT. 17], and 3.3 miles of the coastline are publicly accessible (14%) [CIT. 16]. The recent beach erosion rates have been as much as 2.8 feet per year [CIT. 15] and erosion is expected to continue.

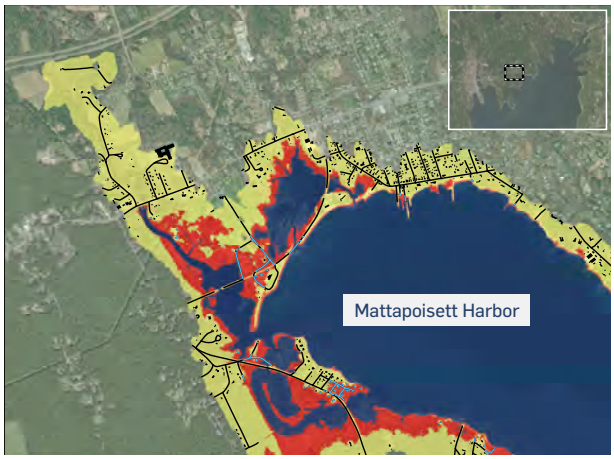
"I wish there was more money to tackle these projects...We do it in baby steps."

MICHAEL LORENCO, TOWN ADMINISTRATOR [CIT. 37]

THE TOWN IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Resiliency improvements for infrastructure at the Harbor.
- Adaptation strategies for low-lying roads such as Angelica Point.
- Preservation of open space to protect the water supply, water quality, and shellfishing resources.

2050 STORM AND TIDAL FLOODING [CIT. 5]



- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline

Fairhaven

The Town of Fairhaven, with 16,072 residents, has the smallest land area of all the towns on Buzzards Bay (12 square miles), however its extensive shoreline stretches 29 miles [CIT. 17] along Buzzards Bay, New Bedford Harbor, and Nasketucket Bay. The New Bedford hurricane barrier, which was constructed to protect the harbor from storm surge, closed 26 times due to high tides in 2019 [CIT. 7] and is projected to close more frequently as the sea rises.

In the next 30 years, Fairhaven is projected to experience a variety of climate impacts to both natural and developed areas along its coast (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding is projected to impact 324 buildings (3.5% of town buildings), including municipal, flood-prone coastal neighborhoods, and the harbor waterfront [CIT. 5]. A 10-year flood may impact 1,433 buildings (16%), and a 100-year flood may impact 1,759 buildings (19%) [CIT. 5]. Water, stormwater, and wastewater systems are aging and at risk. The town's four sewer pump stations are in vulnerable coastal flood hazard areas.

ROADS 5.7 miles of roads (4% of town roads) may see daily tidal flooding, 23 miles (17%) could be inundated in the event of a 10-year flood, and 28 miles (20%) in a 100-year flood [CIT. 5]. Vulnerable roads include the causeway to West Island, Sconticut Neck Road, and Huttleston Avenue (Route 6).

SALT MARSHES Seventy-seven percent (420 of the 547 acres) of critical high marsh habitat may be lost by flooding or conversion to low marsh. Overall, about 7% of total marsh (39 acres of 571 acres) may be completely lost [CIT. 6]. Areas of greatest concern include Winsegansett and West Island salt marshes.

BEACHES Nearly 11 miles of coastline are classified as beach [CIT. 17] and 9 miles of the coastline are publicly accessible (30%) [CIT. 16]. These areas are expected to experience increased erosion rates. Vulnerable areas include Fort Phoenix State Reservation and West Island Town Beach.

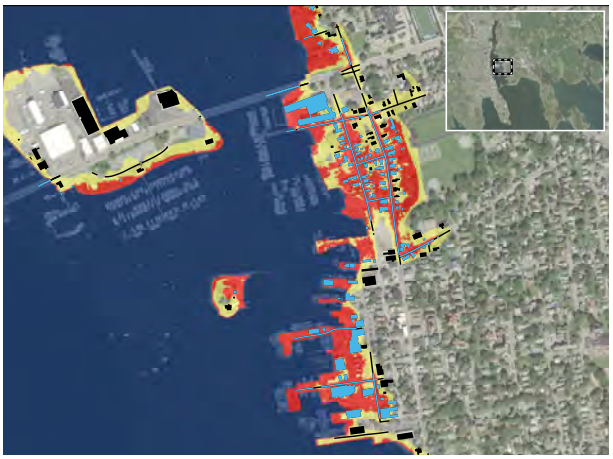
"Personally, I think we need to move away from elevating [vulnerable infrastructure] and more towards retreat."

WHITNEY MCCLEES, CONSERVATION AGENT AND SUSTAINABILITY COORDINATOR [CIT. 37]

THE TOWN IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Collaboration with New Bedford on harbor and waterfront vulnerability assessments.
- Resiliency improvements to sewer pump stations.
- Adaptation strategies for West Island Town beach and salt marshes.
- Bylaws and regulation updates to address resilience.

2050 STORM AND TIDAL FLOODING [CIT. 5]



- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline

New Bedford

Photo courtesy: Keith Joseph Piwowarski

The City of New Bedford, with 101,079 residents, has the largest population of the Buzzards Bay municipalities. Its shoreline extends for 12 miles along Buzzards Bay, Clarks Cove, and the Acushnet River [CIT. 17]. The New Bedford hurricane barrier protects the harbor from storm surge.

In the next 30 years, New Bedford is projected to experience a variety of climate impacts to both natural and developed areas along its coast (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding is projected to impact 48 buildings [CIT. 5]. A 10-year flood may impact 270 buildings (0.9% of town roads), and a 100-year flood may impact 399 buildings (1.3%) [CIT. 5]. The rising sea level is expected to impact the industrial waterfront and heavier storms may bring increased contamination from stormwater. Of concern is the hurricane barrier itself, which was designed in the mid-60s to protect the harbor from floods but has been closing more frequently for high tides. If closed at the same water levels as today, the barrier is projected to close 1–2 times a day at high tides, a rate which is not sustainable for a working waterfront. Comparatively, this barrier closed 26 times in 2019 [CIT. 7].

ROADS Many of the city's roads are protected by seawalls and the hurricane barrier. Daily tides are projected to flood 1.2 miles of roads [CIT. 5]. A 10-year flood event is projected to inundate 10.4 miles of roadway (3% of town roads), and a 100-year flood event could inundate 12.4 miles (3.3%) [CIT. 5]. Low-lying roads such as East Rodney French Blvd are at greater risk.

BEACHES Almost six miles of shoreline are classified as beach, and 8 miles of the coastline are publicly accessible (69%) [CIT. 16]. With stabilization structures along much of its shoreline, the city is expected to see future impacts to its infrastructure from increased storm surge and sea level rise. Severe erosion has already occurred along a seawall on the west side of Clark's Cove Peninsula.

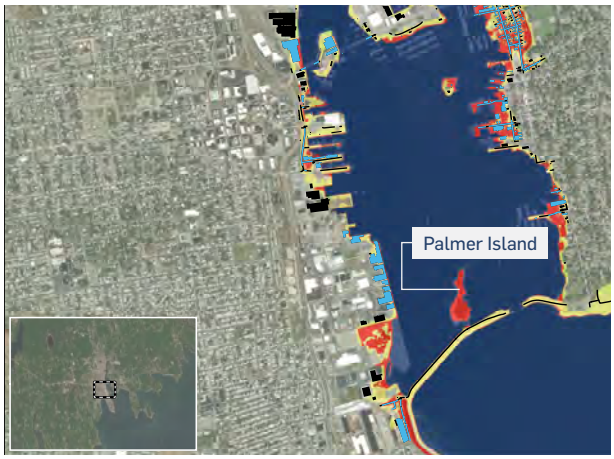
"Although some level of grey infrastructure will always be needed, we are working to develop a Green Infrastructure Master Strategy with natural alternatives."

MICHELE PAUL, DIRECTOR OF RESILIENCE AND ENVIRONMENTAL STEWARDSHIP [CIT. 37]

THE TOWN IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Collaboration with Fairhaven to develop adaptation strategies for the harbor.
- Green infrastructure improvements for West Rodney French Boulevard and East Beach parking lot.
- West Beach renourishment and stabilization to protect the beach, seawall and sewer main.
- Strategies for pollution reduction including the regional Buttonwood Brook Watershed project.

2050 STORM AND TIDAL FLOODING [CIT. 5]



- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline

Dartmouth

The Town of Dartmouth, with just over 34,000 residents, is the largest town by area on Buzzards Bay (62 square miles). Its 20-mile shoreline [CIT. 17] stretches along Buzzards Bay, Clarks Cove, and three large estuaries: Slocums River, Little River, and Apponagansett Bay.

In the next 30 years, Dartmouth is projected to experience a variety of climate impacts to both natural areas and developed areas along its coast (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding is projected to impact 69 buildings [CIT. 5]. A 10-year flood may impact 635 buildings (3.5% of town buildings), while a 100-year flood may impact 902 buildings (5%) [CIT. 5]. At-risk areas include the Town Landing, Padanaram Village, and properties near Destruction Brook, Buttonwood Brook, and Apponagansett Bay.

ROADS Daily tidal flooding may impact 3 miles of roads [CIT. 5]. A 10-year flood is projected to inundate 15.6 miles (5% of town roads), while a 100-year flood may inundate 20 miles (6%) [CIT. 5]. Areas at risk include the Gulf Road causeway, residential streets including Elm Street, Bridge Street, and Smith Neck Road, and access roads to the town's water supply wells.

SALT MARSHES Eighty six percent (868 of 1007 acres) of critical high marsh habitat may be lost by flooding or conversion to low marsh. Overall, about 30% of total marsh (325 of 1,072 acres) may be completely lost [CIT. 6]. Affected areas include the Buttonwood Brook Watershed, Slocums River Corridor, Little River Corridor, Cow Yard Salt Marsh, and Apponagansett Bay salt marshes.

BEACHES Dartmouth has 16.2 miles of shoreline classified as beach [CIT. 17], and 4.1 miles of the coastline are publicly accessible (21%) [CIT. 16]. Beaches are expected to see increased erosion and seawalls may continue deteriorating at Apponagansett Park and Arthur Dias Town Landing.

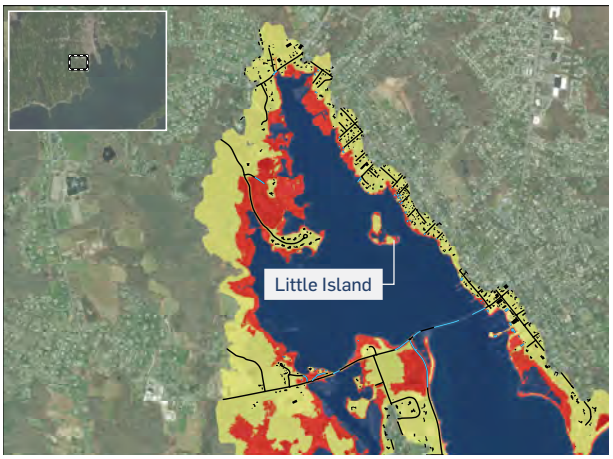
"Everyone runs to the sea. They want to live on the sea or near the sea, and so we have coastal development in places that maybe shouldn't be developed."

MARC J. GARRETT, DARTMOUTH ENVIRONMENTAL AFFAIRS COORDINATOR [CIT. 37]

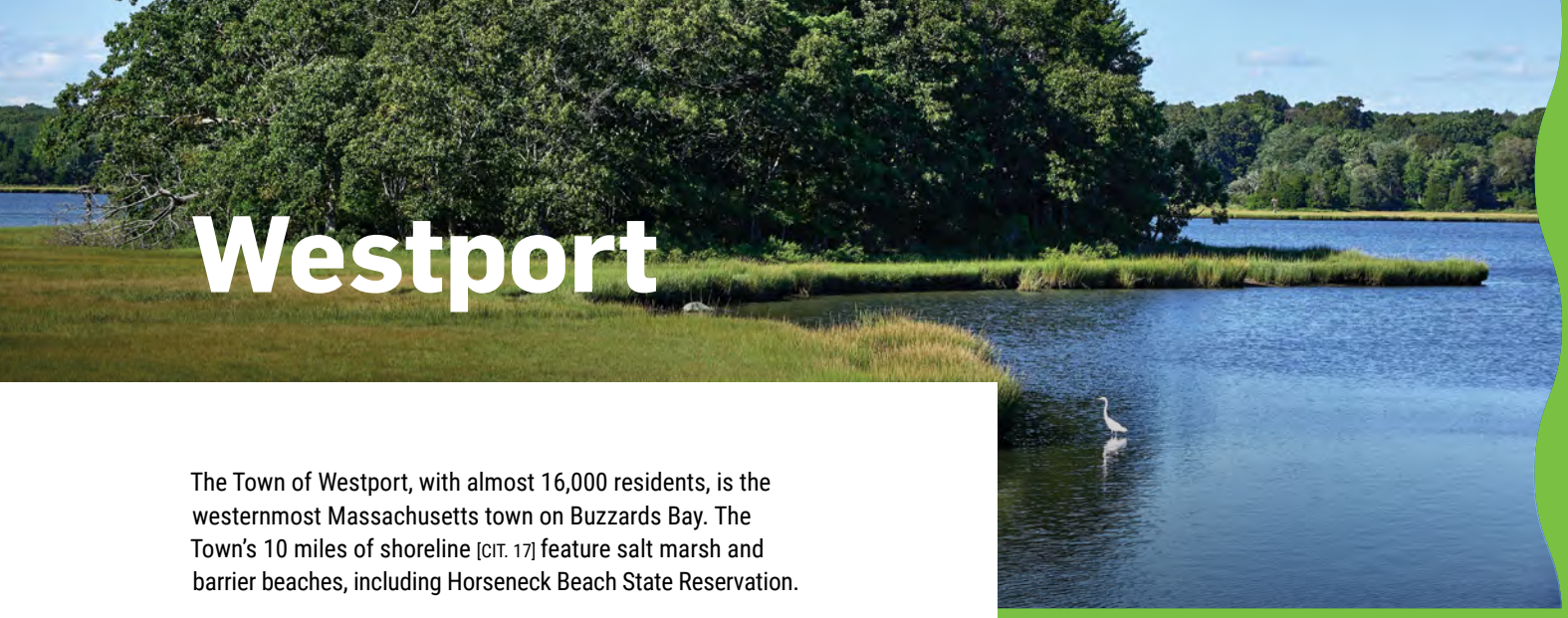
THE TOWN IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Use of nature-based strategies to protect vulnerable developed areas.
- Stormwater assessments and flood resiliency for critical municipal infrastructure.
- Land conservation of key parcels including resiliency planning for agricultural properties.
- Strengthening bylaws for low impact development and floodplain protection.

2050 STORM AND TIDAL FLOODING [CIT. 5]



- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline



Westport

The Town of Westport, with almost 16,000 residents, is the westernmost Massachusetts town on Buzzards Bay. The Town's 10 miles of shoreline [CIT. 17] feature salt marsh and barrier beaches, including Horseneck Beach State Reservation.

In the next 30 years, Westport is projected to experience a variety of impacts (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding may impact 104 buildings [CIT. 5]. A 10-year flood may impact 751 buildings (6% of town buildings), and a 100-year flood may impact 1,026 buildings (8%) [CIT. 5]. The vulnerable East Beach and Horseneck Road area includes 80 homes, a major boatyard, a restaurant, and seasonal trailers. Sea level rise is also projected to impact homes along the Westport River.

ROADS Daily tides may flood 0.8 miles of road [CIT. 5]. A 10-year flood is projected to inundate 14 miles (5% of town roads), while a 100-year flood may impact 19.5 miles (7%) [CIT. 5]. Vulnerable areas include the town docks, low-lying bridges and roads (portions of East Beach Road, River Road, Atlantic Avenue, John Reed Road, Kirby Brook, Main Road and Route 6) and the parking area for the town docks and Harbormaster's office.

SALT MARSHES Eighty nine percent (739 of 828 acres) of critical high marsh habitat may be lost to flooding or conversion to low marsh. Overall, nearly half (48%) of the salt marsh in Westport may be completely lost (417 of 877 acres) [CIT. 6]. Recent studies have shown significant loss of the salt marsh islands in the Westport River.

BEACHES 8.6 miles of shoreline are classified as beach [CIT. 17], and 5.5 miles of the coastline are publicly accessible (58%) [CIT. 16]. East Beach in Westport has seen over 150 feet of erosion in the last 120 years, threatening more than 30 homes and forcing some to relocate. Erosion rates are projected to increase with sea level rise and higher-intensity storms.

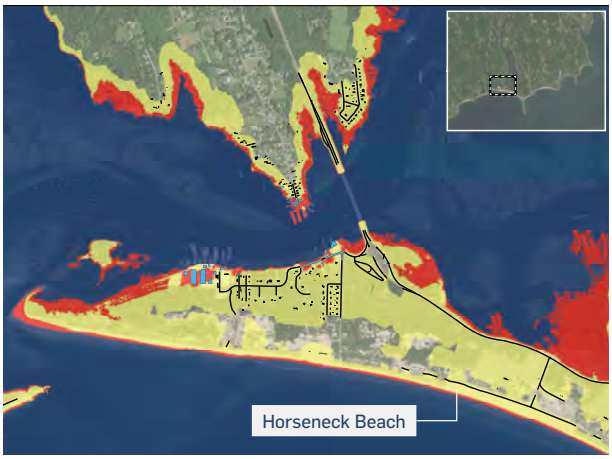
"My worry is that while we look at one or two risks, we'll get blindsided by a risk we're not focusing on. How do we raise funds for all of the issues, not just one?"

JOHN BULLARD, CHAIR OF CLIMATE RESILIENCY COMMITTEE AND PLANNING BOARD [CIT. 37]

THE TOWN IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Restoring salt marsh.
- Reducing sources of water pollution.
- Planning for long-term managed retreat and protection of the East Beach area.
- Pursuing adaptation strategies such as elevating bridges, removing dams, and replacing culverts.

2050 STORM AND TIDAL FLOODING [CIT. 5]



- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline

Narragansett Bay

Narragansett Bay is located west of Buzzards Bay on the north side of Rhode Island Sound. Covering 147 square miles, the bay forms New England's largest estuary, with 26 square miles within Massachusetts. The Bay and all the rivers that flow into it provide spawning grounds, nurseries, and habitat for more than 60 species of fish and shellfish, more than 200 bird species, and many marine mammals. Five towns bordering the bay, within Massachusetts, are included in this report—Fall River, Somerset, Swansea, Rehoboth, and Seekonk.

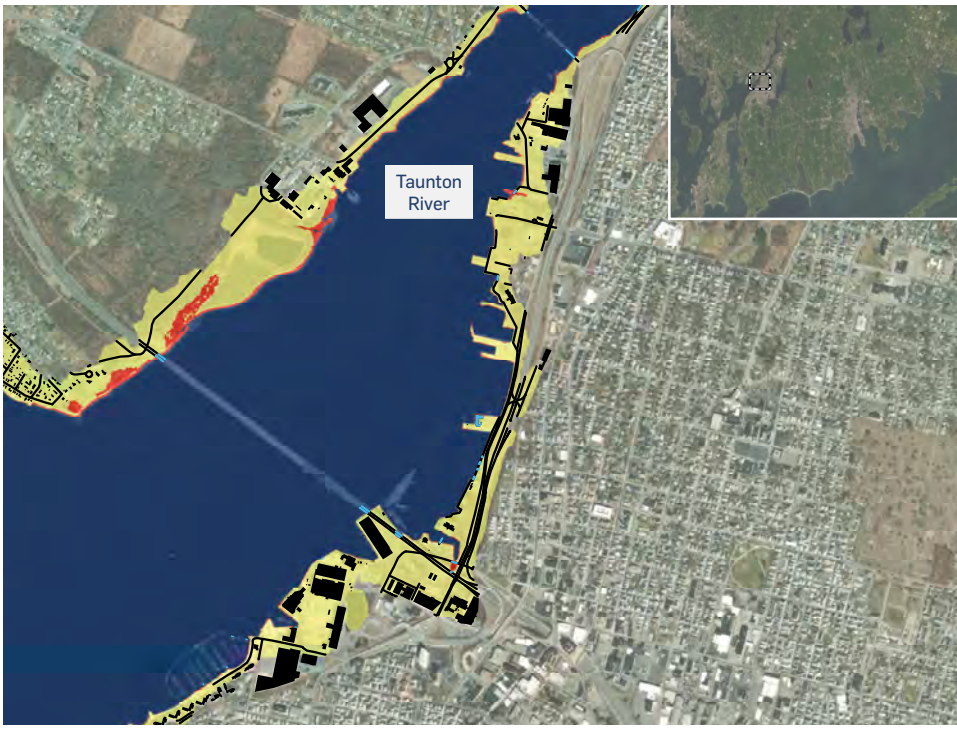
The economy of the region is very much tied to the water with Fall River a designated cargo port and several towns supported by the fishing and recreation industries. The newly developing offshore wind industry is also expected to bring additional investments into both Fall River and Somerset. A decommissioned coal-fired power plant in Somerset, for example, will be the site of a new sub-sea cable manufacturing facility.

The communities of Narragansett Bay are aware of the threats they face from the impacts of climate change, particularly sea level rise and flooding. Over the last decade, Rhode Island universities, local and state officials, and environmental organizations, including Save the Bay, have made huge strides assisting communities with coastal resilience preparedness. With over 1,200 buildings and 28 miles of roadway projected to be inundated in a 10-year storm as soon as 2050 [CIT. 5], communities recognize the need to adapt infrastructure as well as think strategically about retreat.

The impacts of sea level rise and increased storm events threaten the health of coastal habitat such as salt marshes, as well as water quality within the bay. Over the last 200 years, it is estimated that over 90% of the historic eelgrass beds were lost due to both human and natural causes [CIT. 38]. More recently, water quality degradation has impeded the re-growth of these beds, resulting in declining shellfish populations [CIT. 38].

At the outset of this year's report process, calls with town staff were conducted to understand the main challenges and areas where adaptation is needed. These discussions coupled with information from Municipal Vulnerability Preparedness plans for each community, painted a picture of vulnerabilities and resilience needs not unlike the communities in neighboring Buzzards Bay.

- Buildings and roads potentially flooded by 100-year storm flooding
- Buildings and roads potentially affected by daily/frequent tidal flooding
- Areas potentially affected by 100-year storm flooding
- Areas potentially affected by daily or frequent tidal flooding (MHHW)
- Current Shoreline



As soon as 2050, Fall River and Somerset, where the Taunton River meets the Narragansett Bay, are projected to experience a variety of climate impacts to both natural and developed areas along their coast. In Fall River, more than 162 buildings and 10 miles of roadway may be inundated in a 100-year flood event [CIT. 5].

In the next 30 years, Narragansett Bay communities within Massachusetts are projected to experience a variety of impacts to both natural areas and developed areas along the coast (see Coastal Impact Matrix for details, pg. 36).

As soon as 2050:

DEVELOPED AREAS Daily tidal flooding is projected to impact 86 buildings [CIT. 5]. A 10-year flood may impact more than 1,600 buildings (3% of town buildings), and a 100-year flood may impact more than 2,600 buildings (4%) [CIT. 5].

ROADS Daily tides are projected to flood 1.5 miles of roads [CIT. 5]. A 10-year flood event is projected to inundate 28 miles of roadway (3% of town roads), and a 100-year flood event could inundate 46 miles of roadway (5%) [CIT. 5]. Low lying roads such as Atlantic Blvd. and Ferry Street are at a greater risk.

SALT MARSHES Almost a third (40 of 131 acres) of high marsh may be lost by flooding or conversion to low marsh. Overall, about 6% of total salt marsh (10 of 168 acres) may be completely lost to sea level rise [CIT. 6].

THE TOWNS IDENTIFIED THE FOLLOWING RESILIENCE PRIORITIES [CIT. 36 AND 37]:

- Improve stormwater management and wastewater treatment to reduce the amount of nutrients entering the bay and increase resilience to storms and sea level rise.
- Adapt and elevate bridges and roads to address increased flooding.
- Provide support to environmental justice populations along the waterfront who may be less able to prepare for, adapt to, and bounce back from flood hazards.

"Given our current staffing level, we are in reactive mode most of the time, making it hard to have conversations about planning for the future."

KAITLIN YOUNG, FALL RIVER CITY PLANNER [CIT. 37]

Facing the Future

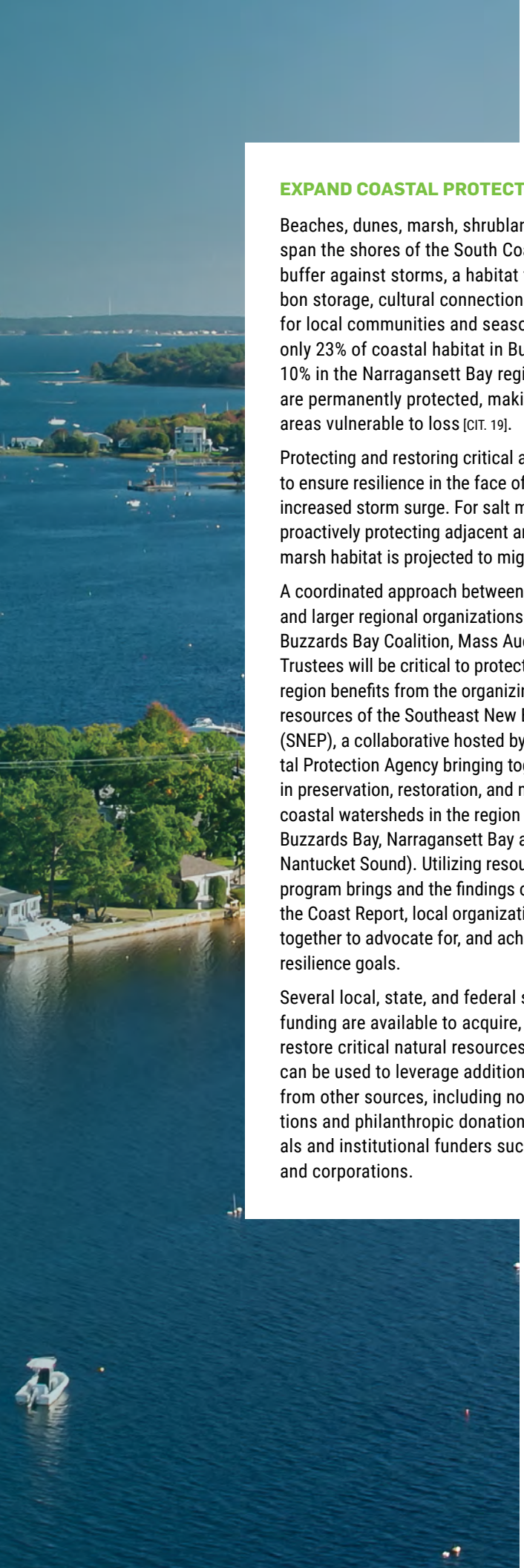
The coast holds a natural draw for many of us, who make homes, livelihoods, and memories on its shores. An incredible 40% of the nation's population live on the coast, in areas that account for less than 10% of the total land in the contiguous United States [CIT. 39]. In the state of Massachusetts, half of the 10 largest cities by population are coastal, including two featured in this report—New Bedford and Fall River [CIT. 39]. Protecting and adapting these areas is critical—the impacts of climate change are expected to significantly affect access, habitat, infrastructure, and economy, as detailed throughout this report.

In many communities, planning is already underway. Projects like Resilient Woods Hole are using the best available science to prepare and adapt. Nature-based solutions used in projects like the Great Marsh restoration are healing landscapes to better enable our natural spaces to keep pace with sea level rise and buffer storm surge and rising seas. And interdisciplinary collaborations like the Envision Resilience Narragansett Bay Challenge are pushing the boundaries of what exists as adaptive solutions now, to reimagine what can be possible to confront tomorrow.

There is a common factor in many of the most compelling resilience solutions—collaboration. The Trustees encourages partners in the region to work together to achieve the following forward-thinking actions.

"**Nature-based solutions** are…practices that weave natural features or processes into the built environment to promote adaptation and resilience." **FEMA**

The Massachusetts Municipal Vulnerability Preparedness program created a toolkit of nature-based solutions that can be found at *resilientma.mass.gov/mvp/*. Some examples include restored wetlands, pervious sidewalks and driveways, green roofs, urban forests, and agroforestry.



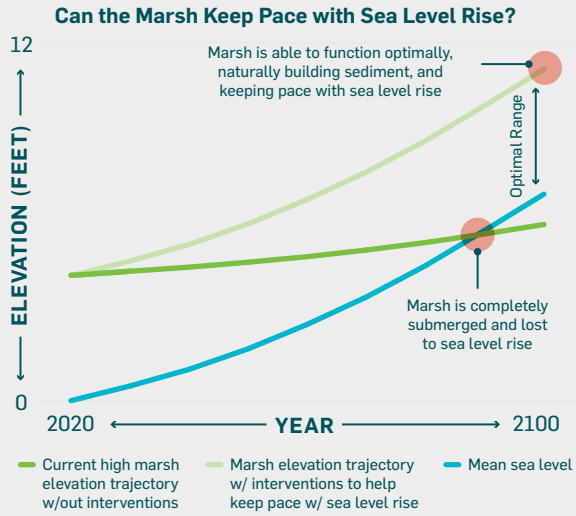
EXPAND COASTAL PROTECTIONS

Beaches, dunes, marsh, shrublands, and forests span the shores of the South Coast, providing a buffer against storms, a habitat for wildlife, carbon storage, cultural connections, and enjoyment for local communities and seasonal visitors. Yet only 23% of coastal habitat in Buzzards Bay and 10% in the Narragansett Bay region of this study are permanently protected, making the remaining areas vulnerable to loss [CIT. 19].

Protecting and restoring critical areas will be vital to ensure resilience in the face of rising seas and increased storm surge. For salt marsh in particular, proactively protecting adjacent areas where salt marsh habitat is projected to migrate is key.

A coordinated approach between local nonprofits and larger regional organizations such as the Buzzards Bay Coalition, Mass Audubon, and The Trustees will be critical to protect our coasts. This region benefits from the organizing and financial resources of the Southeast New England Program (SNEP), a collaborative hosted by the Environmental Protection Agency bringing together partners in preservation, restoration, and monitoring of coastal watersheds in the region (including Buzzards Bay, Narragansett Bay and coastlines of Nantucket Sound). Utilizing resources the SNEP program brings and the findings of this State of the Coast Report, local organizations can work together to advocate for, and achieve, high priority resilience goals.

Several local, state, and federal sources of public funding are available to acquire, protect, and restore critical natural resources. Public funds can be used to leverage additional investments from other sources, including nonprofit contributions and philanthropic donations from individuals and institutional funders such as foundations and corporations.



EXAMPLE In 2017, the Town of Dartmouth used $600,000 from its Community Preservation Act funds to work with the Dartmouth Natural Resources Trust (DNRT), Buzzards Bay Coalition, and Round the Bend Farm to protect the 115-acre Ocean View Farm. The property includes over 3,000 feet of the Allens Pond shoreline, protecting the coastal salt pond system along the shore of Buzzards Bay. One of the most significant coastal habitats in the region, a portion of the property is managed for wildlife habitat while a portion remains a working farm [CIT. 40].

RESTORE SALT MARSHES

The legacy of agricultural and mosquito control ditching on New England salt marshes has lowered the water table and led to land subsidence (sinking). A healthy marsh would naturally accrete and build in elevation over time allowing the landscape to keep up with rising seas. Low-impact nature-based techniques such as the method being utilized by The Trustees and multiple partners to restore the Great Marsh on the North Shore, can harness the power of nature to heal ditches and open natural drainage pathways. A healthy marsh

is a resilient marsh. In addition to restoring the health of these beneficial landscapes, steps must be taken to prepare for inland migration of marshes as seas rise by proactively protecting these migration corridors and removing barriers created by roadways and infrastructure.

A study of Plum Island salt marshes in northern Massachusetts indicates that accretion rates of these marshes have been keeping up with sea level rise through deposition of sediment from both rivers and the ocean, as well as organic material from grasses [CIT. 24]. With the rate of sea level rise projected to increase, however, it is unclear whether our marshes can keep pace. A coordinated approach between municipalities, local land trusts, and regional non-profit organizations could help advance protection and restoration of existing marsh, as well as migration areas.

In addition to healing the hydrology of our marshes, innovative techniques may also be needed to help the marsh build elevation. Thin layer deposition or mud motors are both techniques that have been used in other states to bring additional sediment into the system. As neither of these techniques are allowed under current regulations in Massachusetts, we encourage our agency partners to consider allowing carefully monitored trials on some of our most at-risk habitat.

Continued research into the effectiveness of these restoration techniques will be critical to ensuring the resilience of our marshes. The Salt Marsh Working Group, a network of state, federal and nonprofit partners in New England, promotes this continued research and helps share this information regionally so we can all continue to adapt and improve our work to protect this critical resource.

EXAMPLE Marsh Island in Fairhaven is a peninsula of land jutting into New Bedford Harbor that currently has very little marsh despite its name. Once a twenty-acre salt marsh, the area was filled with sand from dredging of the navigational channel in the early 1900s. Buzzards Bay Coalition is now leading a project to restore 11 acres of the historically filled marsh. The design will excavate and remove the fill to restore a tidal creek salt marsh system with predominantly resilient high marsh habitat and will create adjacent upland grassland areas that will adapt into salt marsh in the future as sea levels rise [CIT. 41].

IMPROVE WATER QUALITY

The Buzzards Bay Coalition identifies the major sources of nitrogen pollution in the bay to be septic systems, insufficient wastewater treatment, and pollutant-laden stormwater runoff. Higher intensity and more frequent storm events due to climate change are expected to exacerbate these problems. Recommended actions include improving septic system design to reduce nitrogen, expanding residential connections to sewer and improving water treatment. Reducing pollution from stormwater runoff is something homeowners and municipalities alike can address. Save the Bay encourages people to reduce polluted runoff from their properties by making their yard a sponge, planting native plants, scooping pet waste, and maintaining septic systems [CIT. 42].

EXAMPLE In 2013, Wareham became the first town on Buzzards Bay to require that any new septic system within 500 feet of the water must be designed to reduce nitrogen [CIT. 32]. Since then, many towns in the region have participated in demonstration projects to support installation of these new systems. Westport recently passed a new regulation requiring all new construction to install systems with nitrogen-removing technology.

ADAPT OR RELOCATE HUMAN INFRASTRUCTURE

Communities across Massachusetts are already seeing the impact of rising seas and increasing storm intensity on critical infrastructure. These impacts are projected to get much worse, demanding that the region be proactive in planning for resilience now. The widespread projected threats to roads, bridges, culverts, buildings, and wastewater treatment infrastructure necessitates a balanced approach that includes both adaptation and retreat. It will be critical to identify and then elevate or adapt infrastructure such as key access roads, wastewater pump stations, buildings, and homes. In some areas, a longer-term and more cost-effective approach may be to retreat and relocate from vulnerable areas over time. Communities have hard choices to make, and values to balance.

Recently filed legislation proposing a Flood Risk Protection Program would create a statewide property buyout program enabling the state, cities, towns, and nonprofit partners to acquire flood-prone property from willing owners on a voluntary basis before disaster hits, while providing support for relocation. Under this legislation, filed by Representative Sarah Peake and Senator Marc Pacheco, properties would be restored to natural landscapes and permanently conserved—providing a buffer against future climate impacts, restoring critical habitat, protecting water supplies, and creating new recreational opportunities. Lawmakers involved in this effort are focused on making sure the majority of investments go to homeowners and tenants who lack remedies and resources, especially those who are members of Environmental Justice communities. With over 15,000 buildings at risk on the South Coast as soon as 2050, this program would make retreat more economically feasible while also creating natural areas along the coastline to further protect our communities. The Trustees is leading efforts to secure legislative support for this effort in close coordination with nonprofit partners at Conservation Law Foundation, Environmental League of Mass, Mass Audubon, Mass Association of Conservation Commissions, Mass Land Trust Coalition, Mass Rivers Alliance, Metropolitan Area Planning Council, The Nature Conservancy, and others.

EXAMPLE Woods Hole, within the town of Falmouth, has become a world-renowned center for scientific research, while also serving as one of two major state ferry hubs to Martha's Vineyard. Home to the Woods Hole Oceanographic Institute, the Marine Biological Laboratory, and NOAA's Northeast Fisheries Science Center, these ocean experts have started to plan for the impacts of sea level rise. The ResilientWoodsHole initiative is a partnership between these research institutions, the town of Falmouth, residents, and businesses. A range of resilience strategies, from adaptation to retreat, have been developed and presented to the community for feedback. This project is an example of bold thinking that can be a model for other communities to follow.

DESIGN FOR THE FUTURE

Communities have an opportunity to design and implement creative approaches to living with water, from deployable barriers and absorptive landscapes to floating and elevated infrastructure. That means engaging multiple disciplines and thinking outside of the box.

EXAMPLE The Envision Resilience Nantucket Challenge inspired coastal communities on Nantucket to consider innovative adaptations to sea level rise. ReMain Nantucket took this challenge to Narragansett Bay in the spring of 2022 to inspire mainland coastal communities to reimagine at-risk sites in the region through a design-driven approach [CIT. 43]. At six participating universities, students in architecture, landscape design, environmental engineering, law, and economics to name a few, are working across disciplines to develop solutions and a path to sea level rise resilience for several Narragansett Bay communities. These design proposals, along with those developed for Nantucket, are a model of the collaborative innovation needed to build truly resilient communities.

ADOPT FORWARD-THINKING TOWN BYLAWS

We need to plan now to reduce impacts to our communities in the future. One of the considerations that can be made on a town-level basis is to consider restricting new development in areas projected to become salt marsh, or flood-prone, in the future.

Two regional planning agencies serve this part of the South Coast—the Southeastern Regional Planning and Economic Development District and the Cape Cod Commission. Both agencies provide recommended updates to town bylaws that encourage nature-based solutions to climate change. Recommended updates have a net-benefit for communities by improving water quality and open space protections that also reduce the costs of road and stormwater infrastructure maintenance. While many towns have not adopted recommended updates, all of the towns are participating in the Community Preservation Act, a smart growth program that provides funding to towns to preserve open space and historic sites, create affordable housing, and develop outdoor recreational facilities.

RETHINK HARD STRUCTURES

Coastal structures such as seawalls, revetments, and jetties are prevalent along this coastline and were constructed to protect against erosion and capture sediment to create beaches in an area with limited sediment supply. But too often these structures cause damage to our coastline—contributing to erosion, exacerbating property damage, and undermining resilience by preventing migration of habitat inland. These hardened structures were also not designed with climate change in mind. Due to increased storm surge and higher seas, these aging structures are now at risk. It's time to rethink these hardened structures and implement nature-based solutions to erosion control such as living shorelines, artificial reefs, and land conservation. These longer-term solutions work with nature instead of against it and offer a win-win for both communities and habitat.

EXAMPLE A large-scale living shoreline project was installed at Collins Cove in Salem in 2019. Led by Salem Sound Coastwatch, the goal of this project was to convert 800 feet of hardened shoreline to saltmarsh through use of softer bio-engineered materials such as coir logs, elevation adjustments with sand, and planting with salt marsh grasses [CIT. 44]. This new saltmarsh is protecting the community from wave energy, providing habitat for wildlife, sequestering carbon, and adding to the aesthetic beauty of the cove.

MOVE FROM PLANNING TO ACTION

All the towns in this region have completed Municipal Vulnerability Plans that assess climate change threats to their infrastructure and are poised to begin implementing projects, yet many cite lack of capacity and resources as barriers to action. Adopting a regional approach to infrastructure adaptation is part of the solution and can help towns work together. The Southeastern Regional Planning and Economic Development District is the Regional Planning Agency for most of the towns in this South Coast region and recently started a two-year project to create a Regional Resilience Plan. The plan will identify environmental, economic, and social vulnerabilities. The District hopes this plan will provide a roadmap to improve resilience to climate change.

In order to move from planning to action, towns must both prioritize infrastructure adaptation work and reach out to partners for collaboration. Where resilience projects contribute to the goals of nonprofit organizations or local businesses (i.e. habitat protection, restoration, water quality improvements, or infrastructure protection), these partnerships can be an effective way to implement projects with dual benefits. Funding for regional staff capacity to support project implementation should be considered.

MODERNIZE PERMITTING PROCESSES

Climate change is already impacting built and natural resources today, and these impacts are projected to increase in intensity and frequency. State agencies need to modernize the permitting process to make it nimble and efficient for projects that align with the Commonwealth's urgent goals to conserve and restore natural resources using nature-based solutions. We recommend that the Massachusetts Environmental Policy Act Office facilitate coordination between regulatory agencies, nonprofit partners, municipalities, and property owners to achieve this important body of work.

Specifically, our coastal salt marshes are losing ground due to a legacy of ditching, and we need to act swiftly to restore their hydrology, allowing them to keep pace with sea level rise. Innovative techniques for healing ditches are proving successful but permitting barriers are delaying many projects. Rather than requiring long and often uncertain monitoring periods that delay other restoration projects using these techniques, we advocate for an adaptive approach that allows project managers to work together with regulators to adjust techniques as needed. We recommend streamlining the MEPA review process and adopting a programmatic Environmental Impact Report for projects or raising thresholds for nature-based solutions to allow for exemptions. In addition, we recommend updating the Chapter 91 regulations, overseen by the Department of Environmental Protection, by amending the definition of "fill" to exclude salt marsh hay for purposes of restoration.

FUND RESILIENCE PROJECTS

We need consistent, robust streams of dedicated local, state, and federal revenue for climate mitigation, adaptation, and resiliency. The American Rescue Plan Act resulted in $5.6 billion in funding for Massachusetts, and several hundred million is being allocated to restoration, land protection, and resilience

work over the next 4 years. This funding provides an incredible, yet short-term, opportunity to advance climate change resilience and mitigation work in the Commonwealth. Longer-term funding needs to match the potential magnitude of the threat. Once past a tipping point, recovery and repair costs can far exceed mitigation costs, if recovery remains an option. The Federal Emergency Management Agency estimates that for every $1 spent to mitigate the impacts of riverine flooding, for example, we save $7 in avoided damage [CIT. 45]. The Trustees proposes that we look beyond our traditional community coffers and grants and develop new ways of funding and incentivizing resiliency and conservation. Lawmakers need to increase investments in land conservation and restoration through traditional bond bills and identify additional dedicated funding sources to implement coastal protection. Programs including emissions trading systems, green/blue/resiliency bonds, real estate transfer fees, and climate funds and derivatives are just the tip of the iceberg. So are mechanisms such as insurance policies that offer lower premiums for steps to reduce climate risks and banks that focus on investing in risk management and sustainability (e.g. Rhode Island Infrastructure Bank and New Jersey's Energy Resilience Bank). As important, we need to support social science research that will help us find ways to make the rapid, significant psychological shifts as a society that are required to adapt to climate change. We need to better understand what it is that holds us back from investing more in climate solutions now and conserving our coast for generations to come.

ENGAGE THE COMMUNITY

Advancing large-scale and sometimes costly resilience efforts across the region is a significant undertaking made more difficult without community buy-in. The public must understand the risks facing their coastal lands and communities and be part of the decision-making. Many local organizations and municipalities have programs aimed at engaging residents in work to build climate change resilience and environmental stewardship. We can learn lessons from the Mashpee Wampanoag tribe, who have long taught the connection between humans and the natural environment to their children, growing a population of people who respect and care for the land as it provides for them in return.

EXAMPLE Groundwork Southcoast is an example of a small grassroots organization that is having a big impact on the local community. Part of a nationwide network, this independent not-for-profit environmental organization invests in the next generation to encourage a new way of thinking about and caring for our environment. Since 2017, youth have maintained 1,200 acres of open space, installed 150 raised beds for low-income and BIPOC residents, and donated over 3,000 pounds of food to families in need. To reduce heat islands and flooding in New Bedford and Fall River, the organization is working to plant over 1,000 urban trees by 2024.

WHAT CAN YOU DO?

As a resident of the South Coast, there are several things you can do to help your community. Here are some ideas.

EDUCATE yourself by participating in public events, reading up on climate-related topics, and staying informed about local policies related to climate change.

REDUCE your carbon footprint to help slow the pace of climate change.

TALK TO OTHERS — your family, friends, neighbors, colleagues — about this report and steps we can all take to improve community resilience and slow the pace of climate change.

VOLUNTEER to help by offering your time to a local project, serving on a board or committee, or reporting climate impacts (e.g. **www.mycoast.org/ma)**.

CONTACT elected officials to encourage them to prioritize and fund climate resilience and mitigation efforts in the commonwealth and in your community.

DONATE to an organization such as The Trustees that is doing work to increase community resilience or slow climate change.

Coastal Impact Matrix

PROJECTED FLOODING IMPACTS TO INFRASTRUCTURE

		BUZZARDS BAY											
		Falmouth*	Bourne	Plymouth*	Wareham	Marion	Mattapoisett	Fairhaven	New Bedford	Dartmouth	Westport	Buzzards Bay Total	Narragansett Bay Total
Structures Flooded from Daily Tidal Flooding **Present Day**	STRUCTURES FLOODED [CIT. 5]	23	0	7	24	6	1	17	21	10	25	**134**	**28**
Structures Flooded from Daily Tidal Flooding **2050**		219	156	0	247	45	111	324	48	69	104	**1323**	**86**
Structures Flooded from 10-Year Coastal Flood **Present Day**		933	1586	6	2468	526	710	929	123	405	453	**8139**	**1006**
Structures in Areas Flooded from 10-Year Coastal Flood **2050**		1386	2655	14	4326	890	1142	1433	270	635	751	**13502**	**1635**
Structures in Areas Flooded from 100-Year Coastal Flood **Present Day**		1407	2547	11	3981	861	1097	1275	253	668	759	**12859**	**1750**
Structures in Areas Flooded from 100-Year Coastal Flood **2050**		2012	3619	26	6365	1464	1576	1759	399	902	1026	**19148**	**2602**
Roads Flooded from Daily Tidal Flooding **Present Day** (miles)	ROADS FLOODED (MILES) [CIT. 5]	0.0	0.0	0.3	0.2	0.1	0.2	0.3	0.2	0.2	0.0	**1.6**	**0.4**
Roads Flooded from Daily Tidal Flooding **2050** (miles)		4.0	2.5	0.0	3.2	0.5	3.0	5.7	1.2	3.1	0.8	**24.0**	**1.5**
Roads Flooded from 10-Year Coastal Flood **Present Day** (miles)		15.6	27.3	0.0	35.0	8.8	13.2	15.6	6.9	10.9	7.4	**140.6**	**15.6**
Roads Flooded from 10-Year Coastal Flood **2050** (miles)		24.5	43.7	0.2	60.9	15.8	19.7	22.9	10.4	15.6	14.1	**227.9**	**28.0**
Roads Flooded from 100-Year Coastal Flood **Present Day** (miles)		24.1	41.8	0.2	56.8	14.9	19.0	21.2	9.5	16.0	14.7	**218.2**	**30.8**
Roads Flooded from 100-Year Coastal Flood **2050** (miles)		34.4	60.1	0.5	94.6	25.5	26.3	27.7	12.4	20.2	19.5	**321.2**	**45.9**

SHORELINE AND HABITAT CONDITIONS AND PROJECTED IMPACTS

		BUZZARDS BAY											
		Falmouth*	Bourne	Plymouth*	Wareham	Marion	Mattapoisett	Fairhaven	New Bedford	Dartmouth	Westport	Buzzards Bay Total	Narragansett Bay Total
Length of Coast (miles)	SHORELINES (MILES) [CIT. 16, 17]	26.1	37.4	NA	26.9	24.4	23.2	29.4	11.7	20.0	9.6	**208.5**	**47**
Salt Marsh (miles)		3.6	11.9	NA	8.4	12.3	10.6	15.9	0.0	4.2	1.3	**68.4**	**No data**
Coastal Dune (miles)		8.1	7.7	NA	9.8	1.2	3.9	4.8	0.5	6.5	6.9	**49.3**	**No data**
Coastal Beach (miles)		19.9	23.8	NA	16.7	9.4	10.6	10.8	5.9	16.2	8.6	**121.9**	**No data**
Bulkhead, Seawall, Revetment (miles)		13.4	10.8	NA	9.7	10.5	8.5	6.7	5.8	6.0	0.9	**72.3**	**No data**
Public Coastal Access (miles)		3.1	9.2	NA	7.5	4.0	3.3	9.0	8.0	4.1	5.5	**53.7**	**5.2**
Average Long Term Erosion Rates (Feet/Year) ~150 years (neg. is erosion)	EROSION [CIT. 15]	-0.1	-0.1	NA	-0.2	-0.3	-0.3	-0.4	0.2	-0.4	-0.8	**-0.2**	**No Data**
High Marsh (acres) **2011**	MARSH (ACRES) [CIT. 6]	221	277	1	830	353	366	547	2	1007	828	**4431**	**131**
High Marsh Change (acres) **2011 to 2050** (neg. is loss)		-136	-209	0	-573	-254	-295	-420	-2	-868	-739	**-3497**	**-40**
Percent High Marsh Change **2011 to 2050**		-62%	-75%	-16%	-69%	-72%	-81%	-77%	-68%	-86%	-89%	**-79%**	**-31%**
Total Marsh (acres) **2011**		257	308	1	869	405	385	571	5	1072	877	**4750**	**168**
Total Marsh Change (acres) **2011 to 2050** (neg. is loss)		-43	-86	0	-89	-86	-67	-39	1	-325	-417	**-1150**	**10**
Total Marsh Percent Change		-17%	-28%	33%	-10%	-21%	-17%	-7%	10%	-30%	-48%	**-24%**	**6%**
Coastal habitat area (sq. miles)	HABITAT [CIT. 19]	7.7	11.4	0.6	20.7	10.8	7.7	6.7	1.8	12.7	12.5	**92.6**	**13.6**
Percent of coastal habitat protected		10%	11%	25%	16%	32%	31%	31%	6%	39%	24%	**23%**	**10%**

* Only the areas within Falmouth and Plymouth that drain into Buzzards Bay were included in this analysis.

This Coastal Impacts Matrix is a summary table of the data that is provided throughout this report. It allows communities to gauge their specific risks and vulnerabilities in relation to each other and the region. The "Flooding impacts to infrastructure" table (left) provides estimates of roads and buildings flooded during present day high tides and storms, as well as projections for 2050 [CIT. 5].

The "Shoreline and habitat conditions and impacts" table (above) provides values for both existing conditions of shorelines and projections to 2050 for erosion and marsh loss [CIT. 6, 15, 17, 19].

Visit *thetrustees.org/coast* for interactive maps to further explore projected impacts, or contact us at *coast@thetrustees.org*.

Mashpee Wampanoag Tribe

DAVID WEEDEN
TRIBAL COUNCILMAN/THPO, TRIBAL HISTORIC PRESERVATION DEPARTMENT, MASHPEE WAMPANOAG TRIBE

The Trustees' State of the Coast Report for the South Coast is an important document to better understand the impacts of climate change in Buzzards Bay and Narragansett Bay and implement a strategy to take corrective actions. The waters in and around Cape Cod and the Islands have been in significant decline for many years, informing citizens of the Commonwealth that the current laws and regulations are insufficient at preserving and protecting water quality. Ecosystems within the region are slowly dying or being impaired to where they are not producing the same amount of shellfish as they used to, and climate change is expected to intensify this.

The Tribe has utilized the abundance the creator has provided for our people for thousands of years and considers what others refer to as "resources" as "gifts". These gifts cannot and must not be taken for granted, so we have a responsibility to look after the fragile environments that support the ecology found within our waters.

The Natural laws that guided and informed our way of life perpetuated healthy biodiverse regions by the basic concept of appreciating and respecting all life. Current society has exploited every "resource" found here in the Americas throughout the brief 400 years since colonization, consequently destroying many of the unique environments which were pristine 400 years ago.

Currently the Cape Cod region is faced with both historic traumas to our environments and the subsequent climate crisis compounding the existing conditions. The increase of development is a long-standing threat that has consistently impacted the region for the past 60 years due to the aggressive nature in which it is being done. The lack of wastewater infrastructure is a core issue with regard to our water quality. The water quality is also being impacted by water temperature increases as a result of global warming.

In order to take corrective actions to save these gifts, the Mashpee Wampanoag Tribe embraces the Trustees' State of the Coast initiative. Through this work we will learn the core areas of concern that threaten the Buzzards Bay and Narragansett Bay watersheds. This area is a resource area significant to our Tribe's survival as we have lived along the shores of Cape Cod since time immemorial.

The Mashpee Wampanoag retain Traditional Ecological Knowledge as stewards of this land, therefore we are compelled to partner with Trustees and the Buzzards Bay Coalition to study the area and develop a mitigation strategy to restore this once abundant watershed.

Shellfish propagation should be considered a proven effective way to reduce nitrogen which is a core issue. Additionally, other aquaculture programs should be considered conceptually. Aquaculture is consistent with the Cape Cod Commission's "Blue Economy Initiatives" and the regional Water Quality 208 program.

The Tribal Historic Preservation Office wants to express our support of the great work The Trustees is doing to preserve and protect land and sea.

David Weeden
Tribal Councilman/THPO
Tribal Historic Preservation Department
Mashpee Wampanoag Tribe

Buzzards Bay Coalition

MARK RASMUSSEN
PRESIDENT, BUZZARDS BAY COALITION

The environment that we all treasure on Buzzards Bay—clear water, access to extraordinary sailing and sport-fishing waters, quahogs under our toes, oysters on our plates, and the beauty and natural abundance of our gentle coastline—is a fundamental part of who we are here on the Southcoast. It's also under unprecedented stress from climate change.

The Buzzards Bay Coalition is focused on taking action today, as there is much that we can do at the local level right now to prevent the worst outcomes. Informed by decades of water quality monitoring and empowered by strong collaborations with scientists and local officials, our strategy focuses on wastewater improvements and salt marsh adaptation.

DOUBLE-DOWN ON WASTEWATER CLEANUP

Reducing nitrogen pollution to Buzzards Bay is the most powerful tool we have to counter the effects of climate change and make our coastal waters more resilient. And, unlike cutting global CO_2, the means for reducing nitrogen are largely within our control. Nitrogen comes primarily from residential wastewater and decisions about septic systems and sewer plants are made each week in our Town Halls.

Here's the difficult truth: our Bay is already warming and higher temperatures are like adding fuel to nitrogen pollution. Many parts of Buzzards Bay have warmed 4 degrees Fahrenheit since the inception of the Coalition's water quality monitoring program in 1992. We see more algae in today's warmer waters, which clouds and robs the Bay of life-sustaining oxygen as it decomposes.

And the impacts don't end with clear water. Nitrogen also makes the Bay more acidic, compounding the increasing acidity the Bay is seeing from more carbon dioxide in the atmosphere. Acidity dissolves shells; meaning a Bay with less scallops, oysters and clams—a blow to our marine economy but also a loss of their water filtering capacity. Even the ability of our salt marshes to stand up to sea level rise is affected by nitrogen pollution. Elevated nitrogen levels in the Bay can lead to a weakening of the roots of salt marsh grasses, reducing their ability to hold firm in the face of rising seas and increased storminess.

That's why our organization remains more committed than ever to working with homeowners, developers, town officials, and state agencies to expand sewer service in our communities and to accelerate the transition to denitrifying septic systems wherever sewer is not possible.

BUY OUR MARSHES AS MUCH TIME AS POSSIBLE

The Trustees State of the Coast report highlights the dire situation facing Buzzards Bay's precious salt marshes which are already struggling to keep up with rising sea levels. Of all landscapes, none provides more ecological services than salt marshes and we must do everything in our power to slow their loss.

The Buzzards Bay Coalition has made the permanent preservation of the uplands that lie just behind our salt marshes our highest land conservation priority. By preventing development or hardening of these fringing lands, we can give marshes a chance to migrate inland as sea level rises. We are making the real estate deals needed to save these lands now.

Second, we are piloting new physical interventions to mitigate marsh loss. Our scientists are working with partners throughout New England to prove the effectiveness of techniques like runneling which help drain water off the marsh and prevent grass die-off. Other techniques like increasing tidal flushing and adding sediment to marshes are also part of this emergency response that are being considered.

ACCELERATE OUR OWN TRANSITION TO RENEWABLE ENERGY

While public officials are increasingly focused on responding to climate change impacts already occurring, reducing the source of this problem—the burning of fossil fuels—can get lost. Ultimately, the scale of how badly climate change impacts our Bay, our communities and our grandchildren still depends on all of us. To be clear, we can't reverse what has already been put in motion, but we can avoid the most catastrophic scenarios by speeding up our own shift away from fossil fuels in our homes and our cars.

Mark Rasmussen
President, Buzzards Bay Coalition

Citations and Sources

Data used in this report came from a variety of sources. Metrics such as marsh transitions, number of buildings flooded and miles of roads impacted are based on assessments of existing model results. The models used are state-of-the-art, but they are based on a number of assumptions and various input conditions that come with inherent limitations. The Trustees used publicly available data for other metrics, including beach erosion rates, public access, and miles of armored shoreline. Our sources include (in order of appearance in the document):

1. **The Worst Massachusetts Hurricanes of the 20th Century.** *(https://www.mass.gov/service-details/the-worst-massachusetts-hurricanes-of-the-20th-century)*

2. **MA Barrier Beach Inventory.** *(https://www.mass.gov/service-details/massachusetts-barrier-beach-inventory)*

3. **Massachusetts State sea level rise projections** were developed by DeConto, R.M. and R.E. Kopp (2017). *Massachusetts Sea Level Assessment and Projections; Technical memorandum.* More details on Massachusetts State Sea Level Rise projections can be found at *(https://resilientma.mass.gov/resources/resource::2152).* The 'high' rate of sea level rise is what is used in our flood risk analyses using MC-FRM (Massachusetts Coast Flood Risk Model) as recommended by the Massachusetts Office of Coastal Zone Management (CZM) and UMass-Boston. Assumed increases in sea level are +1.3 ft,+ 2.6ft, +4.4 ft as soon as 2030, 2050, and 2070. These values of sea level rise were calculated from published projections of sea level elevation using the mean water level for Woods Hole of -0.17 ft NAVD88 in present day (centered around a 2008 baseline).

4. **Climate change projections** from Resilient MA. *(https://resilientma.mass.gov/changes)*

5. **Impacts to buildings and roads from coastal flooding.** Information about the flood modeling can be found at *(https://eea-nescaum-dataservices-assets-prd.s3.amazonaws.com/cms/GUIDELINES/MC-FRM_FAQ_04-06-22.pdf).* Values for roads and buildings inundated were calculated for each town using the flood scenario extents under the "high" rate of sea level rise, as recommended by Massachusetts Office of Coastal Zone Management (CZM) and UMass-Boston. *Technical Memo: Methodologies for assessing coastal vulnerabilities for The Trustees State of the Coast—South Coast*, Woods Hole Group, 2022.

6. **Marsh and coastal habitat changes** were provided by Woods Hole Group and derived from CZM's Massachusetts Sea Level Affecting Marshes Model (SLAMM) project. The high sea level rise scenario from which SLAMM results are presented is 7.1 feet of rise for Buzzards Bay from 2011-2100. Details on the SLAMM model can be found at *(https://www.mass.gov/service-details/report-on-modeling-the-effects-of-sea-level-rise-on-coastal-wetlands)*

7. **Historic closures of New Bedford Harbor Hurricane Barrier** from US Army Corps of Engineers; John MacPerson, Operations Manager (email communication July 19, 2022).

8. **Eelgrass extents** were calculated by the Buzzards Bay Coalition using data from the Buzzards Bay National Estuary Program.

9. **Bay scallop landings** for Buzzards Bay were calculated by the Buzzards Bay Coalition using data from the Massachusetts Division of Marine Fisheries.

10. **NOAA's tide gauge trends** for Woods Hole. *(https://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?id=8447930)*

11. **Hurricane extents** were obtained from data at MassGIS. *(https://maps.massgis.digital.mass.gov/MassMapper/MassMapper-CZM-MORIS.html)*

12. **Massachusetts Coast Sea Level Rise.** *(https://resilientma.mass.gov/changes/sea-level-rise)*

13. **Previous sea level rise projections** from Parris et al. (2012). *Global sea level rise scenarios for the United States National Climate Assessment,* NOAA.

14. **NOAA sea level rise projections** from Sweet et al. (2022). *Global and regional sea level rise scenarios for the United States*. Technical report NOS01. *(https://oceanservice.noaa.gov/hazards/sealevelrise/sealevel-rise-tech-report.html)*

15. **Short- and long-term erosion rates, beach erosion rates, and shoreline change analyses** were derived from USGS Coastal Change Hazards Portal. *(https://marine.usgs.gov/coastalchangehazardsportal)*

16. **Coastal Public Access** data was derived from data at MassGIS. *(https://maps.massgis.digital.mass.gov/MassMapper/MassMapper-CZM-MORIS.html).* This dataset includes more than 1,900 publicly accessible sites along the Massachusetts coast that are owned by government agencies and nonprofits and open to the public. It includes beaches, rocky coasts, shore-side parks, public boat ramps, harbor walks, coves, marshes and creeks, overlooks, islands (some that are only accessible by boat), and rights-of-way.

17. **Shoreline Characterization Layers** from CZM were sourced from the Massachusetts Ocean Resources Information System (MORIS) at *(https://maps.massgis.digital.mass.gov/MassMapper/MassMapper-CZM-MORIS.html)* and the *Report of the Massachusetts Coastal Erosion Commission, Volume 1: Findings and Recommendations*, and *Volume 2: Working Group Reports*, *(https://www.mass.gov/service-details/massachusetts-coastal-erosion-commission)*

18. **Shore Protection Structures** from CZM were sourced from the Inventories of Seawalls and Other Coastal Structures website. *(https://www.mass.gov/service-details/inventories-of-sea-walls-and-other-coastal-structures)*

19. Woods Hole Group, Inc. analysis of **MassGIS Data: Protected and Recreational Open Space** (December 2021) including inventories of the conservation and outdoor recreational facilities owned by federal, state, county, municipal, and nonprofit enterprises.

20. **Massachusetts StormSmart Coasts Program.** *(https://www.mass.gov/stormsmart-coasts-program)*

21. **Salt marsh carbon** sequestration estimate from Mcleod et al. (2011). *A blueprint for blue carbon: toward an improved understanding of the role of vegetated coastal habitats in sequestering CO2.*

22. **NOAA Tide Datums** provide information on tidal ranges for New Bedford, Falmouth, and Boston. *(https://tidesandcurrents.noaa.gov/stations.html?type=Datums)*

23. **Allens Pond restoration** information from Mass Audubon; Danielle Perry, Coastal Resilience Program Director (email communication July, 2022).

24. **Salt marsh accretion rates** for Plum Island Sound estuary from Hopkinson et al. (2018). *Lateral marsh edge erosion as a source of sediments for vertical marsh accretion.* Journal of Geophysical Research: Biogeosciences. *(https://doi.org/10.1029/2017JG004358)*

25. **Economic impact of fisheries at Port of New Bedford** from Martin Associates (2019). *Economic impact study of New Bedford/ Fairhaven Harbor*.

26. **Port of Fall River** *(https://www.fallriverma.org/port-authority/)*

27. **Landings information for fish and shellfish** provided by Massachusetts Division of Marine Fisheries; Erich Drusket (email communication March 29, 2022).

28. **New Bedford Harbor Hurricane Barrier.** *(https://portofnewbedford.org/wp-content/uploads/2021/12/NBHB-2022-Tide-Watch-Schedule.pdf)*

29. **Recommended New Bedford port upgrades and resiliency measures** from Foth Infrastructure & Environmental, LLC and Fathom Resources, LLC (2021). *New Bedford Harbor Port Assessment Summary*.

30. **Resilient Design Guidelines New Bedford Harbor:** *A guide for the Port of New Bedford to bolster building and infrastructure resilience in the face of sea level rise and storm surge,* June 2020.

31. **Buzzards Bay National Estuary Program.** *(www.buzzardsbay.org)*

32. **Nitrogen pollution in Buzzards Bay.** Buzzards Bay Coalition. *(savebuzzardsbay.org)*

33. **Impaired waterbodies** from MA Department of Environmental Protection, Integrated Waters List. *(https://www.mass.gov/lists/integrated-lists-of-waters-related-reports)*

34. **Nitrogen-reducing septic systems** in West Falmouth. Buzzards Bay Coalition. *(savebuzzardsbay.org)*

35. The Upper Bay **Regional Wastewater Feasibility Assessment,** Buzzards Bay Coalition and partners, 2016-2021.

36. **Municipal Vulnerability Planning project reports** prepared under the Massachusetts Municipal Vulnerability Program (MVP). *(https://www.mass.gov/info-details/municipal-vulnerability-preparedness-mvp-program-planning-reports)*

37. **Communications with municipal officials** were conducted with conservation agents, town administrators, conservation agents, engineers, and others in the form of one interview per town and follow-up emails, February–March, 2022.

38. **Eelgrass declines in Narragansett Bay** from Save the Bay. *(https://www.savebay.org/bay_issues)*

39. **Coastal population** of United Stated at *(https://oceanservice.noaa.gov/facts/population.html)*

40. **Ocean View Farm protection project** summary from Dartmouth Natural Resources Trust. *(https://dnrt.org/oceanview/)*

41. **Marsh Island salt marsh restoration** project summary from Buzzards Bay Coalition; Sara Quintal, Restoration Ecologist (email communication August 8, 2022).

42. **Bay friendly living:** yard care and lifestyle tips to save time, money and the bay, Save the Bay. *(savebay.org/bay-friendly-living)*

43. **Envision Resilience Narragansett Bay.** *(https://www.envisionresilience.org)*

44. **Collins Cove Salt Marsh Restoration Project.** *(https://www.salemsound.org/livingShoreline.html)*

45. **Costs of flood mitigation versus loss** from Federal Emergency Management Agency (2018). *Natural hazard mitigation save—Interim Report*. *(fema.gov/sites/default/files/2020-07/fema_mitsaves-fact-sheet_2018.pdf)*

Local Organizations and Resources*

BOURNE CONSERVATION TRUST
bourneconservationtrust.org

BUZZARDS BAY ACTION COMMITTEE
buzzardsbayaction.org

BUZZARDS BAY COALITION
savebuzzardsbay.org

BUZZARDS BAY NATIONAL ESTUARY PROGRAM
buzzardsbay.org

CAPE COD COMMISSION
capecodcommission.org

CZM (THE MASSACHUSETTS OFFICE OF COASTAL ZONE MANAGEMENT)
mass.gov/orgs/massachusetts-office-of-coastal-zone-management

DARTMOUTH NATURAL RESOURCES TRUST
dnrt.org

ENVISION RESILIENCE NARRAGANSETT BAY CHALLENGE
envisionresilience.org/narragansett-challenge

EPA—SOUTHEAST NEW ENGLAND PROGRAM
epa.gov/snep

FAIRHAVEN ACUSHNET LAND PRESERVATION TRUST
facebook.com/falpt

GROUNDWORK SOUTHCOAST
groundworksouthcoast.org

MARINE BIOLOGICAL LABORATORY
mbl.edu

MASHPEE WAMPANOAG TRIBE
mashpeewampanoagtribe-nsn.gov

MASS AUDUBON SOUTH SHORE SANCTUARIES
massaudubon.org

MATTAPOISETT LAND TRUST
mattlandtrust.org

NARRAGANSETT BAY COALITION
narrabay.com

NARRAGANSETT BAY ESTUARY PROGRAM
nbep.org

NATIVE LANDS CONSERVANCY
nativelandconservancy.org

NOAA—NORTHEAST FISHERIES SCIENCE CENTER
fisheries.noaa.gov/about/northeast-fisheries-science-center

PORT OF FALL RIVER
fallriverma.org/port-authority

PORT AUTHORITY OF NEW BEDFORD
portofnewbedford.org

RESILIENT WOODS HOLE
resilientwoodshole.org

SAVE THE BAY
savebay.org

SE REGIONAL PLANNING AND ECONOMIC DEVELOPMENT DISTRICT
srpedd.org

SIPPICAN LANDS TRUST
sippicanlandstrust.org

TAUNTON RIVER WATERSHED ALLIANCE
savethetaunton.org

THE NATURE CONSERVANCY — MASSACHUSETTS
nature.org/massachusetts

THE 300 COMMITTEE LAND TRUST
300committee.org

USGS WOODS HOLE
usgs.gov/centers/whcmsc

WAREHAM LAND TRUST
warehamlandtrust.org

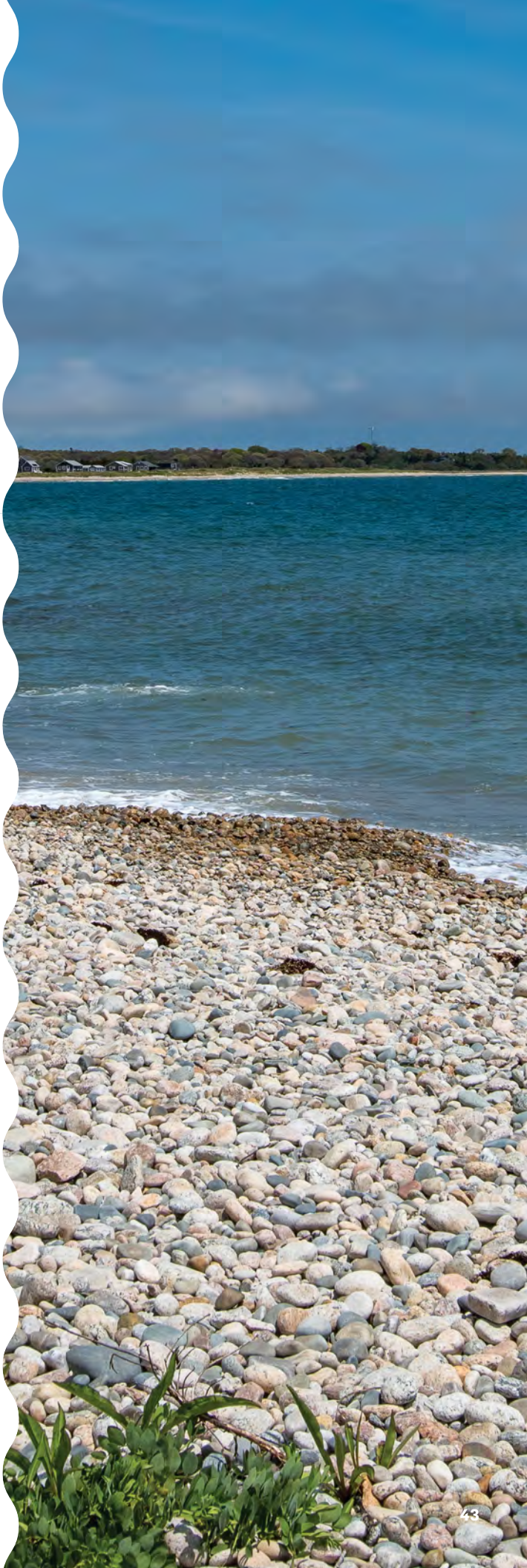
WESTPORT LAND CONSERVATION TRUST
westportlandtrust.org

WESTPORT RIVER WATERSHED ALLIANCE
westportwatershed.org

WOODS HOLE OCEANOGRAPHIC INSTITUTE
www.whoi.edu

WOODWELL CLIMATE RESEARCH CENTER
woodwellclimate.org

**Not a comprehensive list*



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ACKNOWLEDGMENTS

We would like to acknowledge and thank our interdisciplinary team, without whom the publication of this report would not have been possible. Thanks to Cynthia Dittbrenner, Trustees Director of Coast and Natural Resources for her vision and leadership in guiding the development and publication of this report; Eric Nelson, for lending his expertise as a Senior Environmental Consultant/Coastal Geologist to the foundational research, data compilation, and review for this report; Woods Hole Group, and in particular, Climate Resiliency Specialist Brittany Hoffnagle, for analyzing the flood risk modeling and mapping data so integral to this work and Climate and Sustainability Team Leader Joe Famely for data interpretation and content contributions; Christine Boynton, Trustees Coastal Communications Manager for assisting in the report development; Tom O'Shea, Trustees Managing Director of Nature and Resilience for his continued guidance; award-winning journalist Pamela Ferdinand for the many person-to-person interviews at the outset of this work; and to Casey McGee, Lily Robles, Kim Lê, and the Opus team for their beautiful design and creative vision in crafting the look and feel of this publication.